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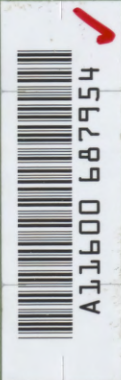
NATIONAL SCIENCE FOUNDATION LEGISLATION, 1973

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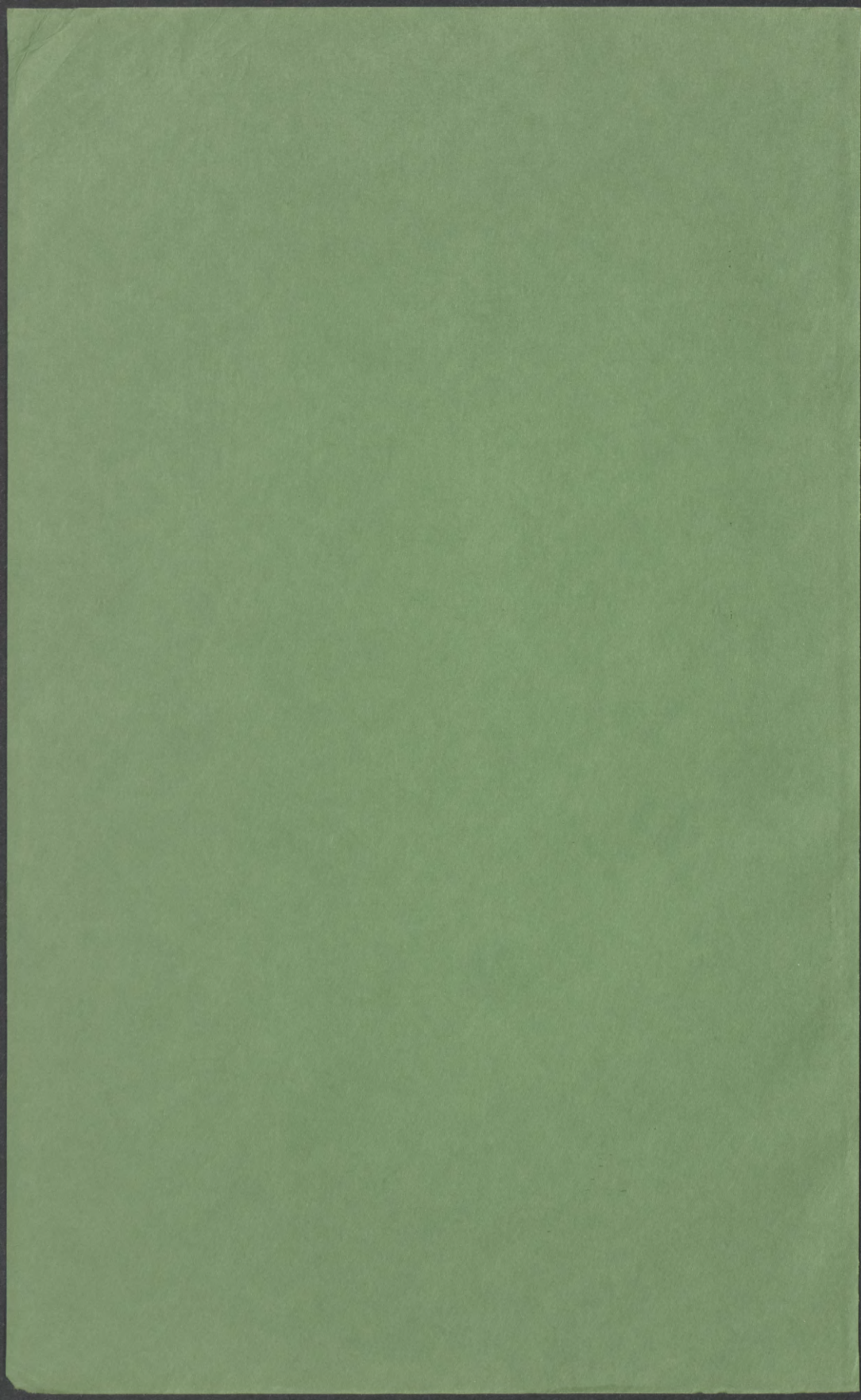


HEARING
BEFORE THE
SPECIAL SUBCOMMITTEE ON THE
NATIONAL SCIENCE FOUNDATION
OF THE
COMMITTEE ON
LABOR AND PUBLIC WELFARE
UNITED STATES SENATE
NINETY-THIRD CONGRESS
FIRST SESSION
ON
S. 1078
TO AUTHORIZE APPROPRIATIONS FOR ACTIVITIES OF
THE NATIONAL SCIENCE FOUNDATION, AND FOR OTHER
PURPOSES

MAY 3, 1973



Printed for the use of the Committee on Labor and Public Welfare



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MAY 3, 1973



Printed for the use of the Committee on Labor and Public Welfare

U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1973

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NATIONAL SCIENCE FOUNDATION LEGISLATION, 1973

THURSDAY, MAY 3, 1973

U.S. SENATE,
SPECIAL SUBCOMMITTEE ON THE
NATIONAL SCIENCE FOUNDATION
OF THE COMMITTEE ON LABOR AND WELFARE,
Washington, D.C.

The Subcommittee met, pursuant to notice, at 10:05 a.m. in room 6202, New Senate Office Building, Senator Edward M. Kennedy (chairman) presiding.

Present: Senators Kennedy, Pell, and Dominick.

Committee staff members present: Ellis R. Mottur, professional staff member, and Roy H. Millenson, minority professional staff member.

Senator KENNEDY. The subcommittee will come to order.

The National Science Foundation has one of the most important responsibilities of any Government agency; it is charged with the mission of maintaining the Nation's scientific strength. The Foundation operates no laboratories or scientific facilities of its own, but through grants and contracts, supports programs of scientific research and education in thousands of universities, research institutes, and other organizations. These programs cover all fields of science and engineering. And they cover all levels of science education—from elementary school through postdoctoral fellowships. And these programs are carried out in all of the 50 States to assure a strong, broadly based national scientific enterprise.

The impact of the Foundation's program is pervasive and profound. For we live in an age of science—from the computers that manage our transactions, to the transistors that power our electronics, to the advanced medical technology which can help so much in health maintenance. Science has become essential to the Nation's military security, the domestic economy and international economic position, and the solution of our widespread social problems.

But scientific research is not a spigot which can be turned on and off at will. Before scientific know-how can be effectively applied in areas such as transportation, health care, nutrition, and pollution control, the underlying foundation of basic research must be patiently built over the years, and the Nation's scientific and technical talent must be carefully nurtured and trained.

In view of the Nation's mounting problems—energy, inflation, productivity, pollution, health care, and many others—we cannot afford to shortchange our superb scientific talent. Science is the key to progress in our time; our science programs represent an essential investment in the Nation's future. If we do not make the necessary

investment today, our children will suffer immeasurably for our shortsightedness.

Yet at this time of maximum need the President has requested only \$583 million for NSF for next year, which is \$63 million less than the \$646 million appropriated for the current year. This is the first time in history that an administration has ever requested less for NSF in a particular year than had been appropriated in the previous year.

The situation is exacerbated by the President's impoundment of 10 percent of NSF's current appropriation—\$62 million out of \$646 million. The poor judgment exhibited by the administration is best demonstrated in the NSF energy research program. The President's energy message claimed that the solar energy program would be increased from \$4 million to \$12 million. But the message neglected to mention that the President has impounded \$6.8 million of the \$19.5 million which the current NSF Authorization Act requires to be allocated to energy research, with an emphasis on solar, geothermal, and other nonconventional energy sources. So the so-called increase for next year consists mainly of the appropriated funds which the President refused to release for research this year.

The Nation is inundated with problems. To solve them and build the kind of world we want, we need the best knowledge we can develop and the best educational system we can shape. The National Science Foundation has a unique role to play in meeting these goals. In an age of immediacy, the Foundation must focus on the far off—but in such a way that the research performed today proves relevant to our needs tomorrow.

I do not believe that the administration's budget request is adequate to meet our needs. I hope these hearings will enable us to determine what level of funding is necessary. Based on the hearing record, I intend to develop an alternative to the administration's woefully inadequate authorization for the National Science Foundation.

[A copy of bill S. 1078 and departmental reports received by the Committee follow.]

93D CONGRESS
1ST SESSION

S. 1078

IN THE SENATE OF THE UNITED STATES

MARCH 1, 1973

Mr. DOMINICK introduced the following bill; which was read twice and referred to the Committee on Labor and Public Welfare

A BILL

To authorize appropriations for activities of the National Science Foundation, and for other purposes.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*
3 That there is hereby authorized to be appropriated to the
4 National Science Foundation for the fiscal year ending June
5 30, 1974, to enable it to carry out its powers and duties
6 under the National Science Foundation Act of 1950, as
7 amended, and under title IX of the National Defense Ed-
8 ucation Act of 1958, out of any money in the Treasury not
9 otherwise appropriated, \$579,600,000.

10 SEC. 2. In addition to such sums as are authorized by
11 section 1 of this Act, there are authorized to be appropri-

II

1 ated to the National Science Foundation for the fiscal year
2 ending June 30, 1974, such additional or supplemental
3 amounts as may be necessary for increases in salary, pay,
4 retirement, or other employee benefits authorized by law,
5 or other nondiscretionary costs.

6 SEC. 3. Appropriations made pursuant to this Act may
7 be used, but not to exceed \$5,000, for official consultation,
8 representation, or other extraordinary expenses upon the
9 approval or authority of the Director of the National Science
10 Foundation, and his determination shall be final and conclu-
11 sive upon the accounting officers of the Government.

12 SEC. 4. In addition to such sums as are authorized by
13 sections 1 and 2, not to exceed \$3,000,000 is authorized to
14 be appropriated for fiscal year ending June 30, 1974, for
15 expenses of the National Science Foundation incurred out-
16 side the United States to be paid for in foreign currencies
17 which the Treasury Department determines to be excess to
18 the normal requirements of the United States.

19 SEC. 5. Appropriations made pursuant to authority pro-
20 vided in this Act shall remain available for obligation, for
21 expenditure, or for obligation and expenditure, for such
22 period or periods as may be specified in Acts making such
23 appropriations.

24 SEC. 6. (a) If an institution of higher education deter-
25 mines, after affording notice and opportunity for hearing to

1 an individual attending, or employed by, such institution,
2 that such individual has been convicted by any court of
3 record of any crime which was committed after the date of
4 enactment of this Act and which involved the use of (or
5 assistance to others in the use of) force, disruption, or the
6 seizure of property under control of any institution of higher
7 education to prevent officials or students in such institution
8 from engaging in their duties or pursuing their studies, and
9 that such crime was of a serious nature and contributed to a
10 substantial disruption of the administration of the institution
11 with respect to which such crime was committed, then the
12 institution which such individual attends, or is employed
13 by, shall deny for a period of two years any further payment
14 to, or for the direct benefit of, such individual under any of
15 the programs specified in subsection (c). If an institution
16 denies an individual assistance under the authority of the pre-
17 ceding sentence of this subsection, then any institution which
18 such individual subsequently attends shall deny for the re-
19 mainder of the two-year period any further payments to, or
20 for the direct benefit of, such individual under any of the
21 programs specified in subsection (c).

22 (b) If an institution of higher education determines,
23 after affording notice and opportunity for hearing to an
24 individual attending, or employed by, such institution, that
25 such individual has willfully refused to obey a lawful regu-

1 lation or order of such institution after the date of enactment
2 of this Act, and that such refusal was of a serious nature
3 and contributed to a substantial disruption of the administra-
4 tion of such institution, then such institution shall deny,
5 for a period of two years, any further payment to, or for
6 the direct benefit of, such individual under any of the pro-
7 grams specified in subsection (c).

8 (c) The programs referred to in subsections (a) and
9 (b) are as follows:

10 (1) The programs authorized by the National
11 Science Foundation Act of 1950; and

12 (2) The programs authorized under title IX of
13 the National Defense Education Act of 1958 relating
14 to establishing the Science Information Service.

15 (d) (1) Nothing in this Act, or any Act amended by
16 this Act, shall be construed to prohibit any institution of
17 higher education from refusing to award, continue, or extend
18 any financial assistance under any such Act to any individual
19 because of any misconduct which in its judgment bears
20 adversely on his fitness for such assistance.

21 (2) Nothing in this section shall be construed as limit-
22 ing or prejudicing the rights and prerogatives of any institu-
23 tion of higher education to institute and carry out an
24 independent, disciplinary proceeding pursuant to existing
25 authority, practice, and law.

- 1 (3) Nothing in this section shall be construed to limit
- 2 the freedom of any student to verbal expression of individual
- 3 views or opinions.

- 4 SEC. 7. This Act may be cited as the "National Science
- 5 Foundation Authorization Act of 1974".

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550



OFFICE OF THE
DIRECTOR

May 1, 1973

RECEIVED

MAY 1 1973

Labor & Public
Welfare Committee

Honorable Harrison A. Williams, Jr.
Chairman, Committee on Labor and
Public Welfare
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

This is in reply to your letter of March 8, 1973, requesting the comments of the National Science Foundation on S. 1078, a bill to authorize appropriations for activities of the National Science Foundation.

The bill is identical to draft legislation submitted to Congress by NSF on January 30, 1973. It would authorize appropriations in the amount of \$579,600,000 for the fiscal year ending June 30, 1974. Also authorized for this period is an appropriation amount not to exceed \$3,000,000 in excess foreign currency funds. Finally, there are authorized to be appropriated for fiscal year 1974 such additional or supplemental amounts as may be necessary for increases in salary, pay, retirement and other employee benefits authorized by law, or other non-discretionary costs. Such authorizations are required by section 16(a) of the National Science Foundation Act of 1950, as amended (42 USC 1875).

The Foundation strongly supports and recommends enactment of S. 1078.

The Office of Management and Budget has advised us that there is no objection to the submission of this report, and that enactment of S. 1078 would be in accord with the program of the President.

Sincerely yours,

H. Guyford Stever
Director

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

MAY 3 1973

Honorable Harrison A. Williams, Jr.
Chairman, Committee on Labor
and Public Welfare
United States Senate
4230 New Senate Office Building
Washington, D. C. 20510

RECEIVED

MAY 7 1973

Labor & Public
Welfare Committee

Dear Mr. Chairman:

This is in reply to your letter of March 8, 1973, requesting the views of this Office on S. 1078, a bill "To authorize appropriations for the activities of the National Science Foundation, and for other purposes."

S. 1078 is identical to draft legislation submitted to the Congress by the National Science Foundation on January 30, 1973.

In a report to your Committee on the subject bill, the NSF strongly supports S. 1078 and recommends enactment.

We concur in this recommendation, and strongly urge prompt action on S. 1078, enactment of which would be in accord with the program of the President.

Sincerely,

(signed) Wilfred H. Rommel

Wilfred H. Rommel
Assistant Director for
Legislative Reference



THE GENERAL COUNSEL OF THE TREASURY
WASHINGTON, D.C. 20220

RECEIVED

MAY 1 - 1973

MAY 7 1973

Dear Mr. Chairman:

Labor & Public
Welfare Committee

Reference is made to your request for the views of this Department on S. 1078, "To authorize appropriations for activities of the National Science Foundation, and for other purposes."

Only section 4 of the bill is of interest to the Treasury Department. That section would authorize the appropriation of not to exceed \$3 million for expenses for the National Science Foundation incurred outside the United States to be paid for in foreign currencies which the Treasury determines to be excess to the normal requirements of the United States.

The Department has no independent knowledge of the need for the funds authorized to be appropriated by section 4, and would, therefore, defer to the views of the National Science Foundation.

The Department has been advised by the Office of Management and Budget that there is no objection to the submission of this report to your Committee, and that enactment of S. 1078 would be in accord with the program of the President.

Sincerely yours,

ACTING General Counsel

The Honorable
Harrison A. Williams, Jr., Chairman
Committee on Labor and Public Welfare
United States Senate
Washington, D. C. 20510



COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-58911.

April 2, 1973

RECEIVED

The Honorable Harrison A. Williams, Jr.
Chairman, Committee on Labor and Public
Welfare
United States Senate

APR 5 1973
Labor & P. W. C.
Welfare Committee

Dear Mr. Chairman:

Concerning your request of March 8, 1973, for our comments on
S. 1078, a bill to authorize appropriations for activities of the
National Science Foundation, this is to advise that we have no comments
to offer.

Sincerely yours,

Paul G. Dembling

Acting Comptroller General
of the United States

pm

Senator KENNEDY. We are now working on a draft bill for the 1974 authorization which we hope to introduce shortly. When this has been introduced in the Senate, without objection, I order the text of that bill printed following the text of S. 1078.

[The bill S. 1977 referred to follows.]

93^d CONGRESS
1ST SESSION

S. 1977

IN THE SENATE OF THE UNITED STATES

JUNE 11, 1973

Mr. KENNEDY (for himself, Mr. CRANSTON, Mr. EAGLETON, Mr. MONDALE, and Mr. PELL) introduced the following bill; which was read twice and referred to the Committee on Labor and Public Welfare

A BILL

To authorize appropriations for activities of the National Science Foundation, and for other purposes.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*

3 That there is hereby authorized to be appropriated to the
4 National Science Foundation for the fiscal year ending
5 June 30, 1974, for the following categories:

6 (1) Scientific Research Project Support, \$292,-
7 700,000.

8 (2) National and Special Research Programs,
9 \$108,600,000.

10 (3) National Research Centers, \$46,000,000.

II

1 (4) Computing Activities, \$10,000,000.

2 (5) Science Information Activities, \$8,300,000.

3 (6) International Cooperative Scientific Activities,
4 \$6,200,000.

5 (7) Research Applied to National Needs, \$115,-
6 200,000.

7 (8) Intergovernmental Science Program, \$1,000,-
8 000.

9 (9) Institutional Improvement for Science, \$15,-
10 000,000.

11 (10) Graduate Student Support, \$20,000,000.

12 (11) Science Education Improvement, \$46,000,-
13 000.

14 (12) Planning and Policy Studies, \$2,000,000.

15 (13) Program Development and Management,
16 \$30,000,000.

17 SEC. 2. Notwithstanding any other provision of this or
18 any other Act—

19 (a) of the amount stipulated for the purpose of
20 “National and Special Research Programs” in category
21 (2) of section 1, not less than \$6,000,000 shall be avail-
22 able for the oceanographic ship construction/conversion
23 program;

24 (b) of the amount stipulated for the purpose of
25 “Research Applied to National Needs” in category (7)

1 of section 1, not less than \$50,000,000 shall be available
2 for energy research and technology programs; including
3 but not limited to solar, geothermal, and other noncon-
4 ventional energy sources, not less than \$10,000,000
5 shall be available for earthquake engineering programs,
6 and not less than \$5,000,000 shall be available for tech-
7 nology assessment programs;

8 (c) of the amount stipulated for the purpose of "Sci-
9 ence Education Improvement" in category (11) of sec-
10 tion 1, not less than \$7,500,000 shall be available for
11 ethnic minority college programs.

12 SEC. 3. In addition to such sums as are authorized by
13 section 1 of this Act, not to exceed \$3,000,000 is authorized
14 to be appropriated for the fiscal year ending June 30, 1974,
15 for expenses of the National Science Foundation incurred
16 outside the United States to be paid in foreign currencies
17 which the Treasury Department determines to be excess to
18 the normal requirements of the United States.

19 SEC. 4. Appropriations made pursuant to authority pro-
20 vided in sections 1 and 3 of this Act shall remain available
21 for obligation, for expenditure, or for obligation and expendi-
22 ture, for such period or periods as may be specified in Acts
23 making such appropriations.

24 SEC. 5. (a) No funds may be transferred to or from
25 any particular category listed in section 1 if the total of the

1 funds so transferred to or from that particular category would
2 exceed 10 per centum thereof, unless—

3 (1) a period of thirty legislative days has passed
4 after the Director or his designee has transmitted to the
5 Speaker of the House of Representatives and to the
6 President of the Senate and to the Committee on Science
7 and Astronautics of the House of Representatives and
8 to the Committee on Labor and Public Welfare of the
9 Senate a written report containing a full and complete
10 statement concerning the nature of the transfer and the
11 reason therefor, or

12 (2) each such committee before the expiration of
13 such period has transmitted to the Director written
14 notice to the effect that such committee has no objection
15 to the proposed action.

16 (b) The provisions of subsection (a) shall not apply
17 during any period in which the Congress is in adjournment
18 sine die.

19 SEC. 6. (a) If an institution of higher education deter-
20 mines, after affording notice and opportunity for hearing to
21 an individual attending, or employed by, such institution,
22 that such individual has been convicted by any court of
23 record of any crime which was committed after the date of
24 enactment of this Act and which involved the use of (or
25 assistance to others in the use of) force, disruption, or the

1 seizure of property under control of any institution of higher
2 education to prevent officials or students in such institution
3 from engaging in their duties or pursuing their studies, and
4 that such crime was of a serious nature and contributed to
5 a substantial disruption of the administration of the institu-
6 tion with respect to which such crime was committed, then
7 the institution which such individual attends, or is employed
8 by, shall deny for a period of two years any further payment
9 to, or for the direct benefit of, such individual under any
10 of the programs specified in subsection (c). If an insti-
11 tution denies an individual assistance under the authority of
12 the preceding sentence of this subsection, then any institution
13 which such individual subsequently attends shall deny for the
14 remainder of the two-year period any further payment to,
15 or for the direct benefit of, such individual under any of
16 the programs specified in subsection (c).

17 (b) If an institution of higher education determines,
18 after affording notice and opportunity for hearing to an indi-
19 vidual attending, or employed by, such institution, that such
20 individual has willfully refused to obey a lawful regulation
21 or order of such institution after the date of enactment
22 of this Act, and that such refusal was of a serious nature and
23 contributed to a substantial disruption of the administration
24 of such institution, then such institution shall deny, for a
25 period of two years, and further payment to, or for the

1 direct benefit of, such individual under any of the programs
2 specified in subsection (c).

3 (c) The programs referred to in subsections (a) and
4 (b) are as follows:

5 (1) The programs authorized by the National
6 Science Foundation Act of 1950; and

7 (2) The programs authorized under title IX of
8 the National Defense Education Act of 1958 relating
9 to establishing the Science Information Service.

10 (d) (1) Nothing in this Act, or any Act amended
11 by this Act, shall be construed to prohibit any institution of
12 higher education from refusing to award, continue, or extend
13 any financial assistance under any such Act to any individual
14 because of any misconduct which in its judgment bears
15 adversely on his fitness for such assistance.

16 (2) Nothing in this section shall be construed as limit-
17 ing or prejudicing the rights and prerogatives of any in-
18 stitution of higher education to institute and carry out an
19 independent, disciplinary proceeding pursuant to existing
20 authority, practice, and law.

21 (3) Nothing in this section shall be construed to limit
22 the freedom of any student to verbal expression of individual
23 views or opinions.

24 SEC. 7. The National Science Foundation shall estab-
25 lish a Division of Energy Research and Technology which

1 shall carry out the Foundation's energy research and tech-
2 nology programs.

3 SEC. 8. Notwithstanding any other provision of this or
4 any other Act, the Director of the National Science Founda-
5 tion shall keep the Committee on Science and Astronautics
6 of the House of Representatives and the Committee on Labor
7 and Public Welfare of the Senate fully and currently in-
8 formed with respect to all of the activities of the National
9 Science Foundation.

10 SEC. 9. This Act may be cited as the "National Science
11 Foundation Authorization Act of 1974".

Senator KENNEDY. Our first witness today, who will testify for the administration is Dr. H. Guyford Stever, Director of the National Science Foundation. Over the years Dr. Stever has had a distinguished career in science policy, administration, research, and teaching. Before coming to NSF he was president of the Carnegie Mellon University in Pittsburgh for 7 years. And before that he spent 20 years at MIT where he was professor of aeronautical engineering and head of the departments of mechanical engineering and naval architecture.

And on July 1, Dr. Stever is slated to assume the additional responsibilities of science adviser to the entire executive branch—to take the place of the former science adviser to the President.

STATEMENT OF DR. H. GUYFORD STEVER, DIRECTOR OF THE NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY DR. RAYMOND L. BISPLINGHOFF, DEPUTY DIRECTOR; DR. ALFRED J. EGGERS, ASSISTANT DIRECTOR FOR RESEARCH APPLICATIONS; MR. THOMAS E. JENKINS, ASSISTANT DIRECTOR FOR ADMINISTRATION; DR. KEITH KELSON, ACTING ASSISTANT DIRECTOR FOR EDUCATION; DR. THOMAS B. OWEN, ASSISTANT DIRECTOR FOR NATIONAL AND INTERNATIONAL PROGRAMS; DR. EDWARD P. TODD, DEPUTY ASSISTANT DIRECTOR, RESEARCH

Dr. STEVER. Chairman and members of the subcommittee:

It is a pleasure to have this opportunity to present the program of the National Science Foundation for fiscal year 1974. We are keenly aware of the important role this committee has played in determining the allocation of the Nation's resources for science. The Foundation appreciates the encouragement and support the committee has given science through the years.

The Foundation's program for fiscal year 1974 recognizes the innovative ability of U.S. science and provides support for a sound structure of research and science education programs that will help the United States to acquire new scientific knowledge; improve economic strength and productivity; enhance environmental quality; and upgrade the effectiveness of services in the public and private sectors.

Mr. Chairman, in developing and managing the Foundation's program, the continuing goal, in each activity, is to provide support for the highest quality and most effective scientific endeavors. Programs that have high leverage, address recognized national problems, or are essential in extending the base of scientific knowledge, are being given increasing emphasis. The Foundation's program has been developed with the help of a broad cross section of science expertise, including advisory committees and other experts. We are convinced that the planned fiscal year 1974 program is well balanced, that it will be highly effective, and that it will permit the NSF to make significant progress toward attaining its program goals.

The Foundation's program for fiscal year 1974 will provide:

Increased support for basic research in the science disciplines, especially in those areas that take advantage of unique research oppor-

tunities—such as gravitation physics, structure and mechanics of the Earth, chemical catalysis, and wind effects engineering.

Expanded research on energy, the environment, and other problems of national concern. These efforts include increased emphasis on research to find ways to achieve practical utilization of solar and geothermal energy and improved engineering methods for earthquake resistant structures, studies that may lead to integrated bioecological techniques for regulation of insect pests.

Senator KENNEDY. I am sure you will understand—as I mentioned in my opening statement—in view of the impoundment of \$6.8 million out of \$19.5 million that was set by law as the minimum which would be spent for the energy research program, that we might not be quite as willing to accept the administration's reference to increased emphasis on energy as an accurate statement.

Dr. STEVER. I do not think the facts either in your statement or mine conflict. You are quite correct that there were programs authorized last year in which the administration removed from the National Science Foundation budget some of the appropriated money but if we get the authorization requested for this year, we will increase our expenditures in fiscal year 1974 for energy research from \$12.7 to \$20.7 million.

Senator KENNEDY. As I remember, in the conference on the NSF authorization last year, the conferees strongly urged NSF to establish a separate division on energy research within RANN, to focus the effort in this area.

Could you tell us what steps were taken?

Dr. STEVER. No steps were taken to establish a separate division within NSF for energy research. However, energy programs are highlighted in a number of things that "Research Applied to National Needs" (RANN) does. We know what our energy program is, and in expectation of my new responsibilities, the National Science Foundation has established an energy task force within the last month or two to focus our studies on energy. So in that sense we have moved in that direction.

Dr. EGGERS. We might also add, Mr. Chairman, that we have, I think in a very real sense been directly responsive to the wishes of the conferees. We have created a major project, in which we are focusing the management of our major energy projects, especially solar energy projects.

Senator KENNEDY. Has this been in the last month or so?

Dr. STEVER. No; there are two facts. Dr. Eggers mentioned the action within the RANN program itself, and the other one was my added action on establishing an overall energy task force.

The Foundation program also includes broad program in polar research, ocean sediment coring, international ocean exploration, global atmospheric research, and the national research centers, with provision made for continued development of the very large array for radio astronomy.

Continued emphasis on international cooperative science efforts.

A restructured science education program designed to meet new and increasingly complex science and engineering education requirements and to find more effective ways to educate students at all academic levels.

The Foundation's program for fiscal year 1974 continues to place strong emphasis on the support of fundamental research; \$554 million of the Foundation's total fiscal year 1974 program of \$641.5 million will be used to support research efforts. Of this amount approximately \$460 million or 83 percent represents support for basic research under the various research programs of NSF, and about \$94 million represents applied research efforts that are focused on selected problems of national concern.

Senator KENNEDY. How do you reach the figure between 83 and 17 percent? How do we know that is really the right balance?

Dr. STEVER. You are asking how we chose 83 percent versus some other number?

Senator KENNEDY. You say your research program is effectively balanced between basic and applied research. You said this reflects a balanced approach.

Dr. STEVER. Mr. Chairman—

Senator KENNEDY. Aren't they usually balanced in the opposite way?

Dr. STEVER. If you would take total research effort of the Government, it certainly would be that way. Our budget is not put together independent of the other agencies. There is no question that they are balanced the opposite way and in fact if you look at the \$17-plus billion dollars that is spent in R. & D. by the Federal Government, I think the development side of that is about two-thirds. If you look at the research side of R. & D., the basic research might be one-third of that total. The basic mission which NSF started with and has continued to support strongly is the maintenance of the fundamental research program. The reason we are in the applied research area is that new opportunities are springing up from that fundamental research program and the quickest way to take advantage of those is to let NSF do the applied research.

Senator KENNEDY. How has it varied over recent years between basic and applied research?

Dr. STEVER. We have increased our percentage of applied research within the last 3 years from something quite small from 2 or 3 percent to 17 percent.

Senator KENNEDY. Do you expect to continue to increase?

Dr. STEVER. That is a question that has been taken up by the National Science Board. Over the last few years, NSF has been increasing its applied research activity. I think the ratio in NSF between basic and applied research will depend more upon our capability to spinoff applied research to the larger agencies.

Senator DOMINICK. Mr. Chairman, if I may, I had an opening statement and I apologize for being a little late. I was meeting with many of my constituents on the subject of cerebral palsy.

Senator KENNEDY. Fine, your statement will be included in the record at this point.

PREPARED STATEMENT OF HON. PETER H. DOMINICK, A U.S. SENATOR
FROM THE STATE OF COLORADO

Senator DOMINICK. Mr. Chairman, the National Science Foundation does not seem to attract the publicity that other Federal agencies do, but I am convinced that their work is every bit as important. I am a firm believer in the necessity for and merit of basic research.

When I introduced NSF's authorization bill I cautioned that the figure \$582.6 million might have to be increased to compensate for the increased responsibilities placed on NSF by the demise of the Office of Science and Technology (OST). The dismantling of OST has thrust NSF into the role of the cutting edge of the Federal science and technology sword.

I am particularly interested in NSF's efforts, through its grants for solar and geothermal energy research, to assist in finding a short as well as a long-term solution to our energy problem.

Mr. Chairman, yesterday I introduced a bill, S. 1686, to assist the States and localities in increasing their science and technology capabilities and to facilitate the transfer of technology from the Federal to the State and local levels. NSF would be a crucial part of this undertaking, and would, I hope, be able to support such an effort.

Last year, the President in his Science and Technology message observed—

"... We must appreciate that the progress we seek requires a new partnership in science and technology—one which brings together the federal government, private enterprise, state and local governments, and our universities and research centers in a coordinated, cooperative effort to serve the national interest. Each member of that partnership must play the role it can play best; each must respect and reinforce the unique capabilities of the other members. Only if this happens, only if our new partnership thrives, can we be sure that our scientific and technological resources will be used as effectively as possible in meeting our priority national needs."

Mr. Chairman, it is now time to ink our signatures on the partnership papers which will put up the money and assign the responsibility to the partners to move the President's objective from the paper to reality.

SOLAR ENERGY RESEARCH

Out of that \$94 million, how much is being used on solar research? I am very grateful to you for the grant that was just given at Colorado State University to determine how best we can continue with solar energy, determining the best method of utilizing it. How much is being used? Because as you well know, and I am sure the chairman knows, we are coming into an energy crunch which is going to be unbelievably important to this country by 1984. I am positive that solar energy is one of the sources of energy that is going to have to be developed.

Dr. STEVER. Total energy research and technology within RANN for fiscal year 1974 is \$20.7 million and, of that, \$12.2 million would be for solar energy.

In the President's energy message, he assigned three areas to the National Science Foundation. One of them was as lead agency in solar energy, and also a major role in the geothermal area, and also roles in energy, policy, and energy resource studies, and so on. Twelve million dollars is included for solar energy in this program.

Senator DOMINICK. When you say, "is directly for solar energy," what does this consist of? Grants given to various universities, and so forth, to determine how best to apply solar energy or how best to store it, or what?

Dr. STEVER. We have a varied program. Dr. Eggers will give you the highlights.

Dr. EGGERS. There are basically seven areas in the solar energy field to be emphasized; solar energy for buildings—this is heating and cooling of buildings, which is the major thrust from a dollar point of view of the seven areas I will mention. About \$3 million of the \$12 million will be focused in that area. We expect in that connection that that is probably the earliest payoff potential for application of solar energy to significantly impact our major energy problems.

The second major area is solar thermal conversion, a big thrust there to determine to what extent we can satisfy central powerplant requirements with solar energy, and we are talking ultimately about powerplants, in thousands of megawatts, and many problems are posed in that connection, including requirements for large land areas to place our solar collection systems and major challenges from a technology point of view, in terms of increasing fraction of instant solar energy that you can collect and store.

The third area is photovoltaic conversion. This is a study area concerned with determining if it is possible to take the kinds of technologies that we have developed in the space program, such as solar cells, and apply it on the ground; the big challenge is the cost. To put that technology in an economically competitive position with other energy technologies that we have available at the present time, we will have to reduce the cost of producing the solar cells by a factor of somewhere between \$100 and \$1,000.

There is research underway, which we are supporting to determine if new means can be developed to get such cost-reduction in the case of silicone cells.

Organic materials conversion to methane is the principal fuel we are concerned with there. That has potential again of relatively early payoff, although it is not likely to yield at best more than say 9 to 10 percent of our total energy requirements, if it were proved successful. The major phenomenon under study there is fermentation phenomenon. The big issue is one of holding down poisoning effects that tend to take place.

Another major area is photo synthetic production. There we are concerned with conversion to hydrogen gas by the photosynthetic process, acting with algae, and using the enzyme hydrogenation as a key factor in the process. There are two small areas primarily concerned with the issues of improving the basic technologies and overall systems analyses of such systems. Then you can say that the big payoff areas we hope to develop technology to exploit would be in areas of heating and cooling of houses, solar central powerplants, generation of fuel, methane by the organic conversion process or hydrogenation through photosynthetic process, and also there are efforts taking a look at the possibilities of improved utilization of wind energy and ocean thermal ingredients.

Senator DOMINICK. It is my understanding, and I hope you will correct me if I am wrong, that there are, at the present time, areas abroad which are using solar energy now for both heating and cooling and also for power purposes, Italy, and a few other places.

Dr. EGGERS. Yes, also Israel, France, and here.

Senator DOMINICK. We have used solar energy here in this country?

Dr. EGGERS. To some degree. They are not economically competitive. In general, there is a home in this area at the present time that is heated by solar energy, only the problem basically there is one of devising technologies that will make the systems economically competitive with other systems so they are attractive for large-scale application. The biggest of the two challenges in the heating and cooling of houses area is by far to cool and there are no systems anywhere approaching economic competitive systems in that particular category.

Senator DOMINICK. What about storage?

Dr. EGGERS. We are supporting research in the storage area. That is a key factor in the application of solar energy, because it is not something that is available to us at all times. Our work is focusing on thermal battery research, not only for storage of fixed installations, which could be a home or even a central powerplant. This work we are carrying out jointly with the Atomic Energy Commission, but there are also applications of these thermal battery systems, which have about 10 times energy density, than conventional batteries.

Senator DOMINICK. What I am trying to find out is whether we are going on the principle that individual units in homes are better than trying to have a power station which would be a centralized production of power for those same homes?

Dr. EGGERS. We must look at both. The individual home application is a particularly attractive one, if it can be made economically competitive, because it off-loads existing central powerplant demands, however they might be satisfied. And it is probably a much earlier payoff area, and just to give you our best estimates at that point in time, we believe if we move aggressively in the heating and cooling of building areas, we can have operational systems coming on line in the eighties. The best estimate for this point in time for central powerplant operation, which involves higher technologies now than the heating and cooling of homes, would be toward the end of the century, and probably not beginning to impact with large-scale operational application, the meeting of our power requirements before the year 2000. So it is a longer term, tougher problem, as far as we can tell, and this is based on judgment.

Senator DOMINICK. I am not trying to argue. People are already using solar energy in Italy. We are using it and other people are using it in Europe and France. Why do we have to wait until the eighties before we can do something about it?

Dr. STEVER. It is simply the economies, sir. It is possible to use it, but it is not economical, so widespread usage will not start until it is economical.

Senator DOMINICK. To what degree are we talking about it? Senator Kennedy's area is going to be in real tough shape on hydrocarbon fuels in a short time.

Dr. STEVER. The very large-scale use of solar energy may follow the large-scale use of new forms of nuclear power.

Senator DOMINICK. I understand that. What I am saying to you is, we are going to have to import all our oil to take care of my area—oil from Arab countries. We are talking about \$37 billion a year in terms of imports by 1985. Now if that is true, with a very drastic effect on the dollar, to what extent can we alleviate that with a faster utilization of solar energy?

Dr. EGGERS. I think the rate at which these operational units come on line will be influenced very importantly, Senator Dominick, by the rate of increased costs of conventional fuels. As you suggested these costs are probably going to go up. That is one of the reasons solar energy is used more extensively in Europe at the present time than it is here, and in this country, I suppose we have maybe a dozen or so homes that are one way or another having part of their energy demands met with solar energy.

As you pointed out, the costs of fuels are substantially higher than they are here at the present time. That is one of the reasons solar energy is used more extensively. We believe technologies for effective heating and cooling can be developed in this decade to be economically attractive and I would expect they would come on line even faster from an operational point of view, if the costs rise more rapidly than their projected rise at the present time.

We are trying to develop technologies that would be sufficiently inexpensive energy supply units for heating and cooling of buildings, so the cost of incorporating them in a building would be paid off in normally a 10-year time period by comparison to the added cost of conventional fuels, if you had to use them in the building.

Dr. STEVER. I would like to speak to that. I do not think there is any thought that the NSF solar energy program will handle the short-term energy problems of the country. I think the problems of getting fossil fuels, particularly oil, also gas from overseas and from the United States, will be the principal emphasis for many years.

The increased reliance on nuclear power of what I call the conventional kind probably sometime in the eighties with the breeder reactors is the second large hope.

Then in addition, probably at a later time, there will be broad-scale use of solar energy and some use of geothermal. Most of us believe that the energy problem is of sufficiently long duration that all of this is justified and we have to work on all of them. That is what the energy program is aimed at.

In the fossil fuel area of course, the problem of getting fossil fuels from overseas is so serious with respect to cost that the administration's program at the Department of Interior, is aimed at using our own well-supplied fossil fuel of coal, so the coal gasification, and coal liquefaction are the second major element in the administration's program.

Senator KENNEDY. I guess you said \$12.2 million on solar?

Dr. STEVER. Yes.

Senator KENNEDY. Is part of your estimate in terms of breakthroughs conditioned on the amount of money that we are prepared to invest in it, in these research areas and other areas?

Dr. STEVER. May I speak to that, Mr. Chairman? I think the administration philosophy on energy research is that in any of the areas that have been mentioned, coal gasification, liquefaction, development of breeder reactors, development of fusion reactors in the Atomic Energy Commission, solar energy, and so forth, if breakthroughs come from our efforts, at any time we can show this, more research would be devoted to that end.

There has not been a predetermined amount that would go into this. The fact that solar energy is jumping this year indicates some good

promise in the long run has been shown. I believe the same thing will happen in the other fields. I believe that this program, instead of being handled by a preinfusion of money, will be constantly monitored and when ideas develop and come to fruition, they will be supported.

Senator KENNEDY. Just to continue on this, have you many applications for research in the solar energy field that you have had to decline because of a shortage of funding?

Dr. EGGERS. We have had some, Mr. Chairman. We try as in all aspects of the Foundation's research program to support of course the highest quality proposals only. I think perhaps the most significant feature of the program at this point in time is the increasing number of first-rate research groups that are performing both in industry and university systems to carry out this research. We view this as a very encouraging sign in terms of achieving or the probability of achieving early success.

Senator KENNEDY. What are some of the European countries spending in this area?

Dr. EGGERS. I do not have the answer to that question. However, I will attempt to obtain it, Mr. Chairman.

Senator KENNEDY. Are you working with them as far as cooperation and exchange of information?

Dr. EGGERS. Yes; we are. There is an international meeting on solar energy in Paris in early July.

Senator KENNEDY. Would you supply for the committee the various solar energy applications for grants, the ones that were turned down?

Dr. EGGERS. Yes, sir.

[The information subsequently supplied follows:]

The following proposed solar energy projects were declined or withdrawn during FY 1973:

SUBMITTED BY COLLEGES OR UNIVERSITIES

1. Investigation of the application of space craft heat rejection radiators to the discharge of domestic and industrial waste heat
2. A residential electrical system for the effective utilization of solar energy
3. Use of solar energy for house and electric power generation
4. Research applied to electric power generated by combustion of cultivated crops
5. Cerium catalyzed photo chemical conversion of solar energy
6. Cuprous oxide photo. cells
7. Solar energy conversion study
8. Travel grant to attend "Deserts and Arid Lands" Symposium in Mexico City, Mexico, June 25-27, 1973

SUBMITTED BY NONPROFIT RESEARCH ORGANIZATIONS

9. Program Astec assessment of solar-to-thermal energy conversion (phase II)
10. Biogasification of solid wastes

SUBMITTED BY INDUSTRY

11. The role of solar energy in a national energy policy
12. Technical design and econ. viability of large-scale solar cell/hydrogen

ENERGY COSTS

Senator DOMINICK. Doctor, just one more question on this before we let you go on with your prepared statement. How much do you estimate that the cost of conventional fuels as we now use them, is going to have to increase before solar energy becomes competitive?

Dr. STEVER. Dr. Eggers, do you have that?

Dr. EGGERS. At the present time, let us talk about the central powerplant that we were discussing earlier, a tough nut to crack. If we were to proceed at this point in time with existing technologies to build a solar central powerplant installation, the cost estimates are that it would be from three to nine times the cost of building a comparable powerplant, using fossile fuels or nuclear—not much difference really.

Senator DOMINICK. What about homes?

Dr. EGGERS. Less of a difference in the case of homes. This is another reason we see heating or cooling application coming on line substantially earlier than central powerplant application.

Senator DOMINICK. If some of the Persian Gulf and Red Sea area countries decide to double the price of gasoline or crude. As far as we are concerned, we are competitive immediately?

Dr. EGGERS. This could be.

Dr. STEVER. If that results in double price here, I am not sure there would be a 1-to-1 relationship, but that is correct.

Senator DOMINICK. It might be 3 to 1?

Dr. STEVER. Could be.

Senator KENNEDY. Just before leaving this area, how important is the space shuttle in the whole area of research on solar energy?

Dr. EGGERS. That is important for any space-based systems.

Senator KENNEDY. I was thinking here on Earth.

Dr. EGGERS. For Earth-based systems, terrestrial applications for solar power, which is the area the Foundation has lead responsibility for—space is NASA—in our area, the space shuttle is not a factor because we are not putting anything into space.

Dr. STEVER. The area of overlap, where we must coordinate with NASA first is in the photovoltaic generation of power. That is the same technique used in space and on the ground. This is very important. NASA has some very fine work and capability.

Dr. EGGERS. Yes; we anticipate that we will use NASA labs and R. & D. doing that, and other NASA laboratories where we have unique capability of carrying out this research in solar energy.

CIVILIAN SCIENCE AND TECHNOLOGY ACT (S. 1686)

Senator KENNEDY. What kind of coordination is there between NSF and NASA on solar energy research. We want to make sure that we don't miss any opportunities for breakthroughs in terms of what Senator Dominick has been questioning you on, whether with reference to individual homes or centralized systems?

Dr. EGGERS. The research plan which we have proposed here is a product of joint effort of NASA and the National Science Foundation, and indeed a report has been put out on this, and we can certainly provide it to you.

Dr. STEVER. Under the Office of Science and Technology Solar Energy, an R. & D. study was made, and NASA and NSF were assigned joint responsibility to produce such a report. It is available and published.

Senator KENNEDY. That panel, as I understand, calls for solar energy of R. & D. of \$1.5 billion over a 15-year period. We are talking about \$12 million now, and there could be a geometric progression over a period of time; but what we are wondering about—obviously

we have to be able to walk before we run—but are we going to be in a perpetual crawl?

Dr. STEVER. No, sir, I believe that NSF growth in energy research from \$12.7 million in fiscal year 1973 to \$20.7 million in fiscal year 1974, and whatever is needed to respond to the promise in the field, could well result in that. I personally believe that this country has got to expect an increased emphasis on R. & D. in energy in all of these fields over the years, responding to the promise that comes up.

I think the growth curve is a healthy one, and I fully expect it to continue to grow, because when you put this much energy in science and technology, results will be obtained. We will have to back those results and we will have to move more strongly.

Senator KENNEDY. Are you hopeful about that means of achieving a breakthrough in this solar energy area, that is the space shuttle?

Dr. STEVER. You mean space-based?

Senator KENNEDY. Yes.

Dr. STEVER. I think it must be pursued by NASA, yes. You must recognize that if they are successful in that, that will also add to the technology for the ground based research too. The photovoltaic successes they have in space will be directly applicable to the ground. I think their work is very important.

Would you agree, Dr. Eggers?

Dr. EGGERS. Yes.

Senator KENNEDY. As one who voted against the space shuttle, I am trying to find out whether this makes more sense in the field of solar energy—how much sense it really makes.

Dr. STEVER. I believe their work is on solar energy in space which has to do with the photovoltaic cell.

Senator KENNEDY. Please continue.

Dr. STEVER. To span a diversity of national objectives, the foundation supports scientific research under all of its major program activities. These include scientific research project support (SRPS) for the science disciplines, 10 national and special research programs; five national research centers; computing activities; international cooperative scientific activities; major problem-focused efforts under research applied to national needs; research in science education; and other program areas. These research support activities constitute a set of functions that are mutually supportive and interrelated. Indeed, they should be looked upon as a unified set, each part of which contributes to the others. Together they reflect the foundation's continued commitment to the important goal of sustaining a strong and healthy U.S. science research enterprise. This, as you know, is a basic charge given the NSF by the Congress.

In establishing program levels for fiscal year 1974, the foundation took into consideration the total requirements in the various fields. For example, the full family of National Science Foundation atmospheric research programs includes basic studies carried out under scientific research project support and Arctic and Antarctic research programs, work at the National Center for Atmospheric Research, the global atmospheric research program, and the weather modification and certain environmental systems studies of the program of research applied to national needs. These activities are carefully coordinated and synchronized.

The National Science Foundation programs contribute in significant ways to the accomplishment of multiple goals. However, for purposes of this overview, I would like to highlight the activities under four goals to which they contribute most directly. These goals are:

- Increasing the base of scientific knowledge;
- Finding ways to deal with problems of the civilian sector;
- Promoting international cooperation through science; and
- Improving the quality and effectiveness of U.S. science education.

Let me turn first to the foundation's principal goal, which is to increase the Nation's base of scientific knowledge.

The activities that contribute directly to the attainment of this goal include major portions of the scientific research project support, national and special research programs, national research centers, and research applied to national needs. These activities are being increased in fiscal year 1974. The increase is more than is readily apparent, because the fiscal year 1973 program included a nonrecurring requirement for the purchase of three aircraft for the U.S. Antarctic research program.

A few highlights of research directed toward this goal include:

Extension of the analysis of sea floor spreading and its meaning in terms of the evolution and behavior of the Earth's crust;

Basic studies in gene transplants from nitrogen-fixing plants that can greatly extend the knowledge in this area and that theoretically can lead to increased production of certain crops, such as corn;

Theoretical studies of the physical makeup and orbits of objects in deep space and of the interior structures and surface properties of individual stars; and

Studies of gravitation and how it affects matter under extreme conditions.

Whenever I take examples of highlights, I am a little embarrassed because we have, as you know, upwards of 10,000 different projects supported by NSF. Obviously, not on all different subjects, but many, many of them have highlights.

Senator KENNEDY. Does the study on the Earth's crust give us some information about earthquake control?

Dr. STEVER. Yes, sir. There is a continued relationship between the understanding of the Earth's crust and the dynamics, the shifting of the continental plate, buildup of mid-Atlantic ridges, earthquake zones. We carry that right through to applied research in the RANN program, where we are supporting a study of earthquake engineering. We cover the entire range from fundamental understanding.

A continued effort in fundamental research areas is essential for the Nation since it is this research that expands the base of scientific knowledge. This continued buildup of new knowledge is essential if the Nation is to be ready to meet tomorrow's problems—many of which are not yet perceived. It is in the nature of research and its applications that work on problem-focused efforts continually identifies gaps in our base of knowledge which can be filled only by basic research efforts. Consequently, there is a continued cross-fertilization of the fundamental and applied research programs of the Foundation, with the results of fundamental research being used in problem-focused efforts and the latter pointing to unresolved questions that require additional basic knowledge.

Another major goal of the Foundation is to support research that can help the Nation to come to grips with certain already recognized economic, technological, social, and environmental problems that are amenable to solution through the application of science and technology. All of the principal National Science Foundation programs contribute to the attainment of this goal. However, it is the primary goal of the program of research applied to national needs, the experimental R. & D. incentives program, and the national R. & D. assessment program, and of part of the work at the National Center for Atmospheric Research, one of the national research centers. In addition, significant contributions to the attainment of this goal are made by elements of the scientific research project support activity—particularly research in chemistry, engineering, materials, and the biological, environmental, and social sciences.

Senator KENNEDY. As I understand your national R. & D. assessment program, that is to increase the role of R. & D. in the civilian sector?

Dr. STEVER. The objective of the experimental R. & D. incentives program is to find innovative ways of studying the processes of our society, to find innovative ways to use better research and development results, and to have it culminate in processes and products.

Senator KENNEDY. Could you develop that a little bit?

Dr. STEVER. Last year we added a new program, the experimental R. & D. incentives program, and we are now at the point where a number of projects have been started. The object is to study the entire flow of basic knowledge and techniques and from basic research, all the way through until they become a product or a service of government or some kind of process. When one studies this process, it varies from field to field as to how efficient we are, and quite often one finds road blocks.

There are things that stand in the way of our moving rapidly. This is an experiment to try a few areas where we can perceive a road block to try to have it removed in an experimental way to see if the flow becomes better.

Let me give you an example. There are certain small companies that when they have ideas and have done research and maybe some development on a product, a point is researched where it needs some testing, some major testing. If these are small companies they are very unlikely to have all the facilities available to them which a larger company might have. This becomes a road block impeding further progress.

One of our mechanisms is we have an agreement which we have with Federal laboratories to step in wherever they have the appropriate equipment and to use it to remove that road block. There are other examples. We are working to develop innovation centers in the universities to—

Senator KENNEDY. I can think of a situation just like that, as a matter of fact, of a small company that has been very imaginative in the development of antipollution devices, and has raised about \$1 million of their own. They have been able to get about \$1 million of investment, speculative investment. The EPA has got a very small budget, only about \$10 million for advanced research of this sort. So they are pretty well locked in, given their guidelines and regulations on

how they are going to approach this particular kind of issue. They do not have the flexibility or resources to consider other kinds of ideas, even though they consider this particular device to be an imaginative kind of idea. The firm is unable to get further investment capital, since the investors say if it made real sense, EPA would back it.

The major automobile manufacturers say it is an interesting idea and imaginative; but it requires additional development before they would be willing to adopt it. There is a kind of gap here.

Dr. STEVER. Our program is really experimental. We are not really in the business of handling every one of these cases. We have been flooded by cases. Our problem is to pick certain types of cases to do some experiments, to see whether in that type of case, help could come and propose further Government action. I hope we are successful. It is very clear that there are very many different kinds of cases here.

CIVILIAN SCIENCE AND TECHNOLOGY ACT—S. 1686

Senator DOMINICK. I introduced a bill, S. 1686, which I hope will come to your attention very shortly. Senator Kennedy was nice enough to make a statement yesterday on the floor about the principle of the bill and the fact that he thought it was good, which I think might help in the individual field which you are talking about.

It is my hope as soon as this does come to your attention, we can get a report on it, what your feelings are, what the problems are with it.

Dr. STEVER. We would be glad to.

The National R. & D. assessment program is a smaller program, but that is designed to study science and technology and economics of the entire process. Even though we have been involved in applied research, basic research, and so forth, there are still many, many people who question our understanding of this whole process, and we are trying to pin it down. This is to get more knowledge, more understanding of the process. If we can come up with it, I think it will enable us to do the job better.

Highlights of the various research programs of the National Science Foundation directed toward civilian sector problems in fiscal year 1974 include:

An increased energy research program to find ways to achieve practical utilization of solar and geothermal energy.

Expansion of earthquake engineering efforts designed to improve our capabilities to construct earthquake resistant structures, including buildings, dams, and others.

All one needs to do is look at what happened to certain overpasses and newly built structures of roads in the earthquake at San Fernando Valley to realize knowledge is needed.

Senator KENNEDY. In your energy research program are you doing research on better insulation and other ways to help conserve energy?

Dr. STEVER. We have some studies in conservation, but the Bureau of Standards has a major role in conservation, but we may have some, too.

Dr. EGGERS. That is true. The Department of Housing and Urban Development has—

Senator KENNEDY. Could you give us sort of a note on that?

Dr. STEVER. Yes.

[The information subsequently supplied follows:]

The NSF-RANN program has supported two projects on energy conservation in buildings. They are:

Building Environmental Control Systems for Energy Conservation, Ohio State University. The project will develop methodologies for minimizing energy consumption of environmental control systems in buildings, in order to provide a basis for design decisions of heating, ventilation, and air conditioning systems.

Energy Conservation in Housing, Princeton University. This project will evaluate the significance of building design, building materials, energy systems, external environment parameters and household composition in determining energy consumption. It will also provide documentation in detail of related decisions by builders, architects and engineering consultants.

The HUD program is currently under review and could change. In FY 72 and 73 it included support for studies of energy systems and uses for waste heat to achieve economies in energy consumption.

Senator KENNEDY. About what is being done and what you are doing?

Dr. EGGERS. Yes.

Dr. STEVER. In this civilian sector area, we also have added emphasis on corrosion research and materials research. We have continued to stress the improvement of excavation and tunneling technology.

Research on environmental systems, including studies to measure and assess the effects of trace contaminants in the environment.

Expanded efforts of technology assessment that will focus on understanding the implications of specific, selected technologies.

Research on biological means for controlling insect pests, with reduced environmental side effects.

Research to find ways to increase the efficiency and speed of conversion of R. & D. results into improved products, processes, and services.

I should again like to stress the interdependence among the several research support activities of the National Science Foundation. For example, progress in Environmental System Studies under RANN frequently benefits from the progress made in the biological, atmospheric, and earth sciences activities of Scientific Research Project Support; and the enzyme technology research in RANN is mutually supportive to the process dynamics work being supported under chemistry and to enzyme work in the biological sciences. This interdependence of programs requires close coordination, and the National Science Foundation staff achieves this through the joint reviews of projects, periodic program reviews, and other coordination mechanisms. It is important to note that each of the Foundation's research support activities is related to the others in a way which enhances the value and progress of all.

I will move now to our next goal, which is promoting international cooperation through science. The principal Foundation activities that contribute toward the attainment of this goal are the international cooperative scientific activities program, the special foreign currency program, and part of the scientific research project support program. Others are the International Decade of Ocean Exploration, the polar programs, and the ocean-sediment coring program, to mention a few.

Many scientific problems are international in scope or interest, such as those associated with the environment and human health.

There is growing interest on the part of other nations in finding ways to link their science programs with ours in areas dealing with problems stemming from industrial development. Science is indeed international, and usually its progress has been brought about by the inter-

action of researchers in several countries. Therefore, in fiscal year 1974, the Foundation plans to increase its efforts in this area by:

Expanding the science cooperation and exchange programs between the United States and East European countries.

Senator KENNEDY. I understand you assumed responsibility for that particular effort. Could you elaborate a little bit on what you are doing?

Dr. STEVER. Between U.S. and the U.S.S.R., we have had the first meeting of the Joint Commission. We consider it a very successful meeting. There were 29 subareas and 7 or 8 major areas in which we had an agreement. These include energy by the way with several subareas, including high voltage transmission of electrical energy, solar energy, geothermal is involved in there, another one is the application of computers to management. The Soviet group are very interested in that, and we are interested in their use of that. By the way, in the energy field, we have super conducting transmission technology, another very important future area. We have design and operation of heat rejection systems to include cooling water supply for large size nuclear and thermal powerplants. The Soviets have some very, very large powerplants of conventional design, nuclear. We can gain greatly there.

We also are looking at air pollution from powerplants, waste disposal and any others. I have mentioned application of computer management. Agricultural research. We have three areas there in our agreement, research in the fields of breeding, growing, and protection of farm crops. Research on methods to increase production of farm animals and poultry, mechanization of agricultural production. In water resources we have four areas, in production of substances employing microbiological means—

Senator KENNEDY. Do you have much exchange of information on the oceans?

Dr. STEVER. A new area under this science and technology, agreement is to explore further in oceanography. We have an agreement on our deep sea drilling project. We are drilling in the seas throughout the world, geophysical studies, shifting continents, a whole study of dynamics of the earth's crust. The Soviets have expressed a great interest in all of these areas. I believe we have completed that agreement that they will contribute \$1 million to that program. I believe that is an annual contribution. They also participate in our planning of that. In that area, we are growing very rapidly.

We continue our bilateral cooperative science programs with 12 different countries. We continue research and science information activities with excess foreign currency countries under the foundation's special foreign currency program. As I indicated above, the scientific research project support program also contributes to the attainment of this goal and, in fiscal year 1974, allowance has been made for the costs of selected international cooperative research projects that are in the process of development.

The Foundation's program for fiscal year 1974 includes an expanded science education program, compared to the revised program for fiscal year 1973. However, I should point out that the revised fiscal year 1973 program was below that authorized by the Congress.

As I indicated to the committee last year, at that time the Foundation was in the process of making a detailed analysis of its education program to determine how each of its elements was contributing to identified science education needs. That analysis revealed that modifications in the program were needed if we were to effectively address the science education problems of the 1970's. For example, curriculum and course development work, in single disciplines was not helping the science student to learn how to cope with real world situations requiring an interdisciplinary problem-solving approach. Programs exclusively designed to turn out more research-oriented Ph. D.s were aggravating the oversupply problems in certain areas, and some programs were not proving to be effective because there was no system for implementing improved instruction techniques in the school systems.

Senator KENNEDY. For the science education program for fiscal calendar 1974, is that above or below what Congress appropriated for 1973?

Mr. JENKINS. In 1973, the appropriation was \$71 million, and in 1974, we are asking for \$60 million. We are using only \$47 million of the \$71 which was appropriated by the Congress last year since the balance is carried forward for use in fiscal year 1974.

Senator KENNEDY. What do you actually expect to obligate this year in terms of science education programs again?

Dr. STEVER. In 1973, it will be \$47 million. in 1974, we are asking for \$60 million.

Senator KENNEDY. You went down rather dramatically to \$47 million. Now you are coming back up to \$60 million, is that correct?

Dr. STEVER. Yes. Mr. Kennedy, I believe if you look at the withholding that the NSF has had in 1973, a fair amount has been concentrated in science education improvement. The reason here is most simply stated by the fact that we have been reorienting that program and in that reorientation, the thought was that we could delay that more easily than cut into some of the other programs. That was not only the program in which there was withholding, but where the principal amount, \$33.8 million, was withheld.

The Foundation's restructured science education program for fiscal year 1974 is designed to:

Find ways to improve the effectiveness of science education through the application of modern educational technology and new methods of instruction.

Provide for the numbers, variety, and flexibility of scientific and technical manpower needed to meet the Nation's changing requirements for trained scientists and engineers as practitioners—in addition to researchers—in industry, Government, and other sectors of the economy.

Senator KENNEDY. How does NSF determine what the manpower needs are? Last year we were in touch with NSF about the number of unemployed technical, scientific personnel, and we were unable to develop those figures with the kind of accuracy I think that we might have expected. How are you able to determine what those needs are in terms of scientific manpower?

Dr. STEVER. This is a judgment into the future of needs and is very difficult to make. We have a fairly good record of the past. We have a

good record of the number of people who are entering the schools, and the universities, and colleges, so we know what the future supply will be. The judgment as to future requirements and needs is the very difficult part. It is clear that in some areas that the growth of the requirements is not as fast as the growth of the output. There are other areas where this is not true.

Engineering, for example, and the physical sciences seem to be coming back, we are not so sure in biological sciences. It is a judgment in that area, Mr. Chairman.

Senator KENNEDY. Are you basing it on any kind of assumption of additional research and development that will be done in the nondefense related industries? Obviously we have got much more research dollars being used in defense related agencies, and relatively little in the nondefense related industry—particularly as you compare it to other industrialized countries of the world.

I am just wondering what your projection is—particularly in the private sector, keeping in mind the various technological advances that we are seeing in more of the industrialized nations of the world. What is your best judgment about the needs in that area?

Dr. STEVER. I think my statement on the growing needs for the physical sciences and engineering drop is based in part on exactly what you have described. There is a growing need by industry and the best we can do is to try to make estimates of the increased support, research, and development, both by the Federal Government and by the industries.

Admittedly, and this is the difficult part, they can only be estimates and a sudden change in the economy can upset those estimates quite a bit or a sudden change in Government program as we have had in recent years that upset previous estimates. The best we can do is to plot those programs.

We also are aiming to make the general public more knowledgeable about the potential uses of science and its limitations so that people can deal more effectively with problems requiring a science and engineering input.

Mr. Chairman, the discussion we have had on the energy program, which will be with this country and all countries of the world for years and decades is a real good example of the need for public understanding for science and technology and their interrelationship, short-term and long-term problems. That is one of the things we would like to help on.

FUTURE ENERGY NEEDS

Senator DOMINICK. Are you endeavoring to get to the public at large on the problem of energy needs for the next couple of decades or more?

Dr. STEVER. We do not have primary responsibility for that. As you know, a group of the President's top counselors form an energy committee within the White House. Mr. Dibona is the Executive Director of that and we are working very closely with him. Some of the first data on this was released by the President in the fact sheet that went with the science message. The R. & D. Task Force which NSF has established recently is aiming to achieve a better understanding of the R. & D. part of that. I believe it is quite important to obtain a much greater spread of the understanding of the energy data,

the problems, and the hoped-for progress. Congress is doing a great deal toward this end, as you know.

I believe we are all going to have to work at it. Let me say one other thing. It is very clear that the broad science community which NSF taps, is represented by the professional societies, physical societies, American Chemistry Society, several biological societies, and are all intensely interested in energy, and they are all increasing their effort to become involved.

Senator DOMINICK. The difficulty with it is now, with anybody who is not scientifically oriented, simply continues to think that we have got as much energy as we need, and if the lights do not go on, they are mad at the company that supplies them with power, without realizing what the fundamental problems are.

Dr. STEVER. That same thinking relates very strongly to the use of solar energy, because everyone knows the sun's energy is practically limitless, so why do we not start using it? Our real problem is we have got many years of work. This is going to be a problem of the Congress and of the administration and everyone who works in science and technology areas, as well as the industry to get the facts before the public, achieve greater understanding, get the tradeoffs. Every decision is going to be tough.

We also have an objective to help meet requirements of scientists and engineers for continuing education.

Senator KENNEDY. We have a provision in our S. 32 legislation which provides for career transition fellowships to help technical professionals to make career changes and bring them up to date in their present fields. What is NSF's current program in this area?

Dr. STEVER. We do not have any substantial program for what I would call a short-term retraining of engineers or scientists from one field to another.

Senator KENNEDY. How about for updating within the same field?

Dr. STEVER. Even within the same field, because there are big differences within fields. Our hope within education is to provide opportunities for scientists and engineers and to develop ways of providing these opportunities, so they can take advantage of it. That reorientation takes a good deal of time. The administration's position on the large-scale problem which you are addressing in S. 32, as I am sure you will recall, was that it was better to get emergency jobs than to approach that directly. I believe the employment situation is better this year than it was last year. At least statistics show that, anyway. We are certainly looking to long-range ways of insuring that people are more flexible in the future. It is not an easy job.

Senator KENNEDY. It seems to me there is certainly a need for both. Obviously for shifting into new fields but also for providing some type of program which is sensitive to the need for updating professional skills within a particular discipline. In our very dynamic and technological society, that need should not be completely borne, I would think, by the person himself.

Dr. STEVER. You should also recognize that this goes far beyond the scientists—the ones we call scientists and engineers. There is a vast group of technicians involved in these industries.

The restructured program provides the basis for the NSF to make significant contributions to national efforts aimed at finding more effective ways to deliver educational services to students at the

college and precollege levels. The program supported by the Foundation will be at the forefront of science education in that it will be attempting to develop new and innovative approaches to the implementation and conduct of science education programs at all academic levels. Here again we have found that the science education problems of the 1970's demand new and innovative approaches, and research must be performed to provide a sound basis on which to proceed.

Mr. Chairman, the Foundation's request for fiscal year 1974 totals \$641.5 million—\$636.5 million for the Salaries and Expenses (S&E) appropriation, and \$5 million for the Special Foreign Currency appropriation. In addition to the new obligational authority of \$582.6 million, the program for fiscal year 1974 includes use of \$58.9 million in funds carried over from fiscal year 1973. The fiscal year 1974 funding level is \$26.5 million greater than the total program level of \$615 million for fiscal year 1973.

Senator KENNEDY. They impounded \$3.5 million for post-doctoral fellowships that has not been released?

Dr. STEVER. That is right.

Senator KENNEDY. Can you tell us why?

Dr. STEVER. I believe there are two bases for the cutback in the fellowship program generally, including post doctoral. The belief is that the supportive education in the science area, where there has been an oversupply, has tended to aggravate the oversupply. The second reason is that there are needs in education across the board and there are many who question why science is singled out specifically. Personally, I am sure you know that any of us in science would like to support our own field in any way possible.

There is a third point, the post doctoral can and are being helped in our research programs themselves. These post doctorals are people who would normally be full candidates for our research programs, any of the ones we have described here. They are working with more senior professors, and we are expecting to handle some of them in that area.

The first year 1974 funding level is \$26.5 million greater than the total program of \$615 million for fiscal year 1973.

On January 30, 1973, the National Science Foundation submitted to the Congress draft legislation to authorize appropriations for fiscal year 1974. This has been introduced as S. 1078 and embodies the President's 1974 budget request for the Foundation. Accordingly, I urge prompt and favorable action on S. 1078.

THREE YEAR AUTHORIZATION

Senator DOMINICK. We have been going on this for a great many years, largely at the insistence at the House. Does this not create problems for you, you cannot get appropriations until the annual authorization is through. How would you feel about a 3-year authorization or something of that kind?

Dr. STEVER. As far as the National Science Foundation is concerned, I think we could adjust to that, with possibly one exception. This point has been made to me by Dr. Bisplinghoff, who is an older hand in government than I. All the problems we are talking about are in rapid change. Our solar energy program that we have talked about today for instance. To have the Congress and authorization committee pay attention to those to bring problems forward, we think is the

important thing for science and technology. I think it is a part of our system that is very good. As far as mechanics are concerned, the National Science Foundation could adjust to a 3-year authorization. As I say, science and technology move fast, and your attention to these problems—

Senator DOMINICK. In general then, you are happy with a 1-year authorization?

Dr. STEVER. I personally am, yes.

Senator KENNEDY. Just a final question, Dr. Stever. How do you know—do we know—or can you give us assurances that there will not be an impoundment of some of these funds for next year? We saw impoundment last year, and now you are talking about spending more in the National Science Foundation next year than you did this year. How do we know we are not going to have another 10 percent freeze? Can you give us any assurances?

Dr. STEVER. Last year I was quite confident that the National Science Foundation would have \$677 million obligation authority, but during the late summer and the fall the fiscal constraint problems that everybody ran into, hit us rather abruptly. I do believe this budget is very carefully calculated to fit into the President's overall total, which many people, and I consider it to be a sound total budget, and within that constraint, I would hope for the best.

I will work as hard as I can to make sure that obligational authority up to this amount is fully used and used well.

Senator KENNEDY. Just a hope, but is this the best we can go on now? Are you pretty well satisfied, after your discussions with OMB and the administration, that they will adhere to this figure here, if Congress provides it? We are very much aware of the House language in that particular area, and the view of the Foundation that it is somewhat restrictive. To the extent that you can give us assurances that the administration will obligate the funds which are appropriated, obviously I think it would serve your interests to persuade the Congress, or at least this committee—

Dr. STEVER. All I can say is, I will pledge myself and I know the National Science Board, and all the National Science Foundation staff will work as hard as we can to insure that. Part of that, sir, comes simply by us putting together the programs of quality that will convince all units of our government, including both the Congress and the administration. Fortunately the science community is responding quite well. They are bringing good programs to us.

Senator KENNEDY. I am going to yield to my colleagues. I have other written questions I would like to submit to you. I want to thank you for your response.

Dr. STEVER. Thank you.

Senator KENNEDY. Senator Pell.

Senator PELL. Thank you, Mr. Chairman.

There are I know many subjects which you are involved in. I have questions on two specific areas. First, in connection with a draft treaty I have proposed for the elimination of environmental warfare, the modification of the environment as a means of warfare, I wonder if you could express a view, informally if not formally, as to the views of the National Science Foundation with regard to prohibiting actions, such as the creation of rain storms, tornadoes, earthquakes, tidal changes, things of that sort, as weapons of war what would your view

be with regard to this draft treaty? Incidentally, this draft treaty was supported unanimously by the North Atlantic Assembly, the parliamentarians, of the NATO nations.

Dr. STEVER. The National Science Foundation itself has not been involved directly in that. But personally, I feel very strongly that work of the National Science Foundation is aimed for the benefit of all, and in all of these natural phenomena, that we are, you might say, taking advantage of, I would hope it was positive. They are all hard to work with. As you know, there are lots of questions on whether we know enough about seeding clouds to produce the hail or seeding clouds to produce more rainfall.

Senator PELL. There is no objection to moving ahead on research for peaceful uses. It is just a matter of doing it openly and letting it be known to the communities that we are not using it for military purposes.

Dr. STEVER. I believe in openness in research.

Senator PELL. In general, you are in sympathy?

Dr. STEVER. Yes.

Senator PELL. Another matter of concern to me is ocean research. In your statement you touched on international ocean exploration. I am upset about the cutbacks and impoundments that are being proposed in funds authorized for operation of oceanographic research vessels, and for the construction of new vessels. Information which you provided to our committee indicates a sharp cutback in the size of the U.S. oceanographic research fleet, including the academic fleet, as a result of the administration's budget action. What is indicated is a reduction of about a fifth in our national fleet of research vessels, from about 83 in fiscal 1972, to 68 in fiscal 1974. And in the academic fleet alone you indicated the budget reduction during 1973 and 1974, will result in laying up, phasing out, of 7 ships because of the short-fall of almost \$3 million in operating money.

This at a very time when many of us have come to realize that the last new frontier is the oceans. We have gotten a little bit tired of repeated trips to the moon, and we realize there is a frontier right here on earth still to be developed. At this very time we are cutting back in these explorations, explorations which can result as well in a economic advantage to mankind.

Would you give me your own estimate of the impact that the fleet reduction will have on our general national ocean research program?

Dr. STEVER. Yes. Let me make a short statement, and I will call on Dr. Owen. It is true that the fiscal squeeze that we are in has resulted in a tightening up in the operation of the academic fleet. Also, the efficiency of the operation has been going steadily up so that the problem is not quite as great as a simple comparison of support levels would indicate. Let me say before I ask Dr. Owen to give you the data, that the National Science Foundation supports oceanographic research just as strongly as we can. We think it is a very productive field of research and we are not backing out of it in any sense. But like in all the fields of science, it is also subject to some trimming in periods of budgetary squeeze.

Senator PELL. Not backing out of it, but willy nilly the amount of vessels is being reduced. You cannot explore oceans without vessels.

Dr. OWEN. I would like to comment on two aspects of the Senator's question. First of all, Senator, review by the National Science Foundation of operation of the academic oceanographic fleet has shown that, in fiscal years 1971 through 1974 the problem of support for the academic fleet derives from rather drastic decreasing support from other elements of the Federal Government, principally the Department of the Navy. The National Science Foundation, working with the Navy, has balanced the resources available for oceanographic research against the number of ships necessary to do that research within the academic fleet. We have examined very carefully the situation that we see before us in fiscal year 1974, and feel that there is indeed a balance but one which admittedly causes problems for certain operator institutions in that the amount available to that institution for research is insufficient to justify full cost of a full-year operation of that ship. We are paying very close attention to this problem of the academic fleet. The academic community through the organization known as the University National Oceanographic Laboratory System is helping us to match the fleet to the research to be done in the best fashion possible.

With regard to ship construction, in fiscal year 1974, you noted that several ships would go out of commission. Several of these, previously supported by either the Navy or National Oceanic and Atmospheric Administration, are relatively new ships, and it did not appear wise for us at this time to press for the construction of more new ships at the very time that there are ships that have to be laid up.

Senator PELL. Why do the ships have to be laid up?

Dr. OWEN. It is a question of the research to be done from these ships not justifying the level of operation that we have enjoyed previously, sir.

Dr. STEVER. Within the amount of support for operations which we have.

Senator PELL. I am confused. I would have thought rather than less research, you need more research, is the problem money?

Dr. OWEN. I think it is a question of the total Federal oceanographic program, and where resources for that program are directed. As I said, within the National Science Foundation we have had a level oceanographic program for 3 years, approximately level, and our support for ships has gone up over those 3 years. As Dr. Stever mentioned, the utilization of those ships has been much more effective. We have data to show that a given number of ships performed about 6,800 ship days at sea in fiscal year 1970, and we feel that by the end of fiscal year they will have given more than 8,100 ship days, the same number of ships being used more effectively. So at this time it does not seem appropriate to add more ships to the fleet. The Navy will be adding two ships in fiscal year 1974, one to Texas A. and M., and one to the University of Hawaii.

Senator PELL. Unless my basic figure is wrong, there were 83 vessels in fiscal 1972, and there will be 68 in fiscal 1974.

Dr. OWEN. You are referring to these figures that we furnished. Within the academic fleet, that reduction is estimated to be six.

Senator PELL. With about 20 percent fewer vessels, you will be able to do better research, more research?

Dr. OWEN. No, what I say, sir, is that the level of research support available to the academic community does not permit substantial increase in support of ship operations at this time. We have balanced one against the other, and there would be no point in providing more ship support than required to conduct the research.

Senator PELL. In other words, the whole body of research is being reduced and for that reason you need fewer vessels, is that what you are saying?

Dr. OWEN. I think research is level, and efficient utilization of ships is substantial—

Senator PELL. I hope you are not going through an exercise here. The message that comes through to me is that you are saying with less money, fewer ships, research will continue unimpeded and the same amount of research will be done. Is that what you are saying?

Dr. OWEN. To a degree that is what I have said. I have pointed out that a fixed number of ships are providing more days at sea for research now than they have in the past 3 years, and that efficiency has gone up. I feel strongly, Senator—

Senator PELL. Is this true right through the program, that they do better work and a better job with less money?

Senator KENNEDY. You have fixed an amount of research on oceanography? Therefore with fixed amounts of money on research, you make assessments on how many ships you are going to need?

Dr. OWEN. That is correct.

Senator KENNEDY. Therefore you cut the cloth to fit the man in this sense?

Dr. OWEN. It is balancing; yes, sir.

Senator KENNEDY. I think what Senator Pell's point is, whether or not you are getting more efficiency out of those ships and the number of days at sea, your real constraint is the amount of money that is available for research?

Dr. OWEN. That is correct.

Senator KENNEDY. I think one of Senator Pell's concerns—considering that the sea is the last great frontier, and given the increasing interest in its exploration—is the limitation on further exploration or research, limits which the budget has placed upon you. As I gather from what you say, those are the controlling constraints—the answer to that is yes?

Dr. OWEN. May I comment?

Senator KENNEDY. I think it has to be yes. Can you answer that?

Dr. OWEN. I think with the two questions involved, let me put it this way, with the potential in the oceans, insofar as the country and the world is concerned, I certainly say that more could be done.

Senator KENNEDY. And done efficiently, effectively?

Dr. OWEN. Yes, sir, I am saying with the resources we have, we try to strike this balance.

Dr. STEVER. I am sure you know we are not singling out oceanography as a special area to carry most of the fund reductions. All of our science areas have opportunities where we could move faster, and our program is simply a result of what the opportunities and what our entire government system will make available to us.

Senator PELL. I am well aware that cuts are striking other parts of the country. As a Senator from Rhode Island, I am rather conscious

of the fact that our State has taken half the defense cuts in the country, although we have only one two-hundredths of the population of the country. We take the oceans seriously in Rhode Island. Our new auto license tags, will say on them "Rhode Island, the ocean State." This is why I am focusing on the oceans here today. Let me ask you another question. If there are nice new ships being laid up, that you do not need, could one of them be made available to us, instead of the old ship that we are presently operating in our State?

Dr. OWEN. You are perhaps well aware of the discussions we have had with Dr. Knauss with respect to support of his ship. We have not discussed with the community how ship services generating from the east coast will be provided. The amount of research available at the University of Rhode Island does not justify the total annual operating cost of the particular ship in question.

Senator KENNEDY. It does down at Texas A. & M.

Dr. OWEN. I do not have the total figures with me.

Senator KENNEDY. Great seafaring State.

Dr. OWEN. We would certainly hope the needs of the University of Rhode Island would be satisfied one way or another.

Senator PELL. I should make it clear, that I am not speaking for Dr. Knauss, I just think more could be done in oceanography research.

Dr. OWEN. We are making every effort to do our best within the resources that are available.

Senator PELL. Some of you may recall, I was the original sponsor of sea-grant college program. A program that NSF reluctantly took and reluctantly let go in the end. In the research applied to national needs program in which you contributed funds, will you be continuing to contribute funds to that with the sea-grant-college program?

Dr. OWEN. Dr. Eggers is in charge of the research applied to national needs program, and does have the responsibility for funding some coastal zone oceanography. I am not sure of the exact amount going to sea-grant colleges.

Dr. EGGERS. We could provide that number that goes to sea-grant colleges for the records, Senator Pell.

[The information subsequently supplied follows:]

The RANN Division of Environmental Systems and Resources has supported research at seven institutions which have also received Sea Grant support. They are Oregon State, Delaware, MIT, Virginia Institute of Marine Sciences, University of Maryland, Woods Hole, Oceanographic Institution, and The Center for Environment and Man.

Senator PELL. Is there a matching requirement now for the RANN programs?

Dr. EGGERS. No, the RANN program is not operated on the basis the sea grant program is operated on. We do require cost sharing.

Senator PELL. What is the difference between cost sharing and matching requirement?

Dr. EGGERS. Cost sharing is not by a fixed formula. It depends upon the nature of the grant, and nature of the type of research being undertaken.

Senator PELL. Thank you very much.

Senator KENNEDY. Senator Dominick.

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Senator DOMINICK. Dr. Stever, getting away from the ocean for just a minute, I want to talk about the atmosphere and our NCAR situation in Boulder. The increase is obviously great that we have in this budget. What I am asking you about in general, I guess, is how will NCAR, if at all, be involved in a global atmospheric research program?

Dr. OWEN. The National Center will be heavily involved in the program through a series of studies at the Center with regard to atmospheric modeling, tests of equipment that will be used in the field for that experiment, and heavy participation particularly in the Atlantic tropical experiment to be conducted in calendar 1974. It will provide not only equipment and coordination of programs, but also possibly three aircraft for use in that particular experiment.

Senator DOMINICK. Thank you. That is very encouraging.

Senator KENNEDY. I want to thank you very much, Dr. Stever. We appreciate your appearance here, and response to questions—Senator Dominick.

Senator DOMINICK. I had not had a chance to read that solar energy report yet. If the hearings are continuing, I hope that, if I come up with additional questions, I can submit them for the record.

Senator KENNEDY. Yes; we want to thank you very much, you have been very helpful.

[The prepared and supplemental statement of H. Guyford Stever and other information submitted for the record follows:]

**STATEMENT OF H. GUYFORD STEVER
DIRECTOR
NATIONAL SCIENCE FOUNDATION**

**BEFORE THE SPECIAL SUBCOMMITTEE ON THE NATIONAL SCIENCE FOUNDATION
OF THE LABOR AND PUBLIC WELFARE COMMITTEE
UNITED STATES SENATE**

May 3, 1973

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to have this opportunity to present the program of the National Science Foundation for FY 1974. We are keenly aware of the important role this Committee has played in determining the allocation of the Nation's resources for science. The Foundation appreciates the encouragement and support the Committee has given science through the years.

The Foundation's program for fiscal year 1974 recognizes the innovative ability of U.S. science and provides support for a sound structure of research and science education programs that will help the U.S. to:

- ☐ Acquire new scientific knowledge;
- ☐ Improve economic strength and productivity;
- ☐ Enhance environmental quality; and
- ☐ Upgrade the effectiveness of services in the public and private sectors.

Mr. Chairman, in developing and managing the Foundation's program, the continuing goal, in each activity, is to provide support for the highest quality and most effective scientific endeavors. Programs that have high leverage, address recognized national problems, or are essential in extending the base of scientific knowledge, are being given increasing emphasis. The Foundation's program has been developed with the help of a broad cross-section of science expertise, including advisory committees and other experts. We are convinced that the planned FY 1974 program is well balanced, that it will be highly effective, and that it will permit the NSF to make significant progress toward attaining its program goals.

The Foundation's program for FY 1974 will provide:

- Increased support for basic research in the science disciplines, especially in those areas that take advantage of unique research opportunities—such as gravitation physics, structure and mechanics of the earth, chemical catalysis, and wind effects engineering.

- Expanded research on energy, the environment, and other problems of national concern. These efforts include increased emphasis on research to find ways to achieve practical utilization of solar and geothermal energy and improved engineering methods for earthquake resistant structures, and studies that may lead to integrated bio-ecological techniques for regulation of insect pests.

- Broad programs in Polar Research, Ocean Sediment Coring, International Ocean Exploration, Global Atmospheric Research, and the National Research Centers, with provision made for continued development of the Very Large Array for radio astronomy.

□ Continued emphasis on international cooperative science efforts.

□ A restructured science education program designed to meet new and increasingly complex science and engineering education requirements and to find more effective ways to educate students at all academic levels.

The Foundation's program for FY 1974 continues to place strong emphasis on the support of fundamental research. \$554 million of the Foundation's total FY 1974 program of \$641.5 million will be used to support research efforts. Of this amount, approximately \$460 million, or 83 percent represents support for *basic* research under the various research programs of NSF, and about \$94 million represents *applied* research efforts that are focused on selected problems of national concern. We firmly believe that the support provided by the Foundation is effectively balanced between basic and applied research. It will permit us to plant the seeds of the scientific harvest to come while helping the nation to reap the benefits of what has gone before.

To span a diversity of national objectives, the Foundation supports scientific research under all of its major program activities. These include Scientific Research Project Support (SRPS) for the science disciplines, 10 National and Special Research Programs; 5 National Research Centers; Computing Activities; International Cooperative Scientific Activities; major problem-focused efforts under Research Applied to National Needs; research in Science Education; and other program areas. These research support activities constitute a set of functions that are mutually supportive and interrelated. Indeed, they

should be looked upon as a unified set, each part of which contributes to the others. Together, they reflect the Foundation's continued commitment to the important goal of sustaining a strong and healthy United States science research enterprise. This, as you know, is a basic charge given the NSF by the Congress.

In establishing program levels for fiscal year 1974, the Foundation took into consideration the total requirements in the various fields. For example, the full family of National Science Foundation atmospheric research programs includes basic studies carried out under Scientific Research Project Support and Arctic and Antarctic Research Programs, work at the National Center for Atmospheric Research, the Global Atmospheric Research Program, and the Weather Modification and certain environmental systems studies of the program of Research Applied to National Needs. These activities are carefully coordinated and synchronized.

The National Science Foundation programs contribute in significant ways to the accomplishment of multiple goals. However, for purposes of this overview, I would like to highlight the activities under four goals to which they contribute most directly. These goals are:

- ☐ Increasing the base of scientific knowledge;
- ☐ Finding ways to deal with problems of the civilian sector;
- ☐ Promoting international cooperation through science; and
- ☐ Improving the quality and effectiveness of U.S. science education.

Increasing the Base of Scientific Knowledge

Let me turn first to the Foundation's principal goal, which is to increase the Nation's base of scientific knowledge.

The activities that contribute directly to the attainment of this goal include major portions of the Scientific Research Project Support, National and Special Research Programs, National Research Centers, and Research Applied to National Needs. These activities are being increased in fiscal year 1974. The increase is more than is readily apparent, because the fiscal year 1973 program included a nonrecurring requirement for the purchase of three aircraft for the U.S. Antarctic Research Program.

A few highlights of research directed toward this goal include:

- Extension of the analysis of sea floor spreading and its meaning in terms of the evolution and behavior of the earth's crust.
- Basic studies in gene transplants from nitrogen-fixing plants that can greatly extend the knowledge in this area and that theoretically can lead to increased production of certain crops, such as corn.
- Theoretical studies of the physical makeup and orbits of objects in deep space and of the interior structures and surface properties of individual stars, and
- Studies of gravitation and how it affects matter under extreme conditions.

A continued effort in fundamental research areas is essential for the Nation since it is this research that expands the base of scientific knowledge. This continued buildup of new knowledge is essential if the

Nation is to be ready to meet tomorrow's problems—many of which are not yet perceived. It is in the nature of research and its applications that work on problem-focused efforts continually identifies gaps in our base of knowledge which can be filled only by basic research efforts. Consequently, there is a continued cross-fertilization of the fundamental and applied research programs of the Foundation, with the results of fundamental research being used in problem-focused efforts and the latter pointing to unresolved questions that require additional basic knowledge.

Finding Ways to Deal With Problems of the Civilian Sector

Another major goal of the Foundation is to support research that can help the Nation to come to grips with certain already recognized economic, technological, social, and environmental problems that are amenable to solution through the application of science and technology. All of the principal National Science Foundation programs contribute to the attainment of this goal. However, it is the primary goal of the program of Research Applied to National Needs, the Experimental R&D Incentives Program, and the National R&D Assessment Program, and of part of the work at the National Center for Atmospheric Research, one of the National Research Centers. In addition, significant contributions to the attainment of this goal are made by elements of the Scientific Research Project Support activity—particularly, research in chemistry, engineering, materials, and the biological, environmental, and social sciences.

Highlights of the various research programs of the National

Science Foundation directed toward civilian sector problems in FY 1974 include:

- An increased energy research program to find ways to achieve practical utilization of solar and geothermal energy.

- Expansion of earthquake engineering efforts designed to improve our capabilities to construct earthquake resistant structures, including buildings, dams, and others.

- Continued emphasis on enzyme technology and process dynamics that can lead to improved industrial processing and increased productivity.

- Added emphasis on corrosion research and materials research.

- Continued stress on the improvement of excavation and tunneling technology.

- Research on environmental systems, including studies to measure and assess the effects of trace contaminants in the environment.

- Expanded efforts of Technology Assessment that will focus on understanding the implications of specific, selected technologies.

- Research on biological means for controlling insect pests, with reduced environmental side effects.

- Research to find ways to increase the efficiency and speed of conversion of R&D results into improved products, processes, and services.

I should again like to stress the interdependence among the several research support activities of the National Science Foundation. For example, progress in Environmental System Studies under RANN frequently benefits from the progress made in the biological, atmospheric, and earth sciences activities of Scientific Research Project Support; and the enzyme technology research in RANN is mutually supportive to the process dynamics work being supported under chemistry and to enzyme work in the biological sciences. This interdependence of programs requires close coordination, and the National Science Foundation staff achieves this through the joint reviews of projects, periodic program reviews, and other coordination mechanisms. It is important to note that each of the Foundation's research support activities is related to the others in a way which enhances the value and progress of all.

Promoting International Cooperation Through Science

I will move now to our next goal, which is promoting international cooperation through science. The principal Foundation activities that contribute toward the attainment of this goal are the International Cooperative Scientific Activities Program, the Special Foreign Currency Program, and part of the Scientific Research Project Support Program. Others are the International Decade of Ocean Exploration, the Polar Programs, and the Ocean-Sediment Coring Program, to mention a few.

Many scientific problems are international in scope or interest, such as those associated with the environment and human health.

There is growing interest on the part of other nations in finding ways to link their science programs with ours in areas dealing with problems stemming from industrial development. Science is indeed international, and usually its progress has been brought about by the interaction of researchers in several countries. Therefore, in fiscal year 1974, the Foundation plans to increase its efforts in this area by:

- Expanding the science cooperation and exchange programs between the U.S. and East European countries.

- Increasing cooperative efforts between the U.S. and the U.S.S.R..

- Continuing bilateral cooperative science programs with 12 countries.

- Continuing research and science information activities with excess foreign currency countries under the Foundation's Special Foreign Currency Program.

As I indicated above, the Scientific Research Project Support Program also contributes to the attainment of this goal and, in fiscal year 1974, allowance has been made for the costs of selected international cooperative research projects that are in the process of development.

Improving the Quality and Effectiveness of U.S. Science Education

The Foundation's program for fiscal year 1974 includes an expanded Science Education Program, compared to the revised program for fiscal year 1973. However, I should point out that the

revised fiscal year 1973 program was below that authorized by the Congress.

As I indicated to the Committee last year, at that time the Foundation was in the process of making a detailed analysis of its education program to determine how each of its elements was contributing to identified science education needs. That analysis revealed that modifications in the program were needed if we were to effectively address the science education problems of the 1970s. For example, curriculum and course development work in single disciplines was not helping the science student to learn how to cope with real world situations requiring an interdisciplinary problem-solving approach. Programs exclusively designed to turn out more research-oriented Ph.D.s were aggravating the oversupply problems in certain areas, and some programs were not proving to be effective because there was no system for implementing improved instruction techniques in the school systems.

The Foundation's restructured science education program for fiscal year 1974 is designed to:

- Find ways to improve the effectiveness of science education through the application of modern educational technology and new methods of instruction;

- Provide for the numbers, variety, and flexibility of scientific and technical manpower needed to meet the Nation's changing requirements for trained scientists and engineers as practitioners—in addition to researchers—in industry, government, and other sectors of the economy;

- Make the general public more knowledgeable about the potential uses of science and its limitations so that people can deal more effectively with problems requiring a science and engineering input; and

- Help meet the requirements of scientists and engineers for continuing education.

The restructured program provides the basis for the National Science Foundation to make significant contributions to national efforts aimed at finding more effective ways to deliver educational services to students at the college and pre-college levels. The program supported by the Foundation will be at the forefront of science education in that it will be attempting to develop new and innovative approaches to the implementation and conduct of science education programs at all academic levels. Here again we have found that the science education problems of the 1970s demand new and innovative approaches, and research must be performed to provide a sound basis on which to proceed.

Mr. Chairman, the Foundation's request for FY 1974 totals \$641.5 million—\$636.5 million for the Salaries and Expenses (S&E) Appropriation and \$5 million for the Special Foreign Currency Appropriation. In addition to the new obligational authority of \$582.6 million, the program for FY 1974 includes the use of \$58.9 million in funds carried over from FY 1973. The FY 1974 funding level is \$26.5 million greater than the total program level of \$615 million for FY 1973.

On January 30, 1973, the National Science Foundation submitted to the Congress draft legislation to authorize appropriations for FY 1974. This has been introduced as S. 1078 and embodies the President's 1974 budget request for the Foundation. Accordingly, I urge prompt and favorable action on S. 1078.

Mr. Chairman, this completes my formal statement. At this point, with your permission, I would like to submit a more detailed statement for the record and am prepared to respond to questions.

SUPPLEMENTAL STATEMENT
OF
H. GUYFORD STEVER, DIRECTOR
NATIONAL SCIENCE FOUNDATION
BEFORE THE SPECIAL SUBCOMMITTEE ON THE NATIONAL SCIENCE FOUNDATION
OF THE
LABOR AND PUBLIC WELFARE COMMITTEE
UNITED STATES SENATE
MAY 3, 1973

Mr. Chairman, in reviewing the details of our program for FY 1974, I will follow the sequence in the Foundation's FY 1974 budget document. As I mentioned earlier, the appropriation request for FY 1974 is \$582.6 million in new obligatory authority. This consists of \$579.6 million for the Salaries and Expenses Appropriation and \$3 million for the Special Foreign Currency Appropriation. The total NSF operating program for FY 1974 will be \$641.5 million which includes the use of \$58.9 million in funds carried forward from FY 1973.

I will discuss the individual FY 1974 budget program activities in terms of their share of the \$641.5 million total funding.

Scientific Research Project Support

In keeping with the firm commitment of the Administration to maintain U.S. strength and vitality in basic science, funds in the amount of \$275 million are included in the budget for Scientific Research Project Support. Included within this total is an estimated amount of \$23.1 million for scientific instrumentation and facilities. These items are necessary to provide researchers with new capabilities for detection, analysis, and measurement -- and to enhance the capability of scientists to deal with large complex bodies of data and subtle phenomena.

The Foundation's Scientific Research Project Support activity provides support for research in the environmental, biological, social, mathematical, and physical sciences, materials research, and engineering. Research in these areas generates new ideas on which will rest future technological accomplishments and, perhaps ~~more~~ important, man's ability to gauge and understand the impact of technology on the quality of life.

The Scientific Research Project Support activity gives scientists major opportunities to pursue research that is motivated principally by their own ideas and judgment as to the most important knowledge gaps in their particular areas of scientific interest. Scientific merit is the principal criterion for selecting research efforts at the project level. The level of support provided to a research area or an entire field of science is

influenced by other factors as well. These other factors include the probability that progress in a particular field will significantly extend available options for practical technology or offer new knowledge, techniques, and instrumentation for other scientific fields.

Mr. Chairman, NSF considers the Scientific Research Project Support activity as the base on which the other science activities of NSF and, to a considerable degree, of the entire nation are built. The results of fundamental research provide the knowledge base needed in the future for recognizing and attacking specific problems of national concern, whether they be environmental, technological, or socio-economic.

The Foundation expects that about 7,400 scientists from 460 institutions will be engaged in scientific research endeavors supported under this activity in fiscal year 1974. In fiscal year 1973 an estimated 14,000 proposals for scientific research project support will be received; the overwhelming majority (more than 94%) are formally submitted by universities on behalf of faculty members. The number is expected to increase in fiscal year 1974.

The number of scientists whose opinions are sought and incorporated into the ranking of proposals is several times the number who actually receive support. The opinions of more than 18,000 scientists will be sought in the course of the year. These are persons from universities, from government laboratories, from industrial laboratories, and from non-profit research organizations.

I would like to mention some of the highlights of the activity for fiscal year 1974.

First, in the environmental sciences which include atmospheric sciences, earth sciences, and oceanography, major program efforts will include the following:

- o Studies of the dynamics of medium scale (on the order of 100 miles) meteorology, including severe storms.

- o Studies leading to a greater understanding of the earth's outermost atmosphere and how it interacts with the lower atmosphere in which we live.

- o A geodynamics program to test and further develop an integrated theory of the structure, composition, and movement of the "plates" of the earth's crust--called "tectonics" theory. This theory may provide answers to such important scientific and practical questions as how and why continents are moving apart, how mountains are made, and how ore deposits are formed.

In the biological sciences the research efforts will include:

- o Increased emphasis on studies of the integrated biological regulation of pest populations, which will involve the development of ecological strategies for holding in check certain insect and noxious plant populations.

- o Studies concerned with learning and memory, principally the psychological and neurological aspects as manifested by man as well as other animals.

Some of the research to be supported in the mathematical and physical sciences includes:

- o New studies in gravitational physics. This research will be directed toward acquiring new knowledge of the gravitational force, exploring consequences of the theory of general relativity and competing theories, and studying the role of gravitational interaction in our understanding of matter under extreme conditions. These conditions are exemplified by pulsars and quasars, as well as the violent events associated with the origin and evolution of the universe.

- o A wide range of approaches to the underlying fundamental mechanisms of chemical catalysis, a phenomenon of profound industrial, biological, and environmental importance.

- o Studies on the development and use of new mathematical methods in the biological and social sciences.

The Social Sciences research program is concerned with fostering the development of scientific knowledge about how human beings interact and about the functioning of societal organizations, customs and institutions. Some of the research in this area in fiscal year 1974 will include:

- o Research designed to develop better techniques of archaeological dating and analysis.

- o Studies on econometric modeling and the computer simulation of economic activity, including interactions between the economies of several nations.

- o Investigations to further the development of scientific linguistics and extend its applications to language theory and speech research.

The Foundation's Engineering research program supports research in electrical, industrial, mechanical, chemical, civil, and other areas of engineering. The following research efforts are among those to be included in this program in fiscal year 1974:

- o New studies on electrical and optical communications and control and automation.

- o Further research focused on chemical engineering principles, techniques, and methodology--including catalysis--in such diverse areas as the petrochemical, medical, pharmaceutical, and food sciences, as well as the control and abatement of environmental pollution in these areas.

- o Studies on industrial technology in the areas of noise control, mechanical design engineering, and the special requirements and technology of large buildings.

- o Research activities in civil and environmental technology including analysis and design of civil structures such as bridges, towers, and dams; studies of the properties and behavior of soil and rock as they relate to building foundations, highway and airport paving, slope stability, dam siting, and tunnels.

The Materials Research program supports research which explores the manner in which mechanical, electrical and chemical properties of solids, and in some instances liquids, are determined by their atomistic constitution. Some examples of the research include:

- o Resonance studies of condensed matter, including studies of both double and pure quadrupole resonance which will make possible the observation of nuclear species of low abundance. This research should prove to be extremely important in developing materials for chemical and medical applications.

- o Mechanical property research designed to enhance our understanding and ability to predict and control the response of well-characterized materials to external forces, and to identify and control significant parameters involved in materials processing, process characterization, and process control.

- o Research focused on polymer science, including further studies of the mechanisms of polymerization, new methods of polymer chain structure characterization, and the flow properties of concentrated and molten polymer systems.

Other Materials Research projects contribute to our broad program on chemical catalysis.

National and Special Research Programs

Mr. Chairman, I would now like to give you the highlights of the ten separate programs which comprise the National and Special Research Programs budget activity. This is the second largest budget category and \$99.6 million is requested for FY 1974.

As you know, these are major research programs which relate to specific geographic areas or constitute such broad scope or magnitude that extensive coordination of planning, management, funding, and logistic support are essential to insure maximum effectiveness and efficiency in program performance.

International Biological Program

The budget includes \$9.5 million for the International Biological Program (IBP). This is the same amount as in FY 1973. Studies are currently being conducted on five major biomes including the Grasslands, Desert, Tundra, and the Coniferous and Deciduous Forests. These studies are providing important data on the structures and functions of major ecosystems. Information on decomposers such as bacteria and fungi, on inorganic nutrients and on the soil-tree-atmosphere system and other ecological data being gathered under the biome studies are of great importance in efforts to improve the Nation's ability to manage its natural resources intelligently.

Global Atmospheric Research Program

An amount of \$4.0 million is included in the Global Atmospheric Research Program (GARP) -- or \$1.0 million above the FY 1973 level. The major part of the funds proposed for FY 1974 will be used for the GARP Atlantic Tropical Experiment (GATE). This experiment is scheduled for June through September of 1974. The requested funds will be used to support research in both oceanography and meteorology.

New R&D Initiatives

Mr. Chairman, a year ago the NSF budget introduced two new initiatives under National and Special Research Programs. These were the Experimental R&D Incentives Program and the National R&D Assessment Program.

Both of these efforts were highlighted in the President's FY 1973 budget, as presented to the Congress, and in his State of the Union Message for 1972. These two programs now form an integral part of the Foundation's overall effort in supporting research that can help the Nation come to grips with certain economic, technological, social, and environmental problems.

Experimental R&D Incentives Program

The Experimental R&D Incentives Program investigates ways in which the results of science and technology can be more effectively moved into productive application. Applications to both the private and public service sectors are included. The budget includes \$18 million for this program -- an increase of \$3 million over the FY 1973 level. This program was initiated as an outgrowth of the concern for the competitive position of U.S. industry in the world marketplace as well as for lags in application of technology in our country. The R&D Incentives Program is designed to provide operational experience with various incentives that the Government might use to augment the application of science and technology in the civilian sector.

Examples of two experiments planned under this program in FY 1973 are:

- o The opening up of Federal and accredited private laboratories to small R&D companies and individuals for the performance of proof-of-concept and performance-verification testing. We expect this stimulus to the innovation process to enhance the opportunities of individuals and small companies to gain entrance into the marketplace with new products and improved technology.

- o A Technology Extension Agent experiment, in which trained personnel will be placed in 30-40 cities to assist local communities to select and pursue technical innovations of their choice.

In FY 1974, the program will initiate experimental incentive projects designed to find ways to overcome the great problems now experienced in launching new products and services and industrial operation.

R&D Assessment Program

An amount of \$2.0 million is budgeted for the R&D Assessment Program for FY 1974--the same as in FY 1973. This program represents an effort to supply objective analyses and to define options available to policy makers with regard to enhancing the contribution of science and technology to the nation. Although the program has been operational for only about six months, it has already resulted in the establishment of a systematic research program aimed at analyzing patterns of R&D and technological innovation, identifying incentives and decisions that underlie the existing patterns of innovation, and assessing the implications of various options in shaping future patterns of R&D and technological innovation.

During FY 1974, the program will continue its efforts to meet its long term objectives of adding to our understanding of:

- o The relationship between government policy options, and innovation (including R&D).
- o The socio-economic effects of R&D and technological change, and
- o The process of innovation

International Decade of Ocean Exploration

An amount of \$17 million is requested for the International Decade of Ocean Exploration (IDOE). The program supports major Federal and non-Federal oceanographic research efforts to contribute to a better understanding of the total ocean environment. The program consists of large-scale research projects, each with carefully chosen objectives. The results of this research will help in efforts to improve the environmental quality of the oceans and to better our ability to forecast the ocean environment. Research results will also make possible improved assessments of the resource potential of the seabed and provide basic knowledge of the living resources of the oceans.

Ocean Sediment Coring Program

The budget request includes \$11.0 million for the Ocean Sediment Coring Program -- an increase of \$2.0 million over the FY 1973 level. The results to date of this program have provided new insights into the geological history of the earth. During 1973 to 1975, the drilling ship GLOMAR CHALLENGER will operate in the Atlantic, Pacific, and Indian Oceans, as well as in antarctic and arctic waters. During this year and next, attempts will be made to drill into the hard crystalline rock beneath the ocean sediments to enhance our understanding of the earth's structure. Knowledge of the nature of this crystalline rock will help scientists determine the process of the formation of some metalliferous ores.

Polar Programs

The Arctic Research Program budget request is \$3.5 million. Emphasis will continue in FY 1974 on the large-scale interaction of sea ice with the atmosphere and the ocean, on tundra ecosystems, and on man and his interaction with the environment.

For the Antarctic Program, \$23.5 million is requested. This is a decrease of \$20.2 million from the \$43.7 million appropriated in FY 1973. However, \$19.74 million of the amount appropriated last fiscal year was for the purchase of three new ski-equipped LC-130 airplanes. The first two of these aircraft are scheduled for delivery at the end of this calendar year and the third in February of 1974. The research program in Antarctica is multidisciplinary in orientation and international in scope. Some of the major efforts to be supported by the program for FY 1974 are completion of a new station at the South Pole for occupancy in FY 1975, expansion of instrumentation at Siple Station to permit year-round study of ionospheric and magnetospheric phenomena, and drilling of cores on the Ross Ice Shelf and in the dry valley area for analysis of geological features.

Oceanographic Facilities and Support

An amount of \$11.0 million is requested in FY 1974 for the program of Oceanographic Facilities and Support to provide for operation of the academic oceanographic fleet and related common-use facilities and equipment. Included in the request is \$0.8 million for the procurement of high priority replacement of ships' gear to maintain operational efficiency.

Marine research carried out by universities and oceanographic institutions, much of it with funds provided through the Foundation's program of Scientific Research Project Support, requires the use of ships and other special platforms. The support of these facilities has been centralized in the Office for Oceanographic Facilities and Support. That office works closely with the University National Oceanographic Laboratory System (UNOLS), a private organization of oceanographic institutions that is active in coordinating the scheduling and scientific workload of the academic fleet. Inasmuch as some support for facilities and ship operations comes from other agencies, this close liaison serves to maximize the service to investigators at the lowest overall cost.

The academic fleet has remained constant in size during recent years, while the number of days at sea has increased at the rate of about 6% per year. A program of replacement of old ships and upgrading of shipboard equipment has been carried out. Improved scheduling has led to a more efficient use of the fleet.

An increase in useable time on available fleet ships will be particularly import to the oceanographic community in Fiscal Year 1974, when total funds from Federal sources for fleet operations are expected to decline, with a resulting decrease in the number of ships in the operating academic fleet.

1974 Solar Eclipse (Logistic Support)

In FY 1974, NSF will coordinate U.S. scientific efforts related to the next total solar eclipse, which will occur on June 20, 1974, and will provide a limited amount of logistic support. Totality will begin in the southern Indian Ocean and cross the southwest edge of Australia. NSF efforts will be limited to coordination activities, site surveys, and appropriate Solar Eclipse Bulletins. An amount of \$100,000 is requested for this effort.

National Research Centers

The planned program for the five National Research Centers supported by the Foundation totals \$48 million in FY 1974 as compared to \$39.5 million in FY 1973. I would like to mention several major items of interest concerning the centers.

National Astronomy and Ionosphere Center

An amount of \$3,100,000 is included for the National Astronomy and Ionosphere Center in Arecibo, Puerto Rico. The resurfacing of the 1000-foot spherical reflector is well under way. When completed at the end of FY 1974, the 18-acre surface will have an accuracy 10 times better than that of the existing surface and will enable scientists to conduct radio astronomy research at wavelengths as short as 6 centimeters.

The National Aeronautics and Space Administration is financing the installation at Arecibo of an S-band (12 centimeters) radar capability. Completion of the S-band radar project is scheduled to coincide with the completion of the resurfacing of the reflector.

The combined effect of these two projects will greatly improve the capability to map the surface of Venus and other planets. In the case of Venus, the resolution should be comparable to that obtained for the moon's surface using the best quality optical telescopes.

Kitt Peak National Observatory

Next is the Kitt Peak National Observatory (KPNO), for which funding in the amount of \$8,000,000 is requested. The new 158" telescope will be dedicated and ready for use in June 1973. It is the third largest optical telescope in the world and the second largest in the United States.

Cerro Tololo Inter-American Observatory

The shipment of components of the mounting for the 158-inch telescope that is being constructed at the Cerro Tololo Inter-American Observatory in Chile is scheduled to commence in April 1973. The mirror, which is being ground and polished at the Kitt Peak National Observatory, is scheduled to arrive in Chile in FY 1974. The telescope is expected to become fully operational in FY 1975.

National Radio Astronomy Observatory

The planned FY 1974 program for the National Radio Astronomy Observatory totals \$17,200,000 or \$7,250,000 more than the FY 1973 level. This includes \$10.0 million for construction of the Very Large Array (VLA) antenna system

for radio astronomy for which initial funding of \$3,000,000 was provided in FY 1973. This very high priority radio astronomy facility will be located on the Plains of San Augustin, 50 miles west of Socorro, New Mexico. The VLA will consist of 27 antennas, movable along an equiangular "Y" configuration of double railroad tracks radiating from a central headquarters complex. Each leg will be approximately 13 miles long. The sensitivity and angular resolution of the array will surpass that of any other radio telescope in the world.

The Army Corps of Engineers has begun the task of site acquisition on our behalf. A request for proposals for the design, fabrication, erection, and testing of the antennas has been issued, and the contract for this work will be awarded early in FY 1974. Numerous design activities are in progress in FY 1973, including those of the antenna transporter, electronic systems, headquarters buildings, and the "Y" layout.

The key events planned for FY 1974, in addition to the contract awards, are fabrication of the first antenna, completion of site architectural and engineering design, and initial construction of site facilities.

National Center for Atmospheric Research

An amount of \$17,100,000 is included for the National Center for Atmospheric Research (NCAR).

NCAR work in FY 1974 will be directed at (1) determining the predictability of the behavior of the atmosphere; (2) increasing the understanding of the nature of global and regional climate; (3) improving knowledge of the nature of severe storms; and (4) determining the effects of the sun's output of gases, particles, radiation, and magnetic fields on the earth's atmosphere. Scientists from other institutions will be involved in all of these efforts. NCAR will also continue a major effort in the Global Atmospheric Research Program (GARP) which is directed to extending the range of accurate weather prediction and understanding the nature of climate and man's impact upon it. NCAR and its university collaborators are also developing models, techniques, and methods for obtaining and processing world-wide atmospheric observations.

Computing Activities

The budget includes \$10 million for the Computing Activities program or the same amount as in FY 1973. In FY 1974, the Foundation will continue to support strong programs in Computer Science and Engineering. In FY 1973, increased emphasis was given to studies of the design principles for computers that will perform correctly even though individual elements may malfunction. The FY 1974 program will include an expansion of efforts to improve reliability and fault tolerance of computing systems and more intensive research on computing procedures.

Our program of Computer Innovation in Education, which was formerly a part of this activity, has been reassigned to the Education Directorate and is now budgeted under Science Education Improvement.

Science Information Activities

An amount of \$8.3 million is included for Science Information Activities. These funds will support projects designed to develop and improve the information systems and services that are necessary to the progress of U.S. science and technology. Emphasis will be placed on cooperative programs to promote economies through sharing of resources and processing costs and on developing new techniques for data storage and retrieval and other mechanisms to make large data files readily accessible to both scientific and non-scientific users.

International Cooperative Scientific Activities

The request for International Cooperative Scientific Activities is \$6.2 million. This is an increase of \$1.5 million over the FY 1973 level. This program enables U.S. scientists to:

- o Participate in bilateral research and exchange programs with scientists of other countries;
- o Join in planning, development, and execution of scientific programs of international nongovernmental organizations;
- o Travel to international scientific meetings and foreign laboratories; and
- o Collaborate in an international research institute whose goal is to bring the scientific and technical expertise of 13 nations to bear on complex problems facing industrialized societies.

During FY 1974, the Foundation will continue to serve as Executive Agency for bilateral research and exchange programs involving at least twelve other countries, including three that were added in FY 1973-- Argentina, Hungary, and Mexico.

A substantial part of the increase of \$1.5 million planned for this program for FY 1974 will be used to support U.S. scientists in their efforts to develop joint scientific programs with the U.S.S.R. The Foundation will play a prominent role in the Agreement for Cooperation in Science and Technology between the U.S. and the U.S.S.R. Cooperative research projects are now under development between U.S. and Soviet scientists in the fields of energy, computers, chemical catalysis, microbiology, agriculture, and water resources. Other subjects may be considered as well.

Research Applied to National Needs and Intergovernmental
Science Programs

Next are the Research Applications Programs. These are the programs of Research Applied to National Needs (RANN) and the Intergovernmental Science Program.

An amount of \$79.2 million is included in the FY 1974 budget for RANN. This is an increase of \$9.2 million over the FY 1973 level. An amount of \$1 million is requested for the Intergovernmental Science Program.

The purpose of the RANN program is to contribute to the practical solution of nationally important societal problems through focused scientific research. This purpose is in accord with the expressed concerns of the President and the Congress for harnessing the discoveries of science to the service man. RANN supports problem-focused research in areas which hold promise of technological, environmental, or socio-economic payoff. By applying the scientific knowledge derived from basic research, RANN bridges the gap between the basic research programs supported by NSF and the research, development, and operations programs of the mission agencies.

The principal implementers of the RANN program are universities, with industry and national laboratories having a strong complementary role.

The three major RANN programs are Advanced Technology Applications, Environmental Systems and Resources, and Social Systems and Human Resources. The fourth RANN program, entitled Exploratory Research and Problem Assessment, is designed to identify and assess the potential of science and technology to contribute to practical solutions of emerging societal problems. This program is the focal point for technology to contribute to practical solutions of emerging societal problems. This program is the focal point for technology assessment activities supported by the Foundation.

The specific thrusts of the RANN programs are developed through an extensive planning and evaluation process which incorporates the views of the leaders of the scientific and technical communities, other Federal agencies, and State and local levels of government. The planning effort has included in-depth program reviews with the National Science Board and major Advisory committees of the Foundation, particularly the Research Applications Advisory Committee. Important contributions have also been made to this effort by Committees of the National Academies of Science and Engineering.

Federal mission agencies participate in this planning and evaluation effort through the RANN Coordinating Committee and its Panels and through special committees of the Federal Council on Science and Technology. These committees and panels are also focal points for identifying RANN projects which have advanced to the stage where mission agencies can undertake the developmental phase.

The RANN program for FY 1974 will give particular emphasis to the terrestrial application of solar energy, earthquake engineering, and technology assessment. Research on uses of solar energy will stress component and systems technologies for heating and cooling homes and other small buildings, solar thermal and photovoltaic conversion for electric power generation, and a number of other efforts. Research in the area of earthquake engineering will include a start on the design for a large-scale earthquake simulator and research to improve the engineering and construction of earthquake resistant structures. Technology assessment efforts will continue to be focused on understanding the implications of technological change. Support will be provided for assessments on selected issues of national concern, studies to aid in the determination of national priorities in technology assessments, and the development of selected state-of-the-art reports on assessment methods and techniques.

State and local government agencies have a crucial interest in many of the major problems addressed by RANN. For this reason the Intergovernmental Science Program (ISP) is complementary to the RANN program. ISP is responsible for communicating to RANN the societal problems perceived by State and local government agencies and for facilitating the transfer of RANN results to these agencies.

Institutional Improvement for Science

Funding in the amount of \$9 million is planned for our program of Institutional Improvement for Science for FY 1974. Within this amount, a total of \$3 million is included for Institutional Grants for Research Management Improvement. These grants will enable academic institutions to support the development of more efficient and effective research management practices for their own use and for consideration by other institutions.

Also included within the total is \$6.0 million for the Institutional Grants for Science, or formula grants. These grants provide discretionary and flexible funds for use by institutional administrators for science needs. The dollar amounts of the individual grants are determined by the amount of Federal research support each institution has received.

Graduate Student Support

The FY 1974 program provides for the continuation of the competitive Graduate Fellowship Program at the same \$9.2 million level as in FY 1973. About 500 new awards will be made in FY 1974, in addition to over 900 awards needed to fulfill previous commitments.

Science Education Improvement

Let us now move on to Science Education Improvement, for which \$60 million is included in the FY 1974 budget. Mr. Chairman, three basic objectives or themes have been developed as the framework for a comprehensive and integrated program plan for Science Education Improvement. They are:

1. Improvement of Education for Those Pursuing Careers in Science
2. Development of Scientific Literacy (that is, education of the non-scientist)
3. Increasing Effectiveness of Educational Processes in Science.

During calendar year 1972, the programs that had been designed to implement those objectives were subjected to an intensive review. It became clear, when we applied the criteria of scientific and social need, feasibility, appropriateness for NSF support, and cost benefits, that a new program structure was needed. We have developed a program structure by aligning it with the three basic objectives and developing sets of program activities that are specifically tailored to each of the objectives.

FY 1973 is a period of transition during which sustaining-type programs are being phased down and efforts reoriented to contribute more directly to achievement of the program objectives. The result will be a much tighter, more effective, and less costly set of programs than those previously employed.

The revised structure of the Science Education Improvement Program will carry forward in FY 1974, in a more sharply focused way, the changes initiated in FY 1973. The need for scientific and technical manpower to perform a wider variety of tasks is recognized and reflected in the program plan. The need for the understanding of science by all citizens is also recognized. Both needs are attacked through programs designed to reach a broader segment of the population. These same programs will promote the introduction into the educational system of a broader scope of educational opportunities leading to a wider variety of career options for scientists. The search for ways to reduce, or at least stem, the increase in the cost of science education will be given increased emphasis. In addition, studies of current science educational practices, current problems, and future needs will be initiated to point the way toward program enhancement.

The Foundation's restructured Science Education Program for fiscal year 1974 is designed to:

- o Find ways to improve the effectiveness of science education through the application of modern educational technology and new methods of instruction;

- o Provide for the numbers, variety, and flexibility of scientific and technical manpower needed to meet the Nation's changing requirements for trained scientists and engineers as practitioners, in addition to researchers, in industry, government, and other sectors of the economy.

- o Make the general public more knowledgeable about the potential uses of science and its limitations so that they can deal more effectively with problems requiring a science and engineering input; and

- o Help meet the requirements of scientists and engineers for continuing education.

The restructured program provides the basis for the National Science Foundation to make significant contributions to national efforts aimed at finding more effective ways to deliver educational services to students at the college and pre-college levels. The program supported by the Foundation will be at the forefront of science education and will develop new and innovative approaches to the implementation and conduct of science education programs at all academic levels. Here, as in other areas, we have found that the problems of the 1970's demand new and different approaches and that research must be performed to provide a sound basis on which to proceed. To support such research efforts, the Foundation has established a fourth subactivity -- Science Education Research and Problem Assessment -- within the new structure of our Science Education Improvement activity.

Planning and Policy Studies

An amount of \$2.0 million is requested for the Planning and Policy Studies, which encompasses the Foundation's activities in three separate areas: science resource studies in such areas as manpower and funding; science policy studies; and program evaluations related to the Foundation's own activities.

Special Foreign Currency Program

A separate amount of \$5.0 million for payment in foreign currencies in excess of the normal requirements of the United States is requested for fiscal year 1974. The activities supported in designated countries under this program include cooperative scientific research and related activities, as well as the procurement of translated foreign scientific literature.

Program Development and Management

The Foundation's Program Development and Management activity for which \$29.0 million is included in the budget, provides for all operating and management costs of the agency. This presents an increase of \$100,000 over the amount for FY 1973. The Foundation will be absorbing, in FY 1974, the annualization costs of new positions filled during FY 1973 by selective cost reductions in other areas. This will decrease dollars per professional employee.

In FY 1972, over 22,000 proposals received programmatic review and evaluation. This compared to over 17,500 in FY 1971. In FY 1974, the level of activity is expected to again increase significantly, both in terms of the number of proposals to be reviewed and evaluated and the number of grants awarded.

Management improvements, such as centralization of administrative aspects of proposal processing, organizational adjustments, implementation of some labor saving devices, and other actions which have been taken, have helped us to accommodate the continuously growing workload, but increase in the agency's staffing between FY 1973 and FY 1974 have been held to a minimum.

Conclusion

In conclusion, Mr. Chairman, the NSF program for FY 1974 provides for:

- o Increased support for research in the science disciplines.
- o Expanded research on energy, environment, and other problems of national concern.
- o Added emphasis on cooperation in science with many other countries of the world.
- o A restructured science education program designed to meet emerging needs.
- o Continuation of research and other science programs that utilize excess foreign currencies.

This concludes my formal statement. I will be glad to answer any questions you may have regarding any of our activities.

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550



OFFICE OF THE
DIRECTOR

May 23, 1973

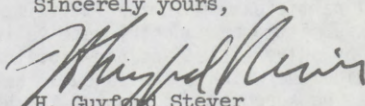
Honorable Edward M. Kennedy
Chairman, Special Subcommittee on
the National Science Foundation
Committee on Labor and Public Welfare
United States Senate
Washington, D.C. 20510

Dear Senator Kennedy:

Attached are answers to questions raised in your letter of May 4, 1973,
in connection with the National Science Foundation authorizations for
FY 1974.

Please let me know if I can be of further assistance.

Sincerely yours,



H. Guyford Stever
Director

Attachments

ATTACHMENT I

Question 1a: What precisely is the role of industry in the RANN program?

Answer : As a result of the President's authorization dated April 15, 1972, industry and other profit-oriented institutions are being encouraged to join with universities in implementing the RANN program in order to provide their special capabilities in such areas as systems management, hardware design and research. This participation of industry will take three forms. First, and most importantly, industrial know-how is required during the proof-of-concept experimentation (POCE) phase when the results of RANN research will be subjected to full-scale demonstration of its socio-economic feasibility and consequences. During this phase, industry is expected to participate in constructing and operating the POCE. The RANN plan for the Terrestrial Solar Energy Program has been developed with industry to assume this role.

Another role planned for industry is to conduct research either as a direct participant (i.e. as a RANN grantee or contractor) or in partnership with a university that serves as the principal RANN grantee. Such arrangements currently exist. As an example, the Ford Motor Company is planned to receive a contract to conduct research in the area of sodium-sulfur batteries, while the University of Minnesota has awarded a contract to Honeywell to conduct research in designated areas of terrestrial solar energy.

The third role is concerned with industry's use of RANN-sponsored research. Proposals submitted to RANN must contain, as a principal feature, a plan that demonstrates the mechanism for conveying research results to the ultimate user. When industry is regarded to be the instrument through which research results can best be implemented, the grant is followed closely to be assured that the grantee is implementing the utilization plan.

Question 1b: How extensive is that role?

Answer : RANN has not created specific limits to govern the extent of industrial participation in the fulfillment of program goals. Unsolicited proposals submitted by industry receive the same consideration as those submitted by universities and non-profit institutions. RANN is following a general guideline which established a "best performer" rule so that the research to be supported is granted to the proposers best able to perform a given task.

Question 1c: What steps are you taking to fulfill that role effectively?

Answer : RANN program objectives will use "Program Solicitations" and "Requests for Approval." Proposals received in response to these invitations will be evaluated by review boards and panels composed of recognized leaders in various disciplinary fields. As a result of this approach to research, greater use will be made of contracts and grants awarded to industry to accomplish specific project goals. While the use of directed-type research is expected to materially increase participation by industry,

no appreciable reduction is planned in the amount of research work awarded to the academic community.

Question 2a: What issues have been selected for technology assessments?

Answer: The following is a list of issue areas which have been selected for assessment during FY 1973. A complete description of these issues is contained in NSF Program Announcement 73-8, which is enclosed for your review.

- Advanced Data Processing and Telecommunication Impacts on Criminal Justice Systems
- Cashless - Checkless Society
- Biological Substitutes for Chemical Pesticides
- Integrated Hog Farming
- Conversion from the English to Metric System in the United States
- Alternative Work Schedules
- Alternative Strategies and Methods for Conserving Energy

Question 2b: Provide a complete description of all Technology Assessment projects which NSF has done, is doing or contemplate doing; and a complete description of all technology assessment proposals which NSF has received, but does not intend to fund.

Answer : A list of technology assessment projects funded in FY 71, FY 72 and FY 73 is included in Attachment 2. Also designated is the status of the project with regard to interim and final reports. Note that this material includes not only the ERPA projects but others which look extensively into secondary impacts but not necessarily in a totally comprehensive way. This applies particularly to the ESR material in FY 71 and FY 72.

We have at the moment no definitive list of future technology assessments, which we plan to fund. However, we have four projects underway to assist us in identifying candidates for technology assessment and to help set priorities among them in terms of rational criteria. Those reports will be available for general distribution in the next two months. We anticipate they will be of substantial value to any agency contemplating funding technology assessments.

With regard to technology assessments which have been proposed to us but not funded, it will be most difficult to give a crisp useful tabulation since the proposals are put before us in varying ways. Proposals range from telephone conversations to face-to-face discussions, preliminary written proposals, letters of inquiry, and formal submissions. Consequently, no reply to this item is made. It should be noted, however, that a very large number of assessment concepts have been put before us in the

last three fiscal years. Most of the projects funded in FY 71 and FY 72 were initiated by voluntary proposals. It should also be noted that we have several technology assessment proposals not submitted in response to solicitations now under review.

Question 3a: What steps do you plan to take in order to carry out your role as Science Advisor to the Executive Branch?

Answer : I am now in the process of establishing a small science policy staff, the Office of National Science Policy, which will provide central staff support to the Science Advisor. I plan to rely very heavily on problem-oriented task groups to assist me in carrying out my responsibilities. These groups will be composed of personnel from NSF staff, from other agencies involved in science and technology, and from outside consultants. In April of this year I established the first group in the NSF R&D Energy Task Force. I will employ NSF staff through the regular NSF organization to provide both in-depth studies and assessments and non-programmatic support. I have been working closely, and will continue to do so, with the Federal Council for Science and Technology. I am now engaged with the Council in an effort to determine the most effective future utilization of its standing committees in the international area. Last March I chaired the meeting of the U.S.-U.S.S.R. Joint Commission on Scientific and Technology Cooperation.

Question 3b: Does the Administration's budget request for NSF provide you with adequate resources of personnel and funds to carry out that role effectively?

Answer : Yes. While NSF has not requested additional funds or personnel in FY 1974 specifically for this mission, the reorganization plan must be considered in light of the President's policy and commitment for science and technology, particularly as stated in his March 1972 special message to the Congress on science and technology. The changes proposed are based on the recognition of significantly increased capabilities in the departments and agencies to plan and carry out R&D programs addressed to high-priority national needs. The President recognizes that the Director of NSF now has the capabilities to satisfy the need for an overview and coordination of our federal and national efforts in science and technology. NSF has experienced two decades of steadily increasing responsibilities in almost all areas of civilian science and technology. Because of this demonstrated capability NSF is requesting no additional resources to support my role as Science Advisor at this time.

Question 3c: Do you anticipate that the Science Advisor function will conflict with the dispatch of your other NSF responsibilities as NSF Director?

Answer : I expect the two roles to be complementary, not conflicting. NSF is the only non-mission science agency in the Executive Branch. As such it supports the complete spectrum of science and technology excluding, of course, defense R&D. Since the departments and agencies are now recognized to be able to effectively plan and carry out their R&D programs, and because NSF has been accepting increasing responsibility for science policy over the last several years; the logical place for the Science Advisor's function is with myself. NSF has no vested interest in any one type or discipline of science; in fact it plays a pivotal role in insuring the health of all science disciplines. Because of its broad spectrum of activities, NSF is also in the best position to make state-of-the-art assessments and priority recommendations in these respects. The roles of Science Advisor and NSF Director complement and reinforce each other.

Question 4 : A letter from the National Association for Equal Opportunity in Higher Education, with reference to the College Science Improvement Program -- Section D, expresses questions and concerns especially with regard to the need for additional funding and the broadening of institutional eligibility for the program. What is the NSF response?

Answer : Dr. Fisher, the Executive Secretary of the Association, is quite correct in his description of the Minority Institutions (COSIP-D) program here at the Foundation. During the first year of the program, FY 1972, there were requests totalling four times the amount awarded. During the second year the program was extended to include two-year institutions. This extended universe represents an expansion of approximately 23% to include a total of approximately 101 eligible two- and four-year institutions. Also, our current estimate is that by the close of FY 1973 the COSIP-D activity will have supported projects in over 40% of the eligible four-year institutions.

The guidelines indicate a normal project support level of \$300,000. Each institution is eligible for two such projects and may participate in two additional projects in cooperation with one or more other institutions.

As Dr. Fisher suggests, the Foundation does plan to fund activities seeking to increase the flow of women and ethnic minorities into scientific careers. The amount planned for FY 1974 for this purpose is only \$600,000 and is funded separately from the COSIP-D activity. The Foundation does not plan at this time to extend the COSIP-D activity to non-minority institutions.

The Foundation appreciates Dr. Fisher's concern for the increased competition for funds and their constant annual level. However, in view of the current economic situation in the country, there is an urgent need for strict economy in Federal programs. Under such circumstances, we have been unable to justify an increase for Fiscal Year 1974 for COSIP over the \$5,000,000 planned. The fact that the program has been able to hold its position, so to speak, results from recognition of the important need it serves. A number of other NSF science education programs have been terminated.

ATTACHMENT II

Date: 5/14/73

TECHNOLOGY ASSESSMENT PROJECTS IN NSF FY 71, 72

Institution	Title	P.I.	Amount	Status
1. Stanford Research Institute Menlo Park, California	"Technology Assessment Study of Winter Orographic Snowpack Augmentation in the Upper Colorado River Basin"	George Hopkins	\$ 147,279	Report in hand as of May 1972, two volumes, main report and executive summary. A layman's version should be completed by July 1, 1973.
2. U. Oklahoma Norman, Oklahoma	"A Technology Assessment of Offshore Oil Operations"	Don E. Kash Jack White	\$ 250,000	Final report under review. Shou be published as a book by September 1, 1973.
3. American Society of Civil Engineers New York, New York	"Case Studies of the Impact of Civil Engineering Projects on People and Nature"	Don Taylor Herbert Poertner	\$ 50,000	Final report due by June 1973.
4. George Washington University Washington, D. C.	"Technology and Public Policy: The Process of Technology Assessment in the Federal Gov't."	Vary T. Coates	\$ 8,500 \$ 9,800	Three-volume report, July 1972. Distributed.
5. Hittman Associates, Inc. Columbia, Maryland	"Evaluation of the Ecological, Resources and Socio-Economic Impacts of Advanced Automotive Propulsion Systems"	D. Harvey	\$ 238,889	Final report including layman's version now under review. Anticipated distribution August
6. Columbia University New York, New York	"The Automobile and the Regulation of Its Impact on the Environment"	Frank Grad	\$ 310,000	Draft report June 1973--final published report December 1973.
7. U. Colorado Boulder, Colorado	"An Investigation of the Interaction between Technology and Our Legal-Political System"	Frank Kreith	\$ 107,100	Final report by June 1973.
8. Center for Advanced Studies in Behavioral Sciences Stanford, California	"Studies of the Social Consequences of Technology"	O. M. Wilson	\$1,500,000	Interim report January 31, 1972 1973 (for administrative purpose only). Substantive report due Ju

<u>Institution</u>	<u>Title</u>	<u>P.I.</u>	<u>Amount</u>	<u>Status</u>
9. National Academy of Science Washington, D. C.	"Assessment of Biomedical Technology"	Leon Kass	\$ 68,000	Final report in book form under review at NAS.
10. Midwest Research Institute Kansas City, Mo.	"An Analysis of Unstructured Technology Assessment"	Edward Lawless	\$ 97,000	Final report April 1. Interim report #2 and #3 with 15 and 17 case histories each now in hand.
11. Kansas State University Manhattan, Kansas	"Political and Scientific Effectiveness in Nuclear Materials Control"	Robert Leachman T. A. Williams	\$ 254,000	Book published--"Preventing Nuc- leart Theft: Guidelines for Industry and Government" April 1972; Prac- tice Publishers; 111 Fourth Avenue, New York, New York 10003.
12. Montana State University	"The Impact of a Large Recreational Development Upon a Semi-Primitive Environment: A Case Study"	Jellenick	\$ 250,000	Progress report May 1972. 187 p
13. U. California Davis, California	"A Research Program in the Lake Tahoe Basin"	Charles Goldman	\$ 561,100	Progress report due April 15, 1973
14. John Muir Institute Albuquerque, N. M.	"Assessment of Man's Activities on Lake Powell Region"	Michael Williams	\$ 38,300	Final report August 1, 1972. Participating institutions: Dartmouth College (GI-29421), U. New Mexico (GI-29422), U. of California, L. A. (GI-29423), John Muir Institute (GI-29424).
15. Washington University St. Louis, Missouri	"A Study of Certain Ecological, Public Health and Economic Consequences of the Use of Inorganic Nitrogen Fertilizer"	Daniel Kohl Barry Commoner	\$ 282,400	First-year progress report May 5, 1972.
16. U. Rochester	"Methyl Mercury and Related Compounds as Environmental Hazards to Man"	Thomas Clarkson	\$ 340,000	Progress report January 1973.

<u>Institution</u>	<u>Title</u>	<u>P.I.</u>	<u>Amount</u>	<u>Status</u>
17. Atomic Energy Commission Washington, D. C. Oak Ridge National Laboratory Oak Ridge, Tennessee	"Environment and Technology Assessment"	James Liverman	\$ 2,502,000	Progress reports December 1970 and February 1971. Overview memorandum attached. For information contact Lou DiVone at 632-4032.
18. Western Interstate Nuclear Board Wheatridge, Colorado	"Technology Assessment of the Plowshare Program"	A. Whatley	\$ 25,000 \$ 25,000	Report due April.
19. Virginia Polytechnic Inst. Blacksburg, Va.	"Assessing the Implementation Aspects of Technology for the Disposal of Solid Waste"	W. McKeefery D. Glancy R. Walker	\$ 40,000	Final report 1 volume, April 1971 No distribution yet.
20. George Washington University Washington, D. C.	"Technology Assessment Applied to Urban Solid Waste Disposal"	Louis H. Mayo	\$ 40,000	Three-volume report. No distribution yet.
21. MIT Cambridge, Mass.	"1971 International Summer Study of Man's Impact on Climate"	Carroll Wilson W. Matthews	\$ 123,000	Book "Inadvertent Climate Modification." Report of the Study of Man's Impact on Climate (SMIC), MIT Press, Cambridge, Mass. 1971.
22. MIT Cambridge, Massachusetts	"1970 Summer Study on Critical Environmental Problems"	Carroll Wilson	\$ 15,000	Book published. "Man's Impact on the Global Environment." Report of the Study of Critical Environmental Problems (SCEP). The MIT Press, Cambridge, Mass., December 1970.
23. George Washington University Washington, D. C.	"An Analysis of Voluntary Citizen Group Uses of Scientific and Technological Information"	Steven Ebbin	\$ 98,500	Final report under review.

<u>Institution</u>	<u>Title</u>	<u>P. I.</u>	<u>Amount</u>	<u>Status</u>
24. University of Michigan	"Assessing the Impact of Remote Sensing of the Environment"	George J. Zissis	\$ 141,500	Report due January 1974.
25. Duke University	"Law-Related Research on Scientific Uncertainty and Technology Assessment"	Clark C. Havighurst	\$ 14,800	Report due by end of fiscal year
26. University of Colorado Boulder, Colorado	"Assessment of Research on Natural Hazards"	Gilbert White E. Haas	\$ 723,900	Report due December 1974.
27. Southern Methodist University	"Study Group on the Societal Consequences of Weather Modification"	Howard J. Taubenfeld	\$ 60,500	Report due December 1974.
28. Engineering Foundation	"TA Conference"	Joel Goldhar	\$ 9,000	Letter report of no substantive value.
29. Peat, Marwick, Mitchell, and Company Washington, D. C.	"Study to Assess Technology Assessment"	Robert K. Morton	\$ 124,495	Final report, "A Survey of Technology Assessment Today", June 1972, Peat, Marwick, Mitchell & Company, 1025 Connecticut Avenue, N. W., Washington, D. C.
30. COPEP, National Academy of Engineering	"Perspectives in Risk Benefit Decision-Making"	E. Wenk	\$ 14,900	COPEP study. "Perspectives in Risk Benefit Decision-Making". Published by NAE 1972.
31. Hawaii Department of Planning and Economic Development	"State Science and Technology Forecasting Program"	Shelley Mark	\$ 21,300 21,300 21,600 (FY '73)	Reports: Manganese Nodule Deposits in the Pacific: Symposium/Workshop Proceedings (Oct. 72); Legal and Administrative Aspects of an Aquaculture Policy for Hawaii, Assessment (Dec. 72);

May 14, 1973

TECHNOLOGY ASSESSMENT PROJECTS IN NSF FY 73

<u>Institution</u>	<u>Title</u>	<u>P.I.</u>	<u>Amount</u>	<u>Remarks</u>
33. George Washington University	"Technology Assessment in the Federal Government (additional funds to FY 72)	V. Coates	\$ 900	Publishing costs on previous grant
34. R.P.I.	"Technology Assessment for Cable T. V."	S. Ghandi K. Rose	\$ 48,900	Final report due June 1974.
35. George Washington University	"Federal Agencies Executive Priorities in Technology Assessment"	H. Reese	\$ 6,995 1,300	Final report in preparation
36. The Mitre Corporation	"A Review of Some Comprehensive Technology Assessment Studies"	M. Jones	\$ 10,181	Final report in preparation
37. Consultant	"Technology Assessment and State Government"	John Mock	\$ 2,475	Final report in preparation
38. IR&T	"Technology Assessment Priority Study"	R. Ayres	\$ 15,000	Final report in hand.
39. George Washington University	"An Analysis of Voluntary Citizens Group Uses of Science and Technology"	S. Ebbin	\$ 25,000	Final report under review Supplement to 1972
40. Futures Group	"Priorities for Technology Assessment - A Survey of Candidates"	W. Boucher	\$ 18,000	Final report under review.
41. Request for Proposal for 2 Technology Assessments	1. Geothermal Energy 2. Solar Terrestrial			
42. "				
			Est. \$4-600,000 Total to be contracted	

1/14/73
Proposed for NSF FY 73

<u>Institution</u>	<u>Title</u>	<u>P.I.</u>	<u>Amount</u>	<u>Status</u>
32. National Academy of Public Administration, Washington, D. C.	"Technology Assessment in State Government"	Richard Chapman	\$ 22,400	Report: Technology Assessment in State Government--A Report on a Working Conference and Recommendations for Action (September 1972)

May 14, 1973

SOME TECHNOLOGY ASSESSMENT PROJECTS IN NSF FY 73

<u>Institution</u>	<u>Title</u>	<u>P.I.</u>	<u>Amount</u>	<u>Remarks</u>
43. Program Announcement 73-8 Soliciting 7 Technology Assessments	1. Advanced Data Processing and Telecommunications Impacts on Criminal Justice System		Est. \$1,000,000 of which \$600,000 is FY '73	To be reviewed by Award by June 22
44. "	2. Cashless-Checkless Society			"
45. "	3. Biological Substitutes for Chemical Pesticides			"
46. "	4. Integrated Hog Farming			"
47. "	5. Conversion From the English to Metric System in the United States			"
48. "	6. Alternate Work Schedules			"
49. "	7. Alternative Strategies and Methods for Conserving Energy			"
50. University of California Los Angeles	"A General Approach to Risk-Benefit Evaluation for Large Technological Systems"	David Okrent	\$349,232	"



**RESEARCH APPLIED
TO NATIONAL NEEDS**

Office of Exploratory Research
and Problem Assessment

PROGRAM ANNOUNCEMENT

**EXPLORATORY TECHNOLOGY ASSESSMENTS
IN SELECTED AREAS**

CLOSING DATE: MAY 17, 1973

SUMMARY

The Office of Exploratory Research and Problem Assessment of the Research Applications Directorate will provide approximately \$1,000,000 for the Preparation of Technology Assessments.

A number of awards will be made at one of two levels. The first will be for in-depth comprehensive technology assessments involving up to approximately sixty man-months of professional effort over a period of up to eighteen calendar months including a three-month period for sponsor review, evaluation and performer re-write. The second will be for a group of preliminary comprehensive technology assessments involving up to approximately eighteen man-months of professional effort over a period of twelve months including three months for sponsor review, evaluation and performer re-write.

Proposals must be received by the Central Processing Section of the Foundation by 5:00 p.m. E.S.T., May 17, 1973; proposals will be considered firm until August 31, 1973. Awards may provide full costs when appropriate.

Awards for Exploratory Technology Assessments in Selected Areas

SUMMARY

The Office of Exploratory Research and Problem Assessment of the Research Applications Directorate will provide approximately \$1,000,000 for the Preparation of Technology Assessments.

A number of awards will be made at one of two levels. The first will be for in-depth comprehensive technology assessments involving up to approximately sixty man-months of professional effort over a period of up to eighteen calendar months including a three-month period for sponsor review, evaluation and performer re-write. The second will be for a group of preliminary comprehensive technology assessments involving up to approximately eighteen man-months of professional effort over a period of twelve months including three months for sponsor review, evaluation and performer re-write.

Proposals must be reviewed by the Central Processing Section of the Foundation by 5:00 p.m. E.S.T., May 17, 1973; proposals will be considered firm until August 31, 1973. Awards may provide full costs when appropriate.

In connection with the assessment of the effects of technology applications upon society the objectives of these awards are:

1. To provide a substantive, comprehensive, useful input into public policy formulation and decision-making with regard to the application of particular technologies.
2. To explore and encourage technology assessment and the application of systematic methods, techniques, protocols, and approaches to complex, policy-related problems.
3. To encourage the growth of organizational capability to conduct impartial, comprehensive technology assessments.

Technology Assessment

Technology assessment is a term which has come to be applied to a class of policy studies which systematically define, explore, and evaluate the full range of economic, social, environmental, institutional, and other consequences of the introduc-

tion of a new technology into our society or the expansion of an extant technology, more extensively, intensively, or in new ways.

The management of technology and the systematic exploitation and development of resources are issues of national importance both in the short and the long run. The alternatives, options, and strategies for the management of technology and the development of resources, it is widely believed, should take into account not only the direct short-term conventional investment considerations, but should be examined also against a wider and deeper background of qualitative and quantitative costs, benefits, risks, and opportunities in the total direct and indirect impacts.

General Proposal Information

Technology assessment proposals may be submitted with regard to the technologies listed below. No funding priority has been set within or among the categories. No subjects other than the ones listed will be accepted under this program announcement. A proposal may only address one of these technologies. Separate proposals addressing different technology assessments may be submitted by any organization.

It is important to note that proposals may be submitted at either of two levels: In-depth Comprehensive Technology Assessments which as the term implies meet the definition and characteristics of technology assessment offered above, as well as the specific points below associated with the individual technologies.

Proposals for Preliminary Comprehensive Technology Assessments may be submitted, either because of the uncertainties associated with the subject itself, the availability of data, the conceptual methodological difficulties in defining a strategic and tactical approach to the assessment; or because of the inability to formulate an adequate full-scale work plan. Such preliminary assessments are anticipated to result in a useful public policy document but will be less definitive than the in-depth comprehensive assessment. They may, in certain instances, only structure the problem and define any useful research study or follow-on effort.

The following are the selected technologies for which proposals may be submitted:

1. Advanced Data Processing and Telecommunications Impacts on Criminal Justice Systems

In recent years, the police component in particular of the criminal justice systems has widely adopted advanced data processing and electronic and computerized gear and telecommunications aids. The impacts of these technical innovations—in the short term, as transitional phenomena, as well as longer term effects—both in and outside of the criminal justice system merit attention. The active cooperation of operating agencies may be a necessary aspect of this assessment.

2. Cashless-Checkless Society

This term connotes the confluence of automatic data processing, high speed transmission of information, electronic banking, the growing diversified use of credit cards and related devices influencing the use of cash and checks as traditional media of monetary exchange. The assessment of the impacts of these growing trends should include not only the effects on financial institutions but effects on small and large business, consumers and consumer attitudes, various socio-economic groups in society, and such issues as vulnerability, privacy, data security, crime, occupational implications, investment pools, and labor force impact. These are suggestive not limiting areas of impacts to be considered.

3. Biological Substitutes for Chemical Pesticides

The increasing constraints on use of chemical pesticides has stimulated great interest in biological agents for the control of crop destructive and disease bearing organisms. The biological methods include viruses and micro-organisms, natural and exotic predatory higher species, as well as pheromones and hormones.

4. Integrated Hog Farming

The chicken is probably the most fully industrialized factory-managed animal in history. The next most likely candidate for such integrated factory type management is the pig. Virtually no work has been done to date on the implications of such a systematic program. Effects may impact land use, waste management, applied genetics, convenience foods, dietary habits, nutrition, rural economy, labor, and industry to suggest a few.

5. Conversion From the English to Metric System in the United States

It is anticipated that any proposed assessment in this area build upon the work already accomplished under the National Bureau of Standards sponsored study of *Metric America*. The conversion to the international system of units should consider relevant foreign experience. Options and alternatives for both public and private sectors should be considered in formulating a study plan.

6. Alternative Work Schedules

This assessment should not be limited to what sometimes is called the four-day work week or the European "flexi-time" and various schedules having to do with the arrangement of time over intervals of a week or two, but might very well include alternate work schedule concepts and proposals covering periods up to a year. The study should address the issue in terms of various labor categories, impacts on the economy, recreation, health, education, social effects, impact on productivity. The problems of alternative strategies for transitioning into viable alternatives should be considered. Occupations now on nonstandard work schedules may provide one base for extrapolation.

7. Alternative Strategies and Methods for Conserving Energy

This assessment should include a discussion and analysis of alternate methods, means, techniques for controlling and moderating the consumption of energy. Attention should be given to the relative feasibility and effectiveness of individual and combinations of methods implementable at Federal, State, and local levels as well as by various non-governmental bodies. This assessment should exclude automobile and related road vehicle energy consumption control strategies but include residential, commerce, industrial and other energy uses.

Alternative physical technologies should be considered for purposes of this study, as impacted by regulation, taxes, incentives, subsidies or other strategies and methods. Macro and micro economic consequences, impacts on work, leisure, life styles, institutions should be considered on a local, regional, and national basis as appropriate.

Proposal Format

Each proposal must be limited to a selected technology as listed in this Program Announcement. Respondents may submit more than one proposal. The proposals should contain the following elements as a minimum:

1. Cover Sheet (See Appendix A)
 2. Abstract (Not to exceed three pages)
 3. Narrative
 4. Budget/Cost Proposal
 5. Appendices, as appropriate
1. Cover Sheet. The cover sheet should be prepared in accordance with Appendix A.
 2. Abstract. At the beginning of each proposal there should be a concise abstract of no more than three single-spaced pages providing a synopsis of the study plan, the design for dissemination and utilization of results, the allocation of personnel on the study, the management plan, and any related programs or activities of the organization.
 3. Narrative.

The Narrative should address the items below which are common to many technology assessments. In addition, it should consider the unique features associated with specific technologies to be assessed as discussed previously.

- a. Study Plan: The proposers have the broadest latitude to define a work plan commensurate with the requirements of the technology assessment to include, but not necessarily limited to, the terms discussed below:
 - i. The proposal should exhibit a substantial detailed knowledge of the technology to be assessed and show how that will form the basis for the assessment.
 - ii. The proposal should demonstrate a working knowledge of the policy literature with regard to the technology to be studied, and relate that to the study plan.
 - iii. It is anticipated that proposers will show substantial experience in the area of policy studies and a demonstrable knowledge of technology assessment.
 - iv. The proposal should show how the study will systematically identify

parties at interest, that is those institutions, organizations, etc. in our society which have or should have a direct or indirect concern with the technologies at hand and their development and exploitation.

- v. The proposal should identify the potential users of the information generated by the study and show how their needs will be met.
- vi. A technology assessment is a policy-related study which, to a substantial degree, is an exercise in organizing certainty and uncertainty and defining the public policy options and alternatives which flow from those relative certainties and uncertainties. Consequently, it is considered important that the study team have an explicit awareness of the kinds of possible outcomes or action consequences of a successful technology assessment. It is anticipated that awareness of such kinds of outcomes will be significant in the organization of the study.

These outcomes include:

- Modifying the project or technology to reduce disbenefits or to increase benefits.
- Defining a monitoring or surveillance program with regard to the technology as it becomes operational.
- Stimulating R&D to:
 - a) Define risks more reliably;
 - b) Forestall anticipated negative effects;
 - c) Identify alternative methods of achieving the goal of the technology; and
 - d) Identify feasible corrective measures for negative effects.
- Identifying regulatory or other control needs.
- Encouraging the development of a technology into new areas to exploit anticipated benefits.
- Identifying needed institutional changes or innovation.

- Preventing a technology from developing (an unusual but not impossible outcome).
- vii. The technology assessment proposal is expected to display a methodology and strategy for the study which will be comprehensive in its identification and examination of direct and indirect impacts, or as sometimes referred to, higher-order effects, higher-order consequences, indirect effects, etc. At the same time it should give focus and saliency to central issues and consequences. A detailed methodology and strategy for the study is a minimum requirement in the proposal.
- viii. The assessment team is expected to build on prior research and bring to bear an appropriate range of synthetic analytical study techniques. This will not be a field research project, although visits to appropriate operating sites may be in order.
- xi. Complementary technologies to the technology being assessed, that is those technologies required to make a system work, should play an appropriate part in the assessment study.
- x. Effects should be explored not only in connection with the direct operating systems, but also with regard to the various ancillary and support activities associated with the development of the technology.
- xi. Consequences should be evaluated in quantitative terms wherever possible, however, the study should not be limited to those outcomes. Qualitative evaluation by alternate scaling techniques and so forth are encouraged where necessary and appropriate.
- xii. Where applicable, sensitivity analyses should be performed.
- xiii. Needs under P.L. 91-190 (NEPA) for the analysis of environmental impacts, on the project and program level, and the analyses of alternatives and resources, etc., should be considered against the background of present practices and likely developments in the preparation of environmental impact statements. This may not apply to all technologies.
- xiv. Alternatives to the technology being assessed should play an appropriate role in the assessment study plan.
- b. Design for Dissemination and Utilization of Results: The aim of these evaluations is to provide decision-makers, including research sponsors, with an improved base for alternative policy actions! The final product of the evaluation must be in a format readily interpretable and useable by decision-makers and the general public. The proposal should specifically address the design of the final product and how it will be disseminated. Innovative means of dissemination are encouraged, and these should be described and justified.
- c. Personnel: The proposal should briefly identify and describe the qualifications of the staff that will conduct the work. The principal investigator will be required to devote a substantial percentage of his time to this project. Full vitae should be included in the Appendices.
A list of consultants to be used in each phase of the study should be included with a statement of qualifications, vitae, and expected type of contribution.
- d. Management Plan: The management plan should include a schedule showing the necessary steps for achieving objectives. Estimates of time and costs to reach each step should also be included. It is essential that there be a single identified focus of responsibility and the proposal should identify the person who will be responsible for planning, coordinating, supervising, and integrating the work. A variety of collaborative arrangements can be utilized, e.g., university consortia or other combinations which may involve both nonprofit or profit-making organizations. In such cases, arrangements should be described for coordinating the proposed work. If the organization has not previously received NSF awards the plan should identify Government agencies with which it is currently dealing or has dealt and the cognizant Government audit agency, if any.

Proposals may be submitted for either of two levels of effort. One for in-depth comprehensive technology assessments anticipated to involve up to approximately sixty man-months of professional effort over a period of up to eighteen calendar months including a three-month period for sponsor review, evaluation and performer re-write.

The other will be for a group of preliminary comprehensive technology assessments anticipated to involve up to approximately eighteen man-months of professional effort over a period of twelve months including three months for sponsor review, evaluation and performer re-write.

At least 10 percent of the resources for the study is to be devoted to the revisions, modifications, and alterations as a result of the sponsors' review. The investigators will be expected to supply 25 copies for said review.

The study team will be expected to organize an independent oversight committee representing an appropriate spectrum of technically and professionally competent individuals. They are not expected to participate in the project but to serve as advisors and reviewers to the study group.

The investigators are expected to submit a phased program plan with definable checkpoints and milestones of progress, including two or three reviews (depending on whether it is a preliminary comprehensive or in-depth comprehensive assessment) by the National Science Foundation in the course of the study.

The services of a skilled writer in preparation of the final draft report is a mandatory requirement of this project.

- e. Related Programs and Activities of the Organization: Proposals should include a brief description of existing or planned research programs or other activities in the organization that parallel or lend strength to the proposed research effort. Related research, both within the organization and elsewhere should be briefly described. Where related efforts are known to be underway in other organizations, plans to coordinate with

other related research groups should be explicitly discussed. It is essential that duplication be avoided and that opportunities for collaboration and coordination be fully exploited.

4. Budget. The budget should be prepared in accordance with Appendix B or C. Awards may provide for full costs. Cost sharing or fees may be negotiated as appropriate.

Who May Submit

Proposals are invited from academic institutions and units of state and local governments, from non-academic non-profit or profit organizations, or from a combination of any such institutions or organizations.

METHOD OF AWARD

Proposals will be judged on a competitive basis. The best proposals will be selected. Only the highest quality proposals will be eligible for award. There is no commitment to the making of any particular number of awards. A panel review system including representatives from Federal agencies, or other government agencies, and from the academic and industrial research communities will be utilized as appropriate to assist in the evaluation of proposals. Final decisions will be the responsibility of the National Science Foundation.

The Foundation has made no prejudice as to the suitability of any area for treatment by either the preliminary comprehensive or the in-depth comprehensive approach. Each proposal will be evaluated on its merits and eligible for award on the basis outlined below.

Criteria of Evaluation

Proposals will be evaluated giving roughly equal weight to the categories A, B, and C below:

A. Understanding of the Problems Including:

- a) Concept of technology assessment
- b) The specific technology being assessed
- c) Socio-economic aspects
- d) Legal aspects
- e) Ecological aspects

B. Organizational Qualifications Including:

- a) Organizational resources, flexibility, experience
- b) Permanent staff qualifications
- c) Outside consultants and sources

- d) Plan for utilization and dissemination of results
- e) Management plan
- C. Approach to Specific Work Areas Including:
 - a) Methodology and/or strategy for the study
 - b) Benefit-cost analysis
 - c) Second and higher order impacts
 - d) Technological forecasts
 - e) Tangible and intangible benefits analysis
 - f) Tangible and intangible disbenefits analysis
 - g) Public policy analysis

The Foundation will select for award those proposals which offer the greatest total value. While the estimated cost will be considered in determining which proposal offers the greatest value, the primary bases for selection will be the review factors described above.

The Foundation reserves the right to make no awards in any selected area or multiple awards (at either level) in any selected area.

Background Literature Technology Assessment

(These documents are cited for reference only and are not available from the National Science Foundation)

The Assessment of Technology by Harvey Brooks and Raymond Bowers, *Scientific American*, February 1970, pp 131, vol 222, Number 2.

A Study of Technology Assessment, Report of the Committee on Public Engineering Policy, National Academy of Engineering, July 1969.

Program of Policy Studies in Science and Technology, George Washington University SDP06 *The Relationship of Technology Assessment to Environmental Management*, Louis H. Mayo, October 1969.

Technology Assessment for the Congress, Staff Study of the Subcommittee on Computer Services of the Committee on Rules and Administration United States Senate. Bibliographic Review of Technology Assessment (reprinted from *Technology Assessment*, Vol. 1, No. 1) Technology Assessment, by Genevieve J. Knez.

ADMINISTRATION

The award competition is administered by the Office of Exploratory Research and Problem Assessment of the Research Applications Directorate.

National Science Foundation
Washington, D.C. 20550

Due to considerations of equity, telephone calls and other contacts are discouraged.

MAILING INFORMATION

Formal proposals (20 copies) should be addressed to:

Central Processing Section, Room 223
National Science Foundation
1800 G Street, NW
Washington, D.C. 20550
Attn: Research Applied to National Needs
Program Announcement 73-8

Proposals must be received by 5:00 p.m. E.S.T., May 17, 1973.

Technology Assessment: The Benefits...the Costs...the Consequences, by Joseph F. Coates, *The Futurist*, December 1971.

Technology Assessment, Chemical and Engineering News, October 5, 1970 by David M. Kiefer, Senior Editor, Washington, D. C.

Technology Assessment: More Talk Than Action, Chemical and Engineering News, January 3, 1972, by David M. Kiefer.

Second-order consequences: a methodological essay on the impact of technology, by Raymond A. Bauer, Richard S. Rosenbloom, Laure Sharp, et al. Cambridge, Mass., MIT Press, 1969.

Technology and public policy: the process of technology assessment in the Federal Government, by Vary Taylor Coates. Program of Policy Studies in Science and Technology. The George Washington University, Washington, D.C., July 1972.

Technology assessment: Understanding the social consequences of technological applications, edited by Raphael G. Kasper, New York, N.Y., Praeger, 1972.

Perspectives on benefit-risk decision making, Report of a colloquium conducted by the Committee on Public Engineering Policy, National Academy of Engineering, April 267, 1971. Washington, D.C., The National Academy of Engineering, 1972.

APPENDIX A

SAMPLE PROPOSAL COVER SHEET

Research Proposal Submitted to the National Science Foundation 73-8

Research Applied to National Needs (RANN)

Name of Organization (including Branch title, if any)

Address of Organization

Title of Proposed Project

Amount Requested _____ Proposed Duration _____ Requested Starting Date _____

Name of PI _____

Social Security No. _____

Position and Title _____

Telephone (w/area code) _____

Other No. where message can be left _____

Department Affiliation _____

Address if different from above _____

ENDORSEMENTS

Principal Investigator

Department Head

Approving Administrative Official

Name _____

Signature _____

Title _____

Date _____

APPENDIX B
RANN PROPOSAL BUDGET

Budget Summary — Nonacademic Organization

A. SALARIES AND WAGES (Indicate time to be devoted to this project)

	<i>Man-months of effort</i>	\$	\$
1. Senior Staff	_____	_____	_____
2. Other Professional Staff or consultants	_____	_____	_____
Sub Total	_____		

B. CLERICAL-TECHNICAL STAFF. _____

C. STAFF BENEFITS (If Charged as Direct Costs) _____

D. TOTAL SALARIES, WAGES, AND STAFF BENEFITS _____

E. PERMANENT EQUIPMENT _____

F. EXPENDABLE EQUIPMENT AND SUPPLIES _____

G. TRAVEL

1. Domestic _____

2. Foreign _____

H. PUBLICATION COSTS _____

I. COMPUTER COSTS (If Charged as Direct Costs). _____

J. OTHER COSTS (e.g., Subcontracts, etc.—Itemize) _____

K. TOTAL DIRECT COSTS (B through I) _____

L. INDIRECT COSTS _____ % of _____ _____

M. TOTAL COSTS (J plus K) \$ _____ \$ _____

APPENDIX C

RANN PROPOSAL BUDGET

Budget Summary — Academic Institutions

A. SALARIES AND WAGES (Indicate time to be devoted to this project)

	<i>Man-months of effort</i>	<i>Requested From NSF</i>	<i>Total Project Costs</i>
1. Professional Personnel			
a. _____ Principal Investigator	_____	\$ _____	\$ _____
b. _____ Faculty Associates or consultants	_____	_____	_____
c. _____ Research Associates—Postdoctoral	_____	_____	_____
d. _____ Non-Faculty Professionals	_____	_____	_____
Subtotal	_____	_____	_____
2. Other Personnel (Non-Faculty)			
a. _____ Secretarial-Clerical	_____	_____	_____
b. _____ Technical, Shop, and Other (Specify)	_____	_____	_____
c. _____ Graduate Students	_____	_____	_____
d. _____ Pre-Baccalaureate Students	_____	_____	_____
Total	_____	_____	_____
B. STAFF BENEFITS (If Charged as Direct Costs)	_____	_____	_____
C. TOTAL SALARIES, WAGES, AND STAFF BENEFITS (A & B)	_____	_____	_____
D. PERMANENT EQUIPMENT	_____	_____	_____
E. EXPENDABLE EQUIPMENT AND SUPPLIES	_____	_____	_____
F. TRAVEL			
1. Domestic	_____	_____	_____
2. Foreign	_____	_____	_____
G. PUBLICATION COSTS	_____	_____	_____
H. COMPUTER COSTS (If Charged as Direct Costs)	_____	_____	_____
I. OTHER COSTS (e.g., Subcontracts, etc.—Itemize)	_____	_____	_____
J. TOTAL DIRECT COSTS (C through I)	_____	_____	_____
K. INDIRECT COSTS _____ % of _____	_____	_____	_____
L. TOTAL COSTS (J through K)	_____	_____	_____

Senator KENNEDY. Dr. Hornig is our next witness.

Senator PELL. It is a very great honor, which I appreciate, to welcome Dr. Hornig, a good friend, a distinguished academician, and president of Brown University, a wonderful university, one which we think in my State is unexcelled. We welcome you here, Dr. Hornig; we are glad you are with us this morning, and look forward to your testimony.

Senator KENNEDY. We join in welcoming you, Dr. Hornig. You have been kind and generous with your time on other occasions appearing before this committee. As Senator Pell has so well stated, you have had an extraordinary career, distinguished public service, in scientific affairs, as well as in community and civic affairs, and we are very much appreciative of your appearance here, and we will undoubtedly profit from your statements and comments. We welcome you. Proceed.

STATEMENT OF DR. DONALD F. HORNIG, PRESIDENT, BROWN UNIVERSITY

Dr. HORNIG. Thank you, Mr. Chairman. I will try to abbreviate my remarks somewhat, since you have the written text. It is my privilege to appear here today on behalf of the Association of American Universities and the National Association of State Universities and Land-Grant Colleges on the National Science Foundation authorization for fiscal year 1974. These two groups of universities are vitally concerned with graduate education and research. The nature and extent of this concern can be seen from the fact that about \$4 out of every \$5 of Federal support for academic science is expended in the laboratories of the 151-member institutions. They are also responsible for the training of about 4 out of every 5 Ph. D.'s in science and engineering.

This brings me directly to the first point which I wish to make. So far as I am aware, neither the executive branch nor Congress has considered the cumulative effect of proposed changes in Federal budgets and appropriations on the Nation's colleges and universities. Their capacity to do well what society needs from them and expects from them is a matter important to the Nation. I suggest that there should be both in the Congress and the executive branch an organized means for reviewing the effects of all Federal programs and activities on higher education. I believe that higher education is as significant an activity in our society as is science, and that the two are to a substantial extent intertwined. Accordingly, the attention paid to higher education as a totality ought to be no less than that paid to science and technology as a totality.

As a case in point, there is a widespread if not unanimous view among university presidents that a nearly impossible situation is generated for them in the coming fiscal year by the combined effects of separate actions taken without regard to their cumulative effects on colleges and universities. I know that this matter is not immediately before this committee, but it is one which I place before you with a sense of urgency. From our point of view, for example, it does not suffice to decide what the budget of NSF should be—important as that is—when we consider the impact of the Federal

Government on us. We have to take into account what happens to the budget of the National Institutes of Health, the National Institute of Mental Health, the Department of Defense, the National Foundation of the Arts and Humanities, the Office of Education, DOT, HUD, AEC, and others. Yet there is no effective forum in the executive branch or in Congress for discussion of these issues.

With that observation, I shall turn to the NSF authorization. I take it for granted that the effort of Congress to adopt its own strategy and priorities with respect to expenditure ceilings, revenue, and spending priorities will have an important effect on the NSF authorization and appropriation.

The universities are fully aware of the urgent need for Congress to take these steps if the traditional sharing of power and responsibility between the legislative and executive branches is not to be replaced by an unprecedented and unhealthy shift of authority to the executive branch.

Accordingly, the essential goals for fiscal year 1974 are to meet particularly urgent needs by moderate increases in specific areas and to insure a greater degree of stability and predictability in Federal expenditures.

There is one general point about the budget which impresses me, as I am sure is the case with the committee. That is, the total amount of money available to NSF in fiscal year 1974 would be \$641.5 million under the President's proposal. This is \$26.5 million above the \$615.0 million available in fiscal year 1973. But some sleight of hand is involved because the \$641.5 million includes \$59.8 million that was impounded in fiscal year 1973 and proposed to be released in fiscal year 1974. Therefore, the increase in fiscal year 1974 is brought about as a consequence of the impoundment in the preceding year.

With respect to urgent needs, we are concerned lest the erosion of support for basic research continue. In this connection, it is important to point out that Federal support for academic science will increase slightly in dollar terms in fiscal year 1974—to \$701 million from a level of \$692 million in the preceding year. This is actually a decline in real terms since the cost of doing research has increased more than the 1.3-percent increase in dollars.

Apart from the overall decline in real terms, there is a firm administration policy to aim Federal R. & D. funds toward targeted, defined objectives. This is the case with respect to research supported by the National Institutes of Health, where research funds for cancer and heart disease are increased and spent to a greater degree on defined objectives. Research expenditures for all other disease categories are decreased in the President's budget. The President has proposed an increase from \$261 million to \$275 million. The \$14 million increase amounts to slightly more than 5 percent—or somewhat less than the increase in the cost of doing research.

The same trends are evident in the President's proposal for NSF. The program of research applied to national needs (RANN) is proposed at a level of \$79.2 million in fiscal year 1974, a 13-percent increase over 1973. In contrast, only a 5-percent increase is proposed for scientific research project support.

The idea of directing research purposefully toward the solution of selected practical problems has real merit, but balance is required.

With the trend throughout the Government toward support of more narrowly targeted research, there is a danger that the Nation will be shortchanged over the long run. We must sustain a vigorous base of basic research from which will be derived the unforeseen solutions to both foreseen and unforeseen problems of the future. This committee has expressed this view forcibly.

Accordingly, we urge as a prudent investment an increase in the authorization for scientific research project support from \$285 million to \$300 million, without decreasing other items in the NSF budget.

The administration takes a hard line against provision of general support to colleges and universities not only in the NSF budget, but throughout the total Federal budget. I do not wish to argue the entire matter of institutional support here, but I would like to explain why institutional support is important in the context of the NSF program.

NSF operates largely on the basis of defined projects. The project is a highly efficient way for the Federal Government to support science in universities. It reconciles the legitimate needs of the Government, academic scientists, and the universities. It also provides a builtin system of quality control.

However, the system is not by itself a fully satisfactory support system. No matter what the size of the grant or contract, the money is for a restricted purpose. This is both proper and necessary, but the weakness of a system based solely on projects is inflexibility. There are always unforeseen expenses, difficulties and emergencies that cannot be met out of restricted funds. Institutional funds uncommitted to any specific project are invaluable in this circumstance. They give younger investigators a chance. They prevent shutdowns when equipment parts must be replaced quickly. They permit exploration of lines of investigation that require small quick investments.

Senator KENNEDY. Tell us about your younger investigators, what you mean by this.

Dr. HORNIG. What I mean is this; a man begins his career with no reputation or record of achievement. In the normal course of events, he begins by writing proposals to Government agencies, NSF in particular. At that point all you know is that he has some very good ideas on which he could begin to work. At best, 6 months or a year later, his proposal is acted on and he has funds, a project grant, to support his work. At worst, having no reputation established he may not receive anything at all, even though people locally may say he is a good man to bet on. We have used very small amounts of institutional grants for in such a circumstance to get the young man going. This gets work going on the basis of what is known at the local level. He then demonstrates what he can do so when he makes proposals, he not only says, "I have a good idea, but also I am making some progress on it."

This increases the efficiency of the whole system. We have also used the institutional grant in another way. At times when a grant is on its way through the mill, and we know it is very good, and going to be granted when it may be desirable to make commitments to people in advance before you have the money, if they are to be on hand when the grant starts. How if you can turn to an institutional grant for this purpose, it serves its purpose even if the money is not spent, because often the project grant has come through before

the man comes on the scene. It is these little elements of flexibility which are important. It has not been much money.

My university has had a maximum of a little over \$100,000 of this institutional money. Last year it was \$37,000. This proves to be extremely valuable money, but I want to emphasize that it is just a few percent of the total government bill. That is being eliminated now, and I think that is a mistake.

Another item where additional funds are required in the NSF budget is funds for the training of graduate students. As a nation we need to insure that the best minds of the country have an opportunity to pursue advanced training—

Senator KENNEDY. How do you respond to Dr. Stever's contention that the graduate students are being plugged into various other research programs which take the place of NSF support for science education?

Dr. HORNIG. In part that is true, thank God. We have a graduate student support crisis in every university I know, and the support that is left is entirely the support through the research program. It does not take care of enough of the graduate students. It is a perfectly proper point as far as I know.

Senator KENNEDY. Do you think, given limited opportunities available for graduate students in those areas, that we are going to end up with a shortage of trained and skilled manpower?

Dr. HORNIG. I think there are two points. In some areas such as engineering, it is becoming plain that the shortage of jobs is not nearly as great as has been thought a year or two ago; in fact, there may be no shortage of jobs at all. It begins to look as though there may be a shortage of people rather than a shortage of jobs, because the situation has turned around.

There can be both unemployment and a shortage of people, in part because the older people who are laid off are not strictly comparable to younger people. I am one of these displaced scientists and the thought of retraining me to compete with the 25-year-olds would not work. I would not have a chance. I think I would bring to some kinds of jobs elements of experience that they could not, but in terms of sheer brightness and quickness and imagination, they would beat me hands down.

I am afraid that is true of a majority of the 50-year-old scientists. That is why they and the young people compete for different jobs. The young people are the ones that are at the forefront of their fields, and bring in the very newest ideas and techniques into an organization. We are going to need them, even if we have not been able to assimilate all of our older people.

Second, you know, even if there is a surplus, the country still requires getting the best people into science. This is what makes our industry competitive for the future, so we have to find some way of getting the very best people in, at the same time that we try to discourage total numbers from exceeding the requirements.

It is for these reasons that I believe budget recommendations for graduate student support are inadequate. The President proposes to phase out graduate fellowship program and to eliminate entirely the traineeship program.

Last year Congress mandated not less than \$20 million for graduate student support, with an additional \$9½ million which had been im-

pounded the previous year to be used for first-year trainingships. The administration only spent \$14 million of this mandated \$29½ million. We urge that the Congress mandate for fiscal 1974 the same level of \$20 million which Congress mandated for fiscal 1973, which would be approximately double the President's budget. To do less, we believe, would seriously endanger the flow of one of our country's most productive resources, its potential young scientists and engineers.

In summary, we suggest that the NSF authorization make provision for \$300 million in scientific research projects, \$12 million in institutional support grants, and \$20 million for support of graduate training activities and that the programs be financed at these levels by adding funds and not financed at the expense of other programs.

These suggestions are made solely on the basis of what appear to be urgent needs without regard to the politics and high finance surrounding the possibility of a veto and impoundment.

I do want to say one word about impoundment though. Without pretending to have mastered the complexity of the appropriation and impoundment and expenditure patterns as they apply to NSF, some fundamentals seem clear. One is that if the President has an unlimited right not only to impound funds but to select the areas of impoundment, the traditional pattern of executive-legislative balance will have been drastically altered, if not destroyed. Impoundment of appropriated funds may be necessary in the future if the Congress cannot establish reasonable limits on appropriations in relation to the income of the Federal Government. It seems important though that this impounding of funds for fiscal reasons not be simultaneously a device for the drastic realtering of congressional priorities as expressed in authorization and appropriation acts.

Accordingly we favor measures in authorizing legislation and appropriation acts which would forestall the undue concentration of impoundment on programs selected for cutting by the President. This is technically a complicated matter to work out so that unanticipated adverse effects are not produced. However, the principle seems to me to be so sound that the effort should be made to evolve a sound and workable formula that would put it into effect.

In conclusion, Mr. Chairman, I wish to make the obvious point that this testimony comes necessarily but awkwardly at a time when major decisions which will probably effect the funding of NSF remain to be made. The universities which I represent are firm advocates of the view that science and technology are indispensable to the solution of many of the most serious problems facing the Nation. High priority in my judgment should be given to efforts to lift the quality of our scientists and engineers, to make our research and development programs excellent and responsive to social needs and to expand our foundation of basic science. We hope that a revision of national priorities will make possible all of these things, and on a scale now not attainable because of what we consider to be poorly adjusted priorities. If I were testifying at a time when a really meaningful reallocation of resources were solidly in prospect, our plea would be for markedly greater funds for the National Science Foundation.

Thank you for the opportunity to express these views. It is always a pleasure to appear before this committee, and I look forward to a discussion of the issues that have been raised.

Senator KENNEDY. Thank you very much. It is a very comprehensive and all-encompassing statement. I am sure you are very much aware of the very significant cuts that have taken place in science education generally over the past few years. I think that this has been enormously distressing; I think you have made the case very well in your statement. There is just one additional area that I wanted to gain your insight on, and that is in the President's abolition of the White House Office of Science and Technology. Can you tell us what impact that will have on the Nation's scientific enterprise?

Dr. HORNIG. You must appreciate I have a personal stake in that since I was once Director of that Office. I was very saddened by it. There were really two functions to that Office that require separate answers. One was the role as President's science adviser, providing an advisory mechanism to the President. The other was its role as coordinator of Federal activities. As far as the first role is concerned, I suppose that nothing is sadder than an adviser whose advice is not wanted.

It is very hard to say the President should have an adviser if he does not want an adviser.

Senator KENNEDY. I think he has gotten rid of the wrong advisers recently.

Dr. HORNIG. I think this is too bad, because there are plenty of sources of economic advice, there are plenty of sources of legal advice, so the President is not at the mercy of agencies with vested interests. But normally at the White House, if there is no science adviser, there is nobody with a background of understanding of technical and scientific things. There is nobody to tell the President what the hard questions he ought to ask the agencies such as DOD are, or tell the President that there may be alternative approaches to disarmament problems or seabed problems, or atmospheric problems. There is no one to go out and get some advice to suggest sometimes that maybe the wool is being pulled over his eyes by agencies, deliberately or not deliberately. So I think the science adviser will be missed.

The job of coordinating the widespread scientific activities of the Government, I think, is most appropriately done in the Executive Office. I am sure that Dr. Stever will do his very best and organize this as well as possible, but it strikes me as being very difficult for any one agency, which is on a level with all the other agencies, many of which have larger activities, to be the coordinating agency.

It seems to me that the Executive Office was the right place. Whether the coordination should necessarily be in OST or perhaps in the Office of Management and Budget, that is open to question. I think it must be in the Executive Office to have enough authority.

Senator KENNEDY. Senator Pell.

Senator PELL. Thank you, Mr. Chairman.

I am thinking—I have an amendment to the State Department authorization bill that would combine international ocean affairs and international environment activities into a statutory office, headed up by an assistant secretary. I am debating in my own mind whether we ought to include the Office of State Department Science and Technology in that. I realize this is a little bit far afield from the subject before us but what would be your reaction to this idea of setting up within the Department of State one bureau for oceans, environment, scientific affairs?

Dr. HORNIG. Let me say right off, I have not tried to think this through, but there has been a science office in State.

Senator PELL. I am trying to raise it to a higher level.

Dr. HORNIG. All of us felt this level ought to be on the level of an assistant secretary. Superficially, I would say the proposal you made sounds like a very good one.

Senator PELL. I was much struck with the point you made that there is no real central office analyzing the cumulative effect of all the budget cuts, of all the different agencies of the Government upon graduate education. I think you are absolutely right. I guess the closest we come to that overall assessment is here in the Congress. I see the problem as chairman of the education subcommittee—we are faced with a real problem—and I am a layman myself, with some other responsibilities—and I have exactly two men to help me to do all the ongoing legislative work in education. We have not yet been able to get any adequate computer capability in the Senate. How do you feel that we could best achieve an overall view of the effects on education of the different agencies' cuts.

How could this be attained? I do not think it should be done within the executive branch, because that is, to quote another politician, like putting the fox in the hencoop, because statistics will be altered. But where do you think it should be done?

Dr. HORNIG. I like to believe that when we tried to do that, when I was in the executive branch, we did it with reasonable objectivity.

Senator PELL. Recently we have seen when they do not like statistics, they fire the statistician. This happened on the domestic side a few years ago in regard to labor statistics. I hope there is no element of this in the CIA overhaul. I think it should be done outside or objectively. Why would not a great university like yours be able to make a project—

Dr. HORNIG. If someone could fund it, I suppose it could be done.

Senator PELL. Would it not be excellent Ph. D. research?

Dr. HORNIG. This is a continuing problem. Congress has to have it every year, not just 1 year. You need it month by month at this season of the year.

Senator PELL. We really need it. I see in my work that it is difficult to determine the general impact. I just know that the state of graduate education is sharply declining. I do not know the full extent or impact. It would be of great help to us in Congress.

Dr. HORNIG. It seems to me if one seriously has to worry that the executive branch of Government cannot be trusted to honestly assemble data, we are really in a terrible state. I would say the answer is not to say we have to construct an independent government outside the Government; we really ought to straighten out our agencies and our executive branch if that is necessary, so that the Congress—

Senator KENNEDY. Do you have any ideas?

Senator PELL. I know in education, when we want to get statistics, and the statistics support us, we do not get the figures from the executive branch until it is too late. If the statistics support the administration's view, we get them very quickly. There is a certain reluctance to give us figures that conflict with the executive's wishes. It is a fact of life. I think it existed a certain amount in previous administrations too, particularly in education, where we found tremendous problems getting figures if they did not support the views of the executive branch.

Dr. HORNIG. One final comment, I think it is more appropriate that instead of a university it might be one of the educational organizations like the American counsel on education. The problem of getting the data for any outside organization would be there too, because the problem you mentioned now simply reflects itself to each of the various agencies. It is very hard, I think, for outside organizations to act very promptly.

Senator PELL. Thank you very much.

Senator KENNEDY. Thank you very much. We appreciate very much your statement.

[The prepared statement of Donald F. Hornig subsequently supplied for the record follows:]

Statement

Before the

Special Subcommittee on the National Science Foundation

of the

Committee on Labor and Public Welfare

Senate

on

Thursday, May 3, 1973

on behalf of

the Association of American Universities and the
National Association of State Universities and
Land-Grant Colleges

by

Donald F. Hornig

President, Brown University

Statement by Dr. Donald F. Hornig, President, Brown University
to the Special Subcommittee on the National Science Foundation
of the Senate Committee on Labor and Public Welfare
on the F.Y. 1974 Authorization for the National Science Foundation
on behalf of the Association of American Universities
and the National Association of State Universities and Land-Grant Colleges
May 3, 1973

Mr. Chairman and members of the Committee:

I am Donald F. Hornig, and I am President of Brown University. In earlier years, I have worked in industry, in universities and in the Federal government. Each of these vantage points has, I believe, provided a useful point of view on the relationships between science and technology and the Federal government.

It is my privilege to appear today on behalf of the Association of American Universities and the National Association of State Universities and Land-Grant Colleges on the National Science Foundation authorization for fiscal year 1974. These two groups of universities are vitally concerned with graduate education and research. The nature and extent of this concern can be seen from the fact that about four out of every five dollars of Federal support for academic science is expended in the laboratories of the 151 member institutions. They are also responsible for the training of about four out of every five Ph.D.'s in science and engineering.

Uncoordinated Federal Budgets

This brings me directly to the first point which I wish to make. So far as I am aware, neither the executive branch nor congress has considered

the cumulative effect of proposed changes in Federal budgets and appropriations on the Nation's colleges and universities. Their capacity to do well what society needs from them and expects from them is a matter important to the Nation. I suggest that there should be both in the Congress and the Executive Branch an organized means for reviewing the effects of all Federal programs and activities on higher education. I believe that higher education is as significant an activity in our society as is science, and that the two are to a substantial extent intertwined. Accordingly, the attention paid to higher education as a totality ought to be no less than that paid to science and technology as a totality.

As a case in point, there is a widespread if not unanimous view among university presidents that a nearly impossible situation is generated for them in the coming fiscal year by the combined effects of separate actions taken without regard to their cumulative effects on colleges and universities. I know that this matter is not immediately before this Committee, but it is one which I place before you with a sense of urgency. From our point of view, for example, it does not suffice to decide what the budget of N.S.F. should be -- important as that is -- when we consider the impact of the Federal government on us. We have to take into account what happens to the budget of the National Institutes of Health, the National Institute of Mental Health, the Department of Defense, the National Foundation for the Arts and Humanities, the Office of Education, DOT, HUD, AEC and others. Yet there is no effective forum in the Executive Branch or in Congress for discussion of these issues.

Significance of Congressional Ceilings and Priorities

With that observation, I shall turn to the N.S.F. authorization. I take it for granted that the effort of Congress to adopt its own strategy and priorities with respect to expenditure ceilings, revenue, and spending priorities will have an important effect on the N.S.F. authorization and appropriation.

The universities are fully aware of the urgent need for Congress to take these steps if the traditional sharing of power and responsibility between the legislative and executive branches is not to be replaced by an unprecedented and unhealthy shift of authority to the executive branch.

Accordingly, the essential goals for fiscal year 1974 are to meet particularly urgent needs by moderate increases in specific areas and to ensure a greater degree of stability and predictability in Federal expenditures.

There is one general point about the budget which impresses me, as I am sure is the case with the Committee. That is, the increase in the total amount of money available to NSF in F.Y. '74 would be \$641.5 million under the President's proposal. This is \$26.5 million above the \$615.0 million available in F.Y. '73. But some sleight of hand is involved because the \$641.5 million includes \$59.8 million that was impounded in F.Y. '73 and proposed to be released in F.Y. '74. Therefore, the increase in F.Y. '74 is brought about as a consequence of the impoundment in the preceding year.

Increased Support for Basic Research

With respect to urgent needs, we are concerned lest the erosion of support for basic research continue. In this connection, it is important to point out that Federal support for academic science will increase slightly in dollar terms in fiscal year 1974 -- to \$701 million from a level of \$692 million in the preceding year. This is actually a decline in real terms since the cost of doing research has increased more than the 1.3 percent increase in dollars.

Apart from the overall decline in real terms, there is a firm administration policy to aim Federal R & D funds towards targeted, defined objectives. This is the case with respect to research supported by the National Institutes

of Health, where research funds for cancer and heart disease are increased and spent to a greater degree on defined objectives. Research expenditures for all other disease categories are decreased in the President's budget. The President has proposed an increase from \$261 million to \$275 million. The \$14 million increase amounts to slightly more than 5 percent -- or somewhat less than the increase in the cost of doing research.

The same trends are evident in the President's proposal for N.S.F. The program of research applied to National needs (RANN) is proposed at a level of \$79.2 million in fiscal year 1974, a 13 percent increase over 1973. In contrast, only a 5 percent increase is proposed for scientific research project support.

The idea of directing research purposefully towards the solution of selected practical problems has real merit, but balance is required. With the trend throughout the government towards support of more narrowly targeted research, there is a danger that the nation will be short-changed over the long run. We must sustain a vigorous base of basic research from which will be derived the unforeseen solutions to both foreseen and unforeseen problems of the future. This Committee has expressed this view forcibly.

Accordingly, we urge as a prudent investment an increase in the authorization for scientific research project support from \$275 million to \$300 million, without decreasing other items in the N.S.F. budget.

Institutional Support

The Administration takes a hard line against provision of general support to colleges and universities not only in the N.S.F. budget, but throughout the total Federal budget. I do not wish to argue the entire matter of institutional support here, but I would like to explain why institutional support is important in the context of the N.S.F. program.

N.S.F. operates largely on the basis of defined projects. The project

system is a highly efficient way for the Federal government to support science in universities. It reconciles the legitimate needs of the government, academic scientists, and the universities. It also provides a built-in system of quality control.

However, the system is not by itself a fully satisfactory support system. No matter what the size of the grant or contract, the money is for a restricted purpose. This is both proper and necessary, but the weakness of a system based solely on projects is inflexibility. There are always unforeseen expenses, difficulties and emergencies that cannot be met out of restricted funds. Institutional funds uncommitted to any specific project are invaluable in this circumstance. They give younger investigators a chance. They prevent shutdowns when equipment parts must be replaced quickly. They permit exploration of lines of investigation that require small, quick investments.

I am confident that there would be virtually unanimous agreement among investigators, laboratory directors and department heads that no money is as useful in elevating the scientific productivity of a laboratory as is an unrestricted institutional grant.

For these reasons, we fail to understand the philosophy which is leading to the termination of this type of support for science. In the case of N.S.F., the institutional grant for science was \$12 million in F.Y. '72 and is proposed at a level of \$6 million in F.Y. '74. Maintenance of the 1972 level of \$12 million for this program is an urgent matter.

Support of Graduate Students

I would like to turn now to a third area where additional funds are required in the N.S.F. budget -- funds for the training of graduate students. This divides into two parts. First, as a Nation we need to ensure that the best minds of the Nation have an opportunity to pursue advanced training at the graduate level. This should be done, in my judgment, without regard

to academic field, although we are here discussing scientists (including social scientists) and engineers. We should not be diverted from this goal and this need by the current condition of the labor market. When the talents of these people are needed, they must be in place, because the lead time for their training ranges from three to seven years.

Second, there are more precise demands for highly-trained manpower that will be increasingly generated by the activities of the National Science Foundation itself. I refer to the training of persons specifically for 10 areas of high priority identified by N.S.F. -- energy research and technology, disaster and national hazard research, technological opportunities, regional environmental systems, weather modification, environmental aspects of trace elements, municipal systems and services, human resources and services, social data processing and evaluation, and exploratory research to identify emerging national needs. The cadres of people required for effective research in these areas cannot be trained entirely in the traditional disciplines. Some of them will have to be educated to take a problem rather than a discipline approach. They will have to be trained to work with others from different backgrounds. A serious effort to turn science and technology to the solution of pressing economic and social programs will involve an equally serious approach to drawing some of the best younger minds into these fields and to giving them the requisite new mix of professional skills and attitudes.

An effective program would encompass not only provision of fellowship and traineeship support for graduate students, but support for development of new curricula, for training devices, materials and experiences, for joint faculty participation and for space renovation. In short, a new training grant on the N.I.H. model would be useful to attain the objectives sought in the RANN program.

These training activities are suggested not to expand the pool of trained manpower in general, but to attract selected students of high competence into rigorous training programs to prepare them to work on the solution of problems selected as particularly serious by the Administration. I am not competent to advise on whether such training activities should be a part of the RANN and other goal-oriented programs, or whether the training activities should be in the graduate student support program of N.S.F.

Since the N.S.F. budget as proposed by the President is tight, with little or no leeway for introducing programs not already provided for in the budget, it is necessary to add funds for support of graduate students. In relation to the two areas of need that I have identified, we strongly feel that the budget recommendations for graduate-student support are inadequate. As you know, the President proposes to phase out the graduate fellowship program and to eliminate entirely the traineeship program. Last year the Congress mandated not less than \$20 million to be spent for graduate-student support, with an additional \$9.5 million impounded from the previous year to be used for first-year traineeships. The Administration, however, spent only \$14 million of the mandated \$29.5 million for the fellowship and traineeship programs. We urge that the Congress mandate for fiscal year 1973 the same level of \$20 million mandated for fiscal year 1973 -- or \$11.8 million above the \$9.2 level in the President's budget. To do less, we believe, would seriously endanger the flow of one of our country's most productive resources -- its potential young scientists and engineers.

In summary, we suggest that the N.S.F. authorization make provision for \$300 million in scientific research projects, \$12 million in institutional support grants, \$20 million for support of graduate training activities and that the programs be financed at these levels by adding funds and not financed

at the expense of other programs. These suggestions are made solely on the basis of what appear to be urgent needs, without regard to the politics and high finance surrounding the possibility of a veto and impoundment.

Impoundment

After the authorization and appropriation process has been completed, there remains the possibility of a veto if Congress appropriates more than the President requests, and of impoundment either on fiscal grounds or to revise priorities.

Without pretending to have mastered the full complexity of the appropriation, impoundment and expenditure patterns of N.S.F. funding for fiscal year 1973, some fundamentals seem clear. One is that if the President has an unlimited right not only to impound funds but to select the areas of impoundment, the traditional pattern of executive-legislative balance in determining priorities will have been drastically altered if not destroyed. Impoundment of appropriated funds may be necessary in the future if the Congress cannot establish reasonable limits on appropriations in relation to the income of the Federal government. However, it is important that this impounding of funds for fiscal reasons not be simultaneously a device for drastic realtering of Congressional priorities as expressed in authorization and appropriation acts.

Accordingly, we would favor measures in authorizing legislation and appropriation acts which would forestall the undue concentration of impoundment on programs selected for cutting by the President. This is technically a complicated matter to work out so that unanticipated adverse effects are not produced. However, the principle seems to me to be so sound that the effort should be made to evolve a sound and workable formula that would put it into effect.

Conclusion

In conclusion, Mr. Chairman, I wish to make the obvious point that this testimony comes necessarily but awkwardly at a time when major decisions which will probably affect the funding of N.S.F. remain to be made. The universities which I represent are firm advocates of the view that science and technology are indispensable to the solution of many of the most serious problems facing the Nation. High priority in my judgment should be given to efforts to lift the quality of our scientists and engineers, to make our research and development programs excellent and responsive to social needs and to expand our foundation of basic science. We hope that a revision of national priorities will make possible all of these things, and on a scale now not attainable because of what we consider to be poorly adjusted priorities. If I were testifying at a time when a really meaningful reallocation of resources were solidly in prospect, our plea would be for markedly greater funds for the National Science Foundation.

Thank you for the opportunity to express these views. It is always a pleasure to appear before this Committee, and I look forward to a discussion of the issues that have been raised.

Senator KENNEDY. Our next witness is Dr. Philip Handler, president of the National Academy of Sciences, distinguished biochemist, science education scholar, who served on many advisory panels, including the President's Science Advisory Committee, who has served as chairman of the National Science Board, who has recently been instrumental in reconstructing the National Research Council and making it more responsive to national needs.

He has appeared here many times before, and we look forward to his testimony.

STATEMENT OF DR. PHILIP HANDLER, PRESIDENT, NATIONAL ACADEMY OF SCIENCES

Dr. HANDLER. Thank you very much. I take it the time is limited. Accordingly I would like to submit my statement for the record.

Senator KENNEDY. We will print it in its entirety at the conclusion of your testimony.

Dr. HANDLER. Much of what I would like to say has already been said. I will try to compress it into a series of remarks. I start with the assertion that the American scientific enterprise is just hugely successful, across all disciplines; in every field of research, American science is either at the top or very close to worldwide leadership.

The most striking illustration of that fact was this year's clean sweep of the Nobel prizes in chemistry, physics, medicine and economics. There is one item concerning those prizes that I would like to insert in the record. Dr. John Bardeen of Illinois who already had a Nobel prize, for his contribution to transistors, received a second for his contributions to our understanding of superconductivity. Earlier today, one witness indicated that this understanding of superconductivity, may assist in diminishing power requirements in the future, because by magnetohydrodynamics, electricity may be both generated and transmitted more efficiently.

Dr. Bardeen did a remarkable thing. He turned over his share of that Nobel prize to Duke University, to the Fritz London Memorial Fund. Fritz London, one of the gifts to the United States by Adolf Hitler, had worked at Duke University much earlier in this same field. Although he laid the foundations, he had gone largely unrecognized. Dr. Bardeen, in his remarkable, magnanimous action, personally recognized the contribution of Dr. London, to bring this to the world's attention.

I bring this matter up in this context, because through the morning we have heard repeated queries concerning the immediate problems of American society and how our technology might help in the alleviation of those problems.

One well understands why it is that members of the Senate raise such questions, that is their quite proper function and duty. The problem that arises is that when such questions are pushed to the extreme, they may wind up by distorting the American scientific enterprise, if one is not careful to guard against it.

The entire array of scientific applications and technologies finds its origins in the science that has already been done. The Science Foundation has recently commissioned a second study which traces a series of technologies to their original scientific origins. The point about that is very simple. Those who want the end-use product would never

have been able to develop it themselves. Those engineers, out there digging subway tunnels under the Potomac, who want to assure the alinement of that tunnel, could not conceivably have imagined, that what they need is a laser until lasers became available. Moreover, if they ever had thought of the desirability of such an instrument, they would not have had any idea as to how to go about building one. That is the history of the entire science-technology process.

If each new technology is traced to its origin, it is quite clear that those who started down the early scientific trail did not know to what technology it was leading; those at the end know where the real beginning was only in retrospect. That is one of the principal reasons for societal support of this great array of basic science, and I trust that the endeavor will not be distorted by overemphasis on end uses. It is already being distorted in some part.

Some years ago it was estimated that the forces operative within the totality of the scientific endeavor were tending to increase annual expenditures on science at a rate of about 12 to 15 percent per year. In addition to general inflation, those forces were the increasing supply of scientists, about 8 percent per year, and the increasing costs of the instrumentation required, as instrumentation becomes more sophisticated and more sensitive. I am not plugging for continual growth of the science budget at 12 to 15 percent per year. My point is that those pressures have been with us, unsatisfied, since fiscal 1967. Those pressures have been going on ever since, and that great scientific establishment is now in trouble.

We do not have one NSF in the U.S. Government. We have a series of NSF's. We have had one in ARPA, one in the Army, in the Navy, one in NASA, one in the National Institutes of Health, and so forth. Each of those has had narrower purview than the Science Foundation, but they contributed to the totality, and, until recently, they were, in fact, the major supporters. Those of us who applauded the idea of multiplicity of supporting agencies, as I did then and do now, nevertheless were always concerned that if times were to become tight, then the pressures would be such that, in each agency and in the OMB, there would be a tendency to protect the mission capability. The "squeezable" item would be the support of basic science. And that has happened. We have witnessed this for 6 or 7 years.

We have witnessed "dropouts," as they have come to be called, entire laboratories which have lost their support, in nuclear structure physics, in radio astronomy, in materials science and in a variety of other disciplines. The AEC is finding it increasingly difficult to contribute its support to nuclear physics. The Navy is no longer the principal supporter of academic oceanography as Senator Pell has noted. The NIH was forced to discontinue support of research in organic chemistry and in photosynthesis.

This year we are going to have one more dropout, Senator; this year it is going to be in the biomedical area. When the war on cancer was being urged, there were those of us who were concerned that if that "war" was not managed properly it would squeeze out the funds for basic biomedical research. From what I understand of the budget request for NIH for fiscal 1974, that is precisely now what is in the offing. The amount of money in the competitive pool for biomedical research in the budget of the National Cancer Institute will be reduced by about one-third. In the budget request for the National Institute

of General Medical Sciences, the funds available for the open competition for new grants or competitive renewals decreases from \$28 million in fiscal year 1972 to \$5 million in fiscal year 1974.

Again, as a result of the emphasis on mission research in the hope of near term payoff, that research which is most eligible for support by the National Science Foundation tends to be dropped by other agencies. Across every area of science, this same phenomenon has been occurring. The result is that the scientific endeavor in the United States is in increasing difficulty. Our scientists are beginning to devote their thought as much to how, financially, to support their research, as they are to science itself, and that is a ghastly mistake.

Some disciplines are in somewhat better shape than others. The atmospheric sciences, for example, look as if they are doing rather well. In nuclear structure physics, all but one of the important new capabilities have now been built abroad. In radio astronomy, until we get the very large array, the same thing will be true, the important new instrumental facilities are all abroad. Those are sciences which are entirely dependent upon instruments, just as oceanography requires those vessels.

The other point I would like to emphasize is that the science endeavor occurs at universities. History does not record that as an overt, simple decision, a moment when it was agreed that, from here on out let us in the United States use the universities as the principal base for scientific endeavor. Other nations have not done it so. The Soviet Union uses separate research institutes, Germany uses the Max Planck Institute arrangement. We did it in the universities; three-fourths of our fundamental research is performed on campus. It was a great idea. It has paid off marvelously. We coupled the wisdom, insight, experience of older investigators with the drive, the energy, the brightness, and enthusiasm of all those young people of whom Dr. Hornig was speaking of a moment ago. It has paid off marvelously, handsomely. Those young people are the labor force of the scientific enterprise. We do not use technicians on a large scale for so doing. Those young graduate students and postdoctoral fellows are the bulk of the basic research labor force.

Now we find that part of the system is in trouble. The administration has explicitly denied that it is a Federal responsibility to support graduate students or postdoctoral fellows, for the sake of their own personal education. That is a matter of philosophy. The elimination of training grants and reduction in fellowships was not undertaken as for fiscal expediency. But that group, the investigators of tomorrow and the unique labor force of today, requires support from some source. The reply we heard this morning was that we will try to support them from research grants. Except, perhaps, for the first year of graduate school, that is great—providing research grants are there and in sufficient amount. That does not appear to be the case at the present time.

Secondly, we have witnessed a phenomenon which has raised a kind of political problem which is really to be solved here in the Congress, rather than by scientists. That is the fact that, as a result of current policy, while first-year graduate registrations in the sciences have been falling in the first-rank universities, they have been rising in those of the second rank.

There has been a net dropoff in first-year graduate registrations in the physical sciences in those institutions which in the past have been the most productive, compensated in part at institutions of the second rank. That poses a political dilemma which is self-evident and I will not embroider it beyond that fact. How to cope with it is not very simple. Gross registrations of new graduate students are declining in the physical sciences, those are down about 17 percent in 2 years and by 30 percent in physics itself. That is not true in biology. The decline is at about half that rate, in engineering.

My own feeling about this situation is very much like that which Dr. Hornig stated. In the future we are going to need those individuals and we will not have a surplus of scientists, but will instead have a scientist deficit. How large I cannot really state. Dr. Hornig has summarized the institutional problems and I shall not repeat those. Thus, we have the problems of graduate students, of science itself, and of the institutions in which science is done.

The principal point raised here this morning is that every one of these problems comes home to roost in the National Science Foundation. Whenever, for fiscal reasons, there is a dropout from any one of the other agencies which serve as if they are smaller national science foundations, every one of those investigators, regardless of discipline, turns to the Science Foundation for help. Decreasingly is it possible to provide that help? There were arrangements whereby specific major dropouts were picked up by the Science Foundation; the Office of Science and Technology at the time, together with the Director of the Foundation, and the OMB made such arrangements. However, each such laboratory was then funded at a lower rate than it had known before; but not even that much money had been transferred and that put a squeeze on the amount of money available for the rest of science funding at NSF. That was particularly true in the case of small laboratories, because no special provisions were made for them. They were simply cast adrift and they entered the general pool of competition of the Science Foundation.

Thus a combination of circumstances, in concert, have made life very difficult for those who must manage the budget of the National Science Foundation: pressures for solutions to short term problems, which we see in all agencies the influence of the Congress in requesting that the Department of Defense minimize the extent to which it supports research relatively remote from its mission, and changing policy with respect to student, fellowship, and institutional support. Bluntly, the NSF does not have enough money for its tasks. The questions directed to Dr. Owen this morning could as well have been directed to every one of the other program directors, I except that we would have had the same sort of answers, given in all honesty and good faith. But they cannot manage with the amount of money that they have and support the very best of American science as far as I can see. Thank you, Mr. Chairman.

Senator KENNEDY. Very good. Very excellent statement.

I am interested in the comments in your statement, where you talk about the general underinvestment in science over the period of the last 6 years.

Recent studies have shown U.S. underinvestment in civilian technology, relative to Western Europe and Japan, and that they are reaping the benefits of this in increased productivity and the growth

of their economies. Do you think our underinvestment in basis research will result in similar harm to the United States over the long run?

Dr. HANDLER. Quite conceivably. You cannot have a categorical answer to that obviously, but quite conceivably we can only assume that history projected into tomorrow will indicate that many problems will find solutions generated in the science being done at the present time. If we do not do the science, then the answers just will not be there. That is the only promise I can make, sir.

The booming economics of Japan and Western Europe today rest in no small part on the competitive use of technologies based on American science for which, in some part, they have paid in royalties. But they have seen the handwriting on the wall and are now investing more heavily in R. & D. In Germany, current expenditures on R. & D., stated as a percentage of their GNP, now exceed ours (approximately 3.2 percent as against approximately 2.7 percent).

But the difficulty is that it is very perplexing to try to come up with some magic formula which says what the level of investment should be. The statement I made earlier was a description of the forces in being within the scientific enterprise, a kind of natural growth of 12 to 15 percent per year, on the other hand, if you ask what should be the rational Federal total support of science, some schools indicate that we should maintain a level of effort about where we were in 1967, as if we had attained some optimal level. I do not know how one can establish that. Others have indicated it might be wise to run at a steady rate proportional to the GNP. Currently we are at about 2.7 or 2.8 for all of R. & D. but the fraction for basis research has been falling. We do not maintain the constancy of effort, in constant dollars, nor have we been keeping pace with GNP. Which of those is more appropriate as an approach is difficult to determine.

From my own standpoint, as long as what is being done is of high scientific quality then our consciences are clear.

Senator KENNEDY. What are we spending in research and development in nonmilitary fields?

Dr. HANDLER. Basic research or applied research?

Senator KENNEDY. In our nondefense related programs of the Federal budget?

Dr. HANDLER. That is somewhat difficult to answer. It is not readily broken out of the special analysis of budget as presented this year. In a mission agency other than NSF, the distinction between "basic" and "applied" research is rather arbitrary in any case. For the total of all military R. & D., the estimate is \$8.9 billion in the current year, while nonmilitary R. & D. is estimated at \$8.2 billion of which space accounts for \$3 billion. Of the \$8.2 billion for civilian R. & D., about half is basic plus applied research but it is not clear what fraction is basic and what applied.

For "academic" research, the fiscal year 1973 total obligation is estimated at \$1.9 billion leading to a crude total for all federally funded research of about \$2.4 billion.

Senator KENNEDY. What about this breakdown between applied and basic research that we heard this morning. Are you satisfied with the 83 percent proportion for basic research?

Dr. HANDLER. That is for the Science Foundation. My answer depends on whether or not the country wishes to have the Science

Foundation undertake new applied initiatives on a large scale, and how that will relate to the missions of other agencies and how they will be budgeted. Although it is 83 percent basic to 17 percent applied in the Science Foundation, it is one part of basic to one part applied for the Federal nonmilitary total. I cannot imagine how one solves the problem for the NSF without looking at the total Federal program.

If NSF is to remain the kind of agency it has been, operate in the same style, utilize similar decisionmaking mechanisms, retain the same high scientific values, then I would think that the ratio should not exceed one part of applied research to two parts of basic research as a maximum for applied research. If, however, it is believed that there is a need for the civilian equivalent of ARPA, as it were, and it is to be lodged in the NSF, then one must understand NSF to be rather a different agency, with two major components which may be managed quite differently.

Senator KENNEDY. Just finally, Dr. Handler, in the general downplaying of science by Government recently, do you see any impact this is having on young people entering the field of science?

Dr. HANDLER. Yes, sir. I mentioned that in my prepared testimony. There is concern. Youngsters look at what is going on, read the handwriting on the wall, and observe that science does not seem to be "the thing," that it may not be regarded as a most critical part of the national enterprise, and that the future of science is uncertain. I do not know how large that effect is. The trouble is, it is probably happening to the very brightest ones——

Senator KENNEDY. OK. Well, I want to thank you for coming. I want to thank you also for your help in setting up the Office of Technology Assessment. You have been extremely helpful to us. We are going to continue to rely on you heavily. We want to thank you very, very much.

Dr. HANDLER. I will be pleased to cooperate.

[The prepared statement of Dr. Philip Handler subsequently supplied for the record follows:]

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Statement

by

Dr. Philip Handler

President

National Academy of Sciences

Before the

Special Subcommittee on the National Science Foundation

of the

Senate Labor and Public Welfare Committee

May 3, 1973

(Statement submitted for the record)

Mr. Chairman and Members of the Committee:

I sincerely appreciate the opportunity to appear before you as you consider the appropriation to the National Science Foundation for FY 1974. It is not my purpose, however, to discuss specific items in the budget request for that agency. To be sure, as a member of the National Science Board I have been privy to extensive discussions of the details of the President's budget request for the NSF but I shall avoid specific reference to such information. Rather, shall I attempt to place that budget request in the context of the circumstances of the national scientific endeavor as those are known to me from generally available information and from continuing discussion with almost all elements of the scientific community.

We are confronted by a paradox. We must start by asserting that, in sum, our national science endeavor is the largest and most successful in the world -- and in virtually every scientific discipline this truly glorious enterprise should be a source of great national pride.

Our astronomers, examining the heavens over the full spectrum of energies -- cosmic rays, gamma rays, X-rays, ultraviolet, the visible spectrum, the infra red

and radio -- have been revealing a cosmos larger, more complex, more remarkable than anything we might have imagined a decade ago. Geophysicists are bursting with excitement over new understanding of the forces that shape the earth's crust. Information derived from the rocks returned by the last several Apollo missions will necessitate reevaluation of all previous theories of the early histories of the moon and the earth. The Pioneer and Mariner missions return vast amounts of information concerning our neighboring planets, while our oceanographers have been learning what factors govern the flow of the major ocean currents, the sources of nutrients in the sea, the factors which govern the productivity of the ocean and its interaction with the atmosphere.

Solid state physicists have been learning to manipulate imperfect crystals in an atom-by-atom fashion, the basis for microminiature electronics. Chemists and crystallographers daily gain powerful new insights into three dimensional molecular structures and their behavior, and from them learn to design and synthesize new and useful molecules, virtually at will.

One hardly knows where to begin to describe the power of our efforts in the life sciences. Perhaps the most

significant advance we have made is to be able to say that we now think we know how to ask the right questions and have acquired powerful new tools with which to seek their answers. The essential nature of "life" is now reasonably clear. Each month we have a greater understanding of the nature of a gene, of how it duplicates itself, how it serves as the architect of a protein molecule (that is what genes do), the circumstances under which it does or does not do so, how a cell converts the chemicals which are its nutrients into the chemicals characteristic of itself, how it generates and utilizes the energy which permits it to maintain itself or grow in an environment so different from itself, of how a single fertilized egg develops into a complex animal. In recent times we have learned much about how muscles contract, how kidneys protect the composition of the blood, erythrocytes transport oxygen, how bones reshape themselves as they grow, how the immune system protects us against invading chemicals, viruses and bacteria but does not normally mistake our own body cells for foreigners, how nerve cells conduct their very weak currents and signal to other nerves, as we also get closer to the ultimate secrets of photosynthesis.

And all the while such detailed information gets us closer to the understanding of the multiplicity of disorders which afflict man. When I was a student one could list a handful of diseases known to be hereditary. Today that list is closer to a thousand and we know the exact genetic defect involved in more than 150 diseases. In other biological realms we witness significant advances in comprehension of the physiological basis -- or correlates -- of individual behavior while, for the first time, large teams of ecologists begin to produce the first quantitative models of the biological productivity of several biomes.

But let there be no mistake. In none of these areas have we come to a comfortable stopping place. Had I with me the proper assembly of scientists, they could relate, for each discipline, where lies the boundary between understanding and ignorance. In each, our history is like one's personal experience in observing an object with the naked eye, with a magnifying glass, and then with the successively higher powered lenses of a microscope. With each step there is revealed a new level of detail which is wondrous as compared with last, and only when the next step is taken does one appreciate how much had previously lain hidden. Biologists know how

crude is their current understanding. Witness the list of diseases the essential nature of which remains baffling, to say nothing of our ignorance of the manner in which the brain thinks, emotes, remembers.

No individual scientist can adequately describe this vast panoply of diverse scientific endeavor. But it is breathtaking, dynamic, marvelously successful -- and in trouble.

The manner in which yesterday's science is finding application today is entirely evident in the manmade world around us. The National Science Foundation has sponsored a recent study which graphically describes the historical development of a series of valuable new technologies, tracing each to its scientific origins. The complexity and the logical step-by-step nature of this process should be understood by all students of modern society. Its most important aspect, however, is that no step in the process could have been skipped or taken much earlier than it was. Conversely, it is evident that no scientist or engineer confronted with a requirement for the end use in question would have known enough to start at what we can now

recognize to have been the beginning. For example, no engineer seeking a device with which to assure the perfect alignment of a tunnel would have known that he needed a laser, much less how to build one. I shall not discuss the status of applied research since this is very largely the concern of agencies other than of NSF, and of industry. But, it is evident that there is an endless list of opportunities and of problems requiring solution to which we may reasonably expect that tomorrow's science will one day contribute.

And yet, instead of euphoria engendered by our great successes, the morale of the scientific community is now shaken. The total new obligational authority for research, basic and applied, for all Federal agencies, in the President's budget request for FY 1974 is \$6.55 billions; that for basic research alone is about one-third of that, a huge sum, capable of sustaining a great enterprise. What then are the causes of our concern?

First, let us note that the climate in which science is done is changing: The Apollo series was completed. The possibility of continuing unemployment or underemployment of scientists and of older engineers seems more real, although predictions for the longer term seem of dubious validity. The principal factors at work in this regard are reduction of Federal expenditures on aerospace

activities, cessation of growth of the universities and colleges due to recognition that the college age population will begin to decline in a few years and concern that Federal funding practices will not contribute to partial financial support of the research-performing faculty. A large fraction of the principal science administrators in government has been replaced or is about to be. The Office of Technology Assessment for the Congress has been legislated into existence but has not yet begun to function. The Office of the President's Science Adviser, the Office of Science and Technology and the President's Science Advisory Committee have all been abolished. The Director of the National Science Foundation, in his person, has become heir to many of the responsibilities of the President's Science Adviser and the Office of Science and Technology. We admire and respect him, as we wish him well in his new role, but it is not yet clear how much of their authority and 'clout' he has inherited, to what extent he can serve as coordinator of the total Federal science enterprise. Patently, a thorough analysis of the consequences of these various matters to the scientific endeavor is not possible in the time available this morning.

The total funds for fundamental research proposed in the President's Budget for FY 1974 remain below those available in FY 1967, when stated in constant dollars. Some years ago it was estimated that the forces at work in the science enterprise were compelling an increase in costs of 12 to 15% per year due to (a) the annual growth in the pool of competent, trained scientists, (b) the intrinsic increase in the costs of doing science itself, largely due to the increased costs of the ever more sophisticated instrumentation required and (c) general inflation. Those forces have been at work but the increments in funding have not been provided for about 6 years, hence the buildup of pressures, of opportunities foregone, of scientists whose talents are not being fully utilized in the public interest. If, at any previous time, the criteria for support of individual projects may have been less rigorous than we should expect, because of the relatively rapid growth of the system, that time is long past. If at any time there was 'fat in the system,' it has long since been wrung out.

Although it is self evident that expenditures on science cannot increase indefinitely at 15% per annum, it is also illogical not to utilize the capability we now have in being. For the future, there is required a rational, overall plan which does not entail an abrupt, painful discontinuity. I shall return to this in a few moments.

At this time, however, one's overall impression is that the position of science in the government has been downgraded. How and why has this happened? It is difficult to know to what extent these events flow from changing general public regard for the values and potential of science. The philosophy of the new counterscientific culture is quite remote from that of the many decision makers who, collectively, fashion the budget, but, together with those who rather thoughtlessly express disenchantment with science-based technology, their voices may contribute to a climate in which reduction of expenditures for science may find too easy acceptance. More importantly, a seemingly unlikely concatenation of other forces appears to operate in the same direction:

(1) The overarching condition is the determination of the President and now, quite possibly, the Congress, to hold down the total level of Federal expenditures.

(2) The Congress has met considerable success in reducing the support, by the Defense Department, of fundamental research relatively remote from the immediacy of the military mission. I shared the desire to remove classified research from the campus. However, I could become concerned if military R&D were conducted entirely in a closed community and, for many reasons, I believe it to be in the national interest to maintain a flow of

communication between the technical community of the Defense Department and that of the universities. The Congress has not identified the specific programs or projects to be reduced or eliminated. But it did enunciate the philosophy which has guided the progressive elimination from support by the Defense Department of a series of major scientific enterprises, both on campus and inhouse, e.g., programs in materials science, nuclear structure physics and radioastronomy.

(3) Increasing emphasis has been placed on the utilization of the resources of government in support of that R&D which promises the earliest payoffs, whether these be in defense, improvement in the international balance of payments or management of a major disease. These are worthy goals to which we all subscribe, but since this priority assignment has occurred within an overall budget which has failed even to meet inflationary increases in costs, the fundamental research effort has been compressed accordingly. Even then, this course might be acceptable if it were clear that fundamental research has already provided the information and understanding requisite to achieving those goals in the near future. Unhappily, this is patently not the case and to some extent we may well be doing the wrong thing for the right reason.

As now managed, the "wars" on cancer and cardiovascular disease have deflected a substantial fraction of the funds formerly available for the support of imaginative individual biomedical scientists into larger, more directed endeavors, funded by contractual rather than grant mechanisms and without "peer review," as commonly understood. It would appear that the entire proposed increment in research funding by the Cancer Institute is to be so utilized and, moreover, that those funds have been gathered in considerable part by reducing appropriations to others of the Institutes at NIH. It was just such a possibility that gave many of us concern when a war on cancer was being urged. These decisions are incompatible with all we have learned concerning the relationship between fundamental research and societally useful technologies, all the evidence that one does not yet understand the nature of the malignant transformation or of the atherosclerotic process. At this moment, no one can even be certain that we now know of the existence of the normal physiological process alteration of which leads to these changes.

Moreover, the "increases" in total appropriations for NIH for FY 1974, indicated in the President's budget request, are reckoned against the baseline of obligations permitted by the OMB for FY 1973, not against either the Congressionally approved level of appropriations or that in the President's budget request for FY '73.

Taken together, these trends seriously jeopardize the scientific endeavor which is the basis of our hopes for the future.

Exacerbating these difficulties is the explicit denial, by the Administration, that it is a responsibility of the Federal Government to contribute to the personal support of graduate students or postdoctoral fellows, except to the extent that these contribute directly to federally funded research. In consequence, we have witnessed the phasing out of postdoctoral fellowships and training grants both at the National Science Foundation and the National Institutes of Health. Although these actions would, indeed, reduce federal expenditures, it is apparent that this mode of budget pruning reflects a deeply held philosophy and does not represent mere fiscal expediency.

It is not, however, a philosophy that I share. This is a complex subject and there is insufficient time to explore it adequately this morning. But the actions taken profoundly affect the stability of the system.

The consequences of this set of actions will be, I believe, far more complex, far more serious than was anticipated by those who made these decisions. With the full knowledge of the bureaucracy and advisory structure at NIH, as well as of the cognizant Congressional committees, NIH training grants have been utilized, in part, to defray

the salaries of faculty engaged in the training, contributing about 8% of the total of such faculty salaries, nationally. Their abrupt withdrawal, coupled with the marked reduction in General Support Grants programmed in the FY '74 budget request, will generate fierce fiscal difficulties for many leading medical schools and universities.

One of the great but unheralded decisions of our national history was that in which we agreed that we would rely on universities, rather than independent research institutes, as the primary loci for the conduct of research. In so doing, we coupled the experience, wisdom and insights of our most productive investigators to the enthusiasm, imagination, drive and energy of students and neophyte investigators. About three-quarters of the total basic research endeavor now occurs on campus. The dividends have been handsome. While graduate students and postdoctoral fellows so engage in their own long-term, self interest, they are also the invaluable junior colleagues and the labor force of the research enterprise, without whom research itself will surely suffer. However, the system entails a high attrition rate; a large fraction of those who perform very well at this early phase of their careers later prove not to

have the staying power or are deflected into other activities. But their throughput is essential to the system, thereby generating a serious dilemma if, indeed, it later proves to be true that there are fewer jobs than adequately trained candidates. This may be the case in some disciplines.

I am uncomfortable with any arrangement for distribution of funds in support of graduate students and postdoctoral fellows which heavily favors some disciplines while ignoring others, but the major abrupt discontinuity in the biomedical area, now in process, because of the multipurpose nature of NIH training grants, seems to me to constitute a uniquely critical situation.

What is not certain is whether there will occur a truly significant decline in total graduate enrollment in the sciences, reducing the pool of manpower which will be available at some future date when it will certainly be needed. To date, it has been the physical sciences which have been most affected; first year graduate enrollment in these sciences declined about 16% from the fall of 1970 to the fall of 1972. One result of these fiscal actions, already evident but quite unintentional, has been to deflect considerable numbers of graduate students from those graduate schools which have been most successful in the past to institutions with lesser records of research productivity. This situation will be applauded by the egalitarians and deplored

by those who think science to be an essentially elitist activity. The political dilemma thus created will be obvious.

In the two decades in which Federal expenditures for science continued to grow, it was facile to say that our government did not have a "science policy." We said that, instead, we had policies for defense, health, agriculture, transportation, nuclear power, etc., and, for national prestige (the conventional justification for much of the space program), and that, within each of these areas, we developed a budget for related science activities. The role of NSF, then, was to see that the whole effort was balanced and no important frontier neglected. The structure did not grow in concert; each element was put in place as opportunity afforded, with fundamental science supported by the multiplicity of federal agencies. Seen in retrospect many of us, then and now, applauded this arrangement. But then the occasionally voiced concern for the instability of this arrangement became reality. Budget ceilings tightened and those in responsible position -- in the agencies and in the OMB -- protected each agency's mission capabilities and began to trim back research budgets preferentially. In various forms and degrees this has occurred in DoD, NASA, AEC, NOAA and NIH, indeed, in a sense, even in NSF.

As each research enterprise loses its funding from any other agency, it presents itself to NSF as a "dropout." As this has occurred in past years, recognizing the high intrinsic merit of the research in question, arrangements were made to increase the NSF budget to accommodate this problem -- but not sufficiently. The increment in the NSF budget has almost invariably been less than that which was lost in the other agency; each such laboratory has been supported by NSF at a lower level than it had previously known. Even so, in sum, these actions squeezed the funds available at NSF for its ongoing programs; moreover, no special provision was made for smaller "dropout" laboratories, those of individual investigators, thereby further exacerbating the competition for funds at NSF.

The next large wave of dropouts will undoubtedly be those generated by the new situation at NIH in FY 1974, if the prospects suggested by the NIH budget request do, in fact, occur.

The funding difficulties of the physical sciences have developed over the last six years as the nation has turned from its preoccupation with those concerns which relate to the missions of DoD, AEC and NASA. But that in the biomedical sciences may occur in one stroke. If the budget request for FY 1974 is funded in its present form, the prodigiously successful academic biomedical research

enterprise could fall into chaos. Funds previously available for support of high quality research undertaken on the initiative of individual investigators, in the budgets of several of the National Institutes of Health are, effectively, being transferred to the Cancer Institute, and to a lesser degree to the Heart Institute for financing of large contract ventures, many with industrial organizations with no "track record" in such research.

According to the analysis furnished to me by the American Association of Medical Colleges, as compared with FY 1972, the budget proposal for all of NIH for FY 1974 entails decreases in funds available in the open competition for regular research grants of \$85 millions, for fellowships of \$16 millions, and for General Research Support of \$38 millions. Indeed, as the programs of the National Cancer Institute are presently managed, even in that Institute funds for the open competition for research grants will decline from \$32.9 to \$24.0 millions. I cannot estimate what fraction of all that deficit will be translated into new applicants for research support by NSF. But with the sharpening of agency missions, the emphasis on more 'directed' research, it will be those investigators engaged in the most fundamental research of unknown application, viz., those whose work would seem most eligible for support by

NSF, who seem in greatest danger of being squeezed out. If that proves to be the case, it will be a ghastly mistake. Moreover, the Institute whose programs might have served as the safety valve against such an eventuality is the Institute most seriously affected. The budget for competitive new grants or renewals of the National Institute of General Medical Sciences, the principal source of support for the most fundamental biomedical research, is scheduled to decline from the \$28.3 millions available in FY 1972 to only \$5.1 millions in FY 1974. I may leave the impression of special pleading for the biomedical sciences and, indeed, I take pride in the fact that it was my testimony before the Congress that led to authorization of the Institute of General Medical Sciences. But my purpose has been to illuminate the basis for concern for that segment of science and the huge problem it will pose to the NSF.

The historic, unplanned, opportunistic growth of the national science endeavor has proved extraordinarily successful. I take no issue with the position that the growth of that endeavor must be leveled off. But I also have no magic formula to suggest for its optimal magnitude. As long as the research supported is of high quality, the conscience of the scientific community will be clear. Many have urged, for some years, that we agree upon and maintain a constant "level of effort" or, alternatively, maintain it at some

constant fraction of the GNP. But we have not been doing that either. The resultant distress has seriously affected the morale of senior scientists and now seems to be deflecting young people, who "think they see the handwriting on the wall," to other careers.

It must also be recognized that it can be disastrous to make budget tightening decisions affecting science solely on an agency-by-agency basis. Since available funds have actually decreased while opportunities and capabilities have expanded, failure to assign priorities and relative funding on the basis of the whole of the Federal science budget can be both painful and wasteful. This is a very complex and large task and, seemingly, it has been done only in some part. It is to be hoped that, in his new role, Dr. Stever will participate in future such exercises.

The difficulties are by no means confined to the biomedical sciences. It is increasingly apparent that the effort in nuclear structure physics is in serious danger with leadership now passing to other nations. NSF support of this field has increased modestly, but both the Navy and AEC have reduced theirs; with the exception of the Los Alamos 'meson factory' all other major facilities of new design and capability have been constructed abroad for several years. Astronomy is hampered not only by failure to acquire new instrumentation but by lack of operating funds for current

facilities. It is ironic that the most remote, perhaps most remarkable celestial object ever observed was recently reported by the radioastronomy facility at Ohio State -- which is about to be shut down for lack of funds.

When the Very Large Array is constructed, leadership, in terms of instrumental capability, will return to the United States. But the other instruments on the radio-astronomy priority list now seem a long time in the future. And of the seven lesser facilities which are campus-based, four or five are now in serious financial trouble, for lack of operating funds.

The space sciences program has seemed amply funded until this year; the leadership of NASA is to be congratulated on their recent valiant effort to keep the High Energy Astronomy Observatory alive. But the future seems dim. If, indeed, the total budget of NASA is to be fixed at about \$3 billion, annually, the rising costs of the shuttle will markedly reduce, perhaps cripple, the space science program in a few years. Already we have seen the Grand Tour and several missions to the nearer planets removed from the NASA schedule, and the future of the space telescope seems uncertain. I am incompetent to discuss the merits of the shuttle within the total NASA program, although I am aware of grave doubts within the scientific community in that regard. However, since science is a principal mission of NASA, the rationale of such budgeting is obscure to me.

Similar situations are arising, I am told, in scientific oceanography for which NSF rather than ONR is now the lead agency. It is more difficult to assess the status of those scientific disciplines which do not revolve about the use of large instruments. But from what I am told, in all disciplines there is in being a national capability of highly qualified scientists and laboratories that is not finding the funds needed for its optimal use. Young investigators cannot find the funds with which to begin their independent careers and highly productive, mature scientists begin to share that fate; many go seriously underfunded.

I am not in position to suggest the absolute sum necessary to alleviate these difficulties, but it would be a significant fraction of the total NSF budget. I hope that several of the trends I have summarized can be reversed, but if they continue then repair is possible only by appropriately increased support of the NSF. I do not believe that the support of science should be over-generous, much less lavish. But neither do I believe it to be in the national interest that our capability in being -- either major instruments or the brains of competent investigators -- should be utilized at less than their full capability.

Thank you.

Senator KENNEDY. At this point I order printed all statements of those who could not attend and other pertinent material submitted for the record.

[The material referred to follows:]

Statement of

Dr. William K. Stephenson

Professor of Biology

Earlham College, Richmond, Indiana

and

Dr. Lewis S. Salter

Vice President & Dean

Knox College, Galesburg, Illinois

on behalf of the

Associated Colleges of the Midwest

and the

Great Lakes Colleges Association

Senate Special Subcommittee on the National Science Foundation

Committee on Labor and Public Welfare

Mr. Chairman and Members of the Subcommittee:

The Great Lakes Colleges Association and the Associated Colleges of the Midwest are consortia of private, liberal arts colleges. Our 24 institutions are located in eight states: Colorado, Illinois, Indiana, Iowa, Michigan, Ohio and Wisconsin.¹⁾

We do not intend, however, to limit our remarks to the needs of our own institutions or our own region of the country. The problems and challenges facing undergraduate science education are common to all colleges and universities throughout America.

We would like to speak to these issues:

- Concern about our national policy for undergraduate science education.
- Evaluation of and support for several specific National Science Foundation programs.
- The effects of impoundment of authorized funds on specific NSF programs.

National Policies for Undergraduate Science Education

Effective undergraduate science education is a crucial link, possibly the most crucial link, in the continuing development of the supply of scientifically trained persons which this nation must have. We need policies for science education which assure an even flow of well-trained persons into basic research,

1) Associated Colleges of the Midwest

Beloit	Knox
Carleton	Lawrence
Coe	Macalester
Colorado	Monmouth
Cornell(Iowa)	Ripon
Grinnell	St. Olaf

Great Lakes Colleges Association

Albion	Hope
Antioch	Kalamazoo
College of Wooster	Kenyon
Denison	Oberlin
DePauw	Ohio Wesleyan
Earlham	Wabash

various technological fields, and science teaching. We should provide opportunities for the continuous retraining and updating of practicing scientists. Failure to do so will probably result in the continuation of "feast or famine" fluctuations in scientific manpower like those we have experienced in the period following World War II. We need a coherent science education policy. What is perhaps an overreaction by Federal agencies to a temporary manpower crisis has put education into a turmoil of uncertainty because this overall science education policy is lacking.

National Science Foundation Budget -- General Comments

Since its inception the National Science Foundation has been the principal governmental agency which has held responsibility for the programs serving undergraduate science education. The NSF "Statement of FY 1974 Budget" outlines four major goals of the National Science Foundation. In brief they center on:

- science research
- science in service to the public
- international scientific cooperation
- science education

Public Law 92-372 enacted last year, amends the National Science Foundation Act of 1950 to "authorize and direct" NSF to: (in part) "initiate and support basic scientific research potential and science education at all levels." This reemphasized mandate is not recognized in the projected fiscal 1974 budget. In a period of financial restraint, government agencies should hesitate to commit large amounts to new and experimental programs outside the range of that mandate. They should not cut back on program budgets that support the basic mandate.

In general the NSF programs have contributed very significantly to the

improvement of undergraduate science education in the United States, and they have done so with relatively modest yearly budgets. In a continuing effort to improve its effectiveness during the past ten years, the Foundation has added and dropped specific programs and has shifted its emphasis among programs. During the past two years, however, we have seen an overall decrease in the NSF funding directed toward science education in general, and toward undergraduate science education in particular. These decreases have been the result of OMB and NSF policy decisions, effected both through initial program budget requests and through the selective impoundment of funds for specific programs despite the efforts of this Subcommittee to set science education high among NSF priorities.

The proposed 1974 NSF budget request designates \$46.5 million for traditional science education programs. For the first time they have included Computer Innovation in Education, Graduate and Continuing Education and Public Understanding of Science under Science Education Improvement. This represents a modest \$7.36 million increase in the traditional programs. The newly added programs account for \$4.15 million of the increased request. The request is still \$16.29 million less than the 1972 expenditures and \$24.5 less than Congress appropriated for the traditional science education programs.

A fundamental issue has emerged in discussions between members of the Congress and the leadership of the National Science Foundation during Subcommittee testimony over the past few weeks. Namely, the decreasing priority which NSF is giving in its budgetary allocations to science education, and a radically different thrust within its programs for science education. The support of well-established and tested programs which maintain quality science education is to be totally phased out in favor of programs which support innovation in science

education. The decision to jettison sustained support in favor of innovation is a drastic one and presumably represents the effects of pressures from the Office of Management and Budget. There is scant evidence that such a decision is the result of science policy considerations, and none whatsoever that it represents any consensus within the scientific community. The original Act of 1950 establishing the National Science Foundation sets forth its mandate for concern with science education, and amendments to that Act added in 1972 make particularly clear the Foundation's role in supporting both basic research and education in the sciences.

The basic policy decision to de-emphasize the role of science education in NSF programming can be defended by appeal to current manpower statistics, which reveal a present over-supply of scientists and engineers in some phases of the economy. It is decidedly dangerous to push this argument very far in the interest of reducing federal expenditures for the education of scientific and technological personnel, simply because of the long lead time required for the preparation of quality scientific personnel. There are already indications that in the next few years we will again experience a shortage of appropriately trained personnel in some areas of engineering. Many of us are worried that OMB pressures aimed at short-range budget reduction can have very serious long-range implications for the scientific leadership role of the United States. At the moment Congress is the principal bulwark against such short-sighted policies.

Dr. Keith Kelson, Assistant Director for Education, has argued that the kind of science education programs that NSF has maintained in the past are no longer needed and that studies of their efficacy have shown them to be not worthy of continuing support. The first statement quite definitely flies in the face of the experience of those of us who are engaged in the process of science education,

and the alleged studies cannot be found. Conversations with staff members within the Foundation's Division of Science Education Improvement reveal that they are unaware of the existence of such studies. Repeated requests to the Foundation for the documentation of such studies have failed to elicit anything except a single study of the Summer Science Institute Program which is very seriously out of date.

Another reason given by NSF for its new look in educational programs (i.e., the support only for innovative and "revolutionary" science education programs) is that the students of today find traditional science education programs irrelevant and not germane to their educational needs. This kind of rhetoric indicates something like a two-year lag between the perceptions of NSF leadership and the realities of the university campus. The fact is that students on our campuses, and at almost all of the colleges and universities with which we are familiar, are enrolling in increasing numbers in traditional chemistry, biology, physics, and mathematics courses. The "know-nothingism" and cry for relevance of 1970 and 1971 have receded into the past. We are particularly disturbed by this aspect of NSF's description of its new thrust in science education. It is a very shallow and fashionable echoing of the trends in educational reform which were in vogue two years ago. The role of quality science education in NSF policy is far too important to allow the indulgence of faddism of this sort.

The data make it obvious that within the NSF budget for the current fiscal year, funds appropriated for science education suffered with particular severity from the device of impoundment. Programs in these areas were cut back by 37 per cent through impoundment. The device of delaying the expenditure of funds beyond the presumed twelve-month period has already been discussed by members of this Subcommittee with NSF leaders. We would certainly support the inclusion of explicit statements in the appropriating legislation which would make mandatory the

expenditure of the funds within the twelve-month period. We are definitely supportive of the efforts of the Congress to fight the device of impoundment.

Specific Recommendations for NSF Programs

A. Undergraduate Research Participation (URP)

(Funds requested and expended in the NSF URP Program, in millions of dollars)

1968	1971		1972		1973		1974
<u>exp.</u>	<u>exp.</u>	<u>req.</u>	<u>exp.</u>	<u>req.</u>	<u>exp.</u>	<u>req.</u>	<u>NSF req.</u>
6.8	3.9	4.0	4.0	0	2.3	4.0	1.3

As indicated in the above Table this program has been cut \$1.7 million in '73 and \$2.7 million in '74 as compared to '72. The '74 request is \$5.4 million below the program high of about \$6.8 million in 1968.

The grant awards made under this program to our colleges are small, typically involving four to six undergraduates and two to four faculty at a total cost of \$15,000 per grant for our colleges. Hence, the relatively small amount of money spent in this program affects science education in a large number of institutions.

The Undergraduate Research Participation (URP) program has been judged to be the most effective program at the undergraduate level by science faculties at our institutions. By allowing students and teachers to work together in significant research activities, it contributes to both the quality of science learning by undergraduates and to the continuing updating and research involvements of faculty. Participation in URP also helps a student to make a career decision about science which is based on a direct involvement in research. Thus the URP program contributes to three of the four objectives noted earlier for undergraduate science education. In recent years the evaluation of URP proposals was linked to curriculum improvements, thus extending the impact of the program on undergraduate science education. Unfortunately, URP has been evaluated by NSF almost exclusively in terms of its original aim of increasing the scientific

manpower pool by encouraging students towards careers in science and maintaining the focus of those already inclined to science. We feel that improvement of the effectiveness of undergraduate science education, the continued research involvement of faculty, and clarifying student career choices are the criteria by which URP should be judged today. We view URP as the top priority program for undergraduate science education.

---We respectfully recommend that an earmarked appropriation for the URP program be returned to its 1968 level of \$6.78 million, and that serious consideration be given to increasing funding by about 20 percent for 1975---

B. Instructional Scientific Equipment Program (ISEP)
(Funds requested and expended in NSF ISEP Program, in millions of dollars)

1968	1971		1972		1973		1974
<u>exp.</u>	<u>req.</u>	<u>exp.</u>	<u>req.</u>	<u>exp.</u>	<u>req.</u>	<u>exp.</u>	<u>NSF req.</u>
8.9	0	0	0	2.9	2.4	1.8	0

Instructional Scientific Equipment Program has provided support, on a matching basis, for equipment which was linked to course and curriculum improvements. In our collective experience, the program stimulated science departments toward course updating and toward rethinking and revising their overall pattern of course offerings. ISEP frequently made possible changes which could not have been undertaken otherwise. It also focused the attention of college and university administrators on the needs for equipment for undergraduate education, as opposed to equipment for research.

---We recommend that a 1974 budget allocation for ISEP be earmarked at \$8.9 million, the amount allotted in 1964, and attention be given to evaluating ISEP as a component of a comprehensive undergraduate science education program---

C. Science Faculty Fellowships

The Science Faculty Fellowship program is specifically directed toward the updating of faculty members. If national policy fosters research (as it does) which adds to scientific knowledge, then those who are charged with the responsibility of teaching this new knowledge must have access to it. Hence programs which foster the updating of undergraduate teaching faculty are essential. Science Faculty Fellowships therefore speak to the goals of teacher retraining, improvement of education for science majors, and improvement of science education for all undergraduates.

---We recommend that the Science Faculty Fellowship program be funded in '74 to the amount of \$4.16 million, the fiscal 1966 amount. The program should be evaluated in the context of the overall programs for undergraduate science education, in conjunction with other programs directed toward the continuing in-service education of teachers---

D. College Teacher Programs (Summer Institutes - Academic Year Workshops) (Funds requested and expended in NSF-College Teacher Programs, in millions of dollars)

1968	1971		1972		1973		1974
<u>exp.</u>	<u>req.</u>	<u>exp.</u>	<u>req.</u>	<u>exp.</u>	<u>req.</u>	<u>exp.</u>	<u>req.</u>
5.5	5.0	5.2	3.5	3.2	3.6	4.0	2.5

As have other undergraduate programs, the College Teacher Program has also suffered reductions since 1968. In addition, there has been a shift of emphasis from summer institutes and workshops to Chautauqua-type seminars held during the academic year. The importance of regular retraining and updating to undergraduate science teachers cannot be overemphasized. The effectiveness of courses and curricula for science majors and for non-majors alike depend on competent science professors.

---We recommend that funding for College Teacher Programs be earmarked at a level of \$5.5 million. College Teacher Programs should also receive evaluative attention in the context of the overall program of support for undergraduate science education---

E. Summer Institutes for Secondary School Teachers

While this program is not directed toward undergraduate teachers, several of our colleges have conducted institutes in past years. In our experience these have been an effective means of providing updating and stimulus for public school educators.

---We support the Summer Institute Program and urge budget allocations to as high a level as is consistent with balance among programs in the NSF budget---

F. Student Science Training Program

We support the Student Science Training Program which serves to enrich the science education of high school students by providing summer study at colleges and other specialized institutions. Especially when high schools are inadequate to meet special needs, it is important to give students the opportunity to become immersed in a learning experience.

---We recommend that funding for the Student Science Training Program be maintained at the fiscal 1973 level of \$2 million---

G. Peer Panel Evaluation Procedures

In the past few years the practice of peer panel evaluation has been called into question by OMB and high echelons of NSF primarily on the basis of cost.

We continue to favor peer panel review for proposals in undergraduate programs. The evaluation of science education programs by other persons actively engaged in science education we believe to be the most effective form of evaluation possible. Peer panel activity also serves to facilitate the exchange of new ideas and information among the science teachers who participate.

We regret to see the deterioration of the NSF peer panel review system and hope that you will recommend that it be strengthened from its present form.

Thank you.

NATIONAL SCIENCE FOUNDATION BUDGETS, FY '71, '72, '73 and '74 (in millions of dollars)

(This analysis does not include three new programs now listed in FY '74 Education Improvement Programs: Graduate & Continuing Education, Public Understanding of Science & Computer Innovation.)

	FY '71	FY '72	FY '73 (req'd)	FY '73 Expended Est'd	FY '74 NSF Request
<u>New Names in '73 and '74 Budgets</u>					
PRE-COLLEGE EDUCATION IN SCIENCE (Totals)					
Student Science Training Program					
1. Special Suppl. Activities	2.0	2.0	2.0	2.0	1.5
2. Science Curriculum Development					
3. Course Content Improvement	1.4	3.3	4.2	2.7	7.9
4. Cooperative College-School Science	1.8	1.5	2.3	.5	2.2
5. Special Projects	4.7	4.4	5.0	2.5	5.5
6. Institutes (Totals)	.4	0	0	0	0
7. Summer Institutes (includes item 12)	23.1	13.1	10.3	10.8	7.7
8. Academic Year					
9. In-Service	.5	2.2	2.1	2.3	0
10. Systems Grants	3.3	3.1	2.8	0	0
11. Comprehensive Grants No line item Began 1971 under Institutes	.3	2.7	2.0	1.0	2.5
12. Short Courses (or Conferences) No line item	.1	3.4	4.9	0	0
TOTALS	40.9	35.7	35.6	21.8	27.3

In '71 other programs producing curriculum materials accounted for \$.6m in CCI category; Elementary & Secondary materials for \$.4m; and Resource Personnel Projects for \$1.8m for a total of \$6.7m under CCI.

Prepared by: Midwest
Colleges Office
February, 1973

NATIONAL SCIENCE FOUNDATION BUDGETS, FY '71, '72, '73 and '74 in millions of dollars (continued)

New Names in '73 and '74 Budgets		FY '71	FY '72	FY '73 (req'd)	FY '73 (exp'd)	FY '74 (NSF req't)
UNDERGRADUATE EDUCATION IN SCIENCE (Totals)						
1. Undergraduate Research Participation	Undergraduate Student Projects	3.9	4.0	4.0	2.3	1.3
2. Student-Originated Studies	Undergraduate Student-Originated Projects	1.5	1.9	2.0	1.0	2.0
3. College Teacher Program	College Teacher Projects	5.2	3.2	3.6	4.0	2.5
4. Science Curriculum Improvement						
5. Course Content Improvement	Undergraduate Instructional Materials	5.2	4.6	4.5	2.3	4.4
6. Pre-Service Teacher Education	Same	2.6	1.5	2.0	.4	1.5
7. Technical Training	Technician/Technologist Ed'n. Projects	.1	1.3	1.5	.4	0
8. Special Projects	0	.75	0	0	0	0
9. Instructional Scientific Eqpm.	Undergraduate Scientific Instructional Equipment Projects	0	2.9	2.4	1.8	0
10. College Science Improvement	College & University Projects (with Undergraduate Scientific Instructional Eqmat. Project or ISEP)					
COSIP A	Four Year College & University Projects	3.5)	-3.0)	2.0	1.1	0 *
COSIP B		.4	.3			
COSIP C	State & Urban Systems Projects (with PES Systems Grants)	1.5	1.0	.8	0	0
COSIP D	Ethnic Minority College Projects	0	5.0	5.0	4.1	5.0
TOTALS		24.8	28.4	27.8	17.4	19.2

* New Program presently named "Restructuring the Undergraduate Learning Environment."

Prepared by: Midwestern Colleges Office
February, 1973

New York University

Washington Square College of Arts and Science
Department of Mathematics

251 Mercer Street
New York, N.Y. 10012
Telephone: (212) 460-7100

May 9, 1973

STATEMENT ON
THE NATIONAL SCIENCE FOUNDATION
FUNDING OF EDUCATIONAL PROGRAMS

Submitted by: Melvin Hausner
Chairman, Department of Mathematics
Washington Square College, N. Y. U.

On January 29, 1973 New York University received word from the National Science Foundation that that Foundation will no longer fund our In-Service Institute for High School Teachers of Mathematics. We subsequently discovered that in fact all In-Service Institutes over the country were similarly being abandoned. This action on the part of the National Science Foundation severely affected a large number of high school teachers in the country, and approximately 55 high school teachers at New York University who are now being supported by the National Science Foundation. These teachers are currently enrolled in a specially devised New York University Master's Program and the abrupt withdrawal of Foundation support for them represents, in our view, a breach of moral commitment to them.

Our program - the Master of Arts in Mathematical Scholarship - was devised in cooperation with the National Science Foundation and at their urging. All students enrolled in this program did so with the understanding that their tuition would be paid by N.S.F. Therefore we feel that if N.S.F. wishes to withdraw from this aspect of their educational program they should do so by phasing it out over a two year period. We feel that this two year phase-out will have discharged our obligation to the students and would be the proper course for N.S.F. to take. We submitted such a two year phase-out budget to N.S.F. on February 14, 1973 but were turned down on February 28th.

New York University's In-Service program has been in operation for about 16 years and has been, we were told, one of the better In-Service programs. We have felt, and continue to feel, that the In-Service program for High School Teachers is an extremely effective educational device with far-

reaching beneficial consequence to the teachers participating and to their high school students. Therefore we would like to go on record as opposing the termination of In-Service courses all over the country. But given the decision to terminate, we do not understand how this can be done without prior warning and with no period of transition. We feel that no agency of the U.S. Government should act in this manner and we urge reconsideration on the part of N.S.F. which would allow them to help us phase out this program in a systematic, orderly, and decent manner.

Respectfully submitted,

Melvin Hausner
Chairman



national association for equal opportunity in higher education

2001 S Street, N.W. • Washington, D.C. 20009 • Suite 450 • Telephone (202)232-8500

April 27, 1973

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North Carolina Central
University, N.C.

Executive Secretary
Miles Mark Fisher, IV

Senator Edward M. Kennedy
Chairman
Special Subcommittee on the National
Science Foundation
Committee on Labor and Public
Welfare
United States Senate
Washington, D. C.

Dear Senator Kennedy:

The National Association for Equal Opportunity In Higher Education which represents the traditionally Black Institutions of Higher Education is concerned about the National Science Foundation authorizations for Fiscal Year 1974.

In Fiscal Year 1972, the National Science Foundation embarked on a program which was known as the College Science Improvement Program - Section D. This program was to improve the quality of science education in the black colleges. This program was funded at a level of five million dollars. Proposals submitted for this program were on the order of fifteen to twenty million dollars. Four year traditionally black institutions made up the universe of the eligibles.

The Fiscal Year 1973 level of this program was equal to that of the previous year but it was broadened to include two year black institutions and also two year and four year ethnic minority institutions.

It was our hope and expectation that this five million would be increased annually to allow for a greater participation of these institutions in the program. At present the available funds are adequate for participation of only about ten percent of the universe of eligible institutions.

There are three basic concerns that we have about this program, namely: authorization, appropriations and the guidelines. We feel that this program should be continued and authorized at a higher level in view of the more than twenty-five percent increase in the number of eligible institutions. The present program typically provides grants of \$300,000 to eligible institutions over a three year period. We feel that this amount should in no way be diminished by increasing the number of eligible institutions or eligible activities. To offset the universe of eligible institutions, we feel that authorizations need to be made at a higher level and we are suggesting 7.5 million for this program in FY74. There is no danger of oversupport to these institutions at this level of funding.

Senator Edward M. Kennedy
April 27, 1973
Page 2

We have been informed that the National Science Foundation intends to modify the program to broaden institutional eligibility and supportable activities to include projects at non-minority institutions. We feel that this would be a mistake in view of the fact that existing needs of the initially eligible institutions are far from being met. Programs seeking to increase the flow of women and ethnic minority members into scientific careers should be funded completely separately thereby leaving the present COSIP-D Program unchanged and the level of support to the black colleges undiminished.

The guidelines of the program should not continue to broaden the institutional eligibility before it has begun to meet the existing needs of the initially eligible institutions. In the past black colleges have not participated in the National Science Foundation Programs to the extent that other institutions have been included. Funds have moved to these institutions in inequitable sums.

In addition to other benefits, the COSIP - D Program has provided black colleges involvement with the National Science Foundation. This has helped in part to end the isolation of these institutions and their students. If the students, instructors, and institutions are to deal effectively with economic, social, technological and environmental problems of the seventies their involvement in the National Science Foundation's Science Education Programs must not be diminished.

A definitive program of assistance to the science departments of the traditionally black colleges and universities is needed to offset the years of neglect in this area. New directions in the allied health fields and the other science related areas make this an imperative for these institutions.

We would like to point to the successes of these institutions in educating students. It has been reported that over seventy-four percent of all black Ph. d's in the Sciences received their collegiate education at traditionally black institutions. The COSIP - D Program is a means of strengthening the science departments at these institutions.

Senator Edward M. Kennedy
April 27, 1973
Page 3

We will be happy to supply additional information and/or testimony before the Special Subcommittee on the National Science Foundation.

Thank you for your consideration of this matter.

Sincerely,

Miles Mark Fisher, IV

Miles Mark Fisher, IV
Executive Secretary

MMF:jbm

STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305

DEPARTMENT OF CHEMISTRY

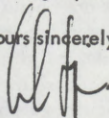
May 8, 1973

The Honorable Edward Kennedy
United States Senate
Washington, D. C.

Dear Senator Kennedy:

In view of your concern with the National Science Foundation, I am herewith enclosing a letter which I have recently written to Dr. Stever and which calls attention to an exceedingly serious funding problem in NSF insofar as chemistry is concerned. It seems to me that it is not generally known that, while the NSF appropriation for chemistry has essentially remained unchanged, this has happened while virtually all support from the National Institute of General Medical Sciences of the NIH has been terminated in addition to all predoctorate and postdoctorate fellowship programs. The cumulative effect of these three actions appears to be disastrous, especially for the high quality institutions.

Yours sincerely,



Carl Djerassi
Professor of Chemistry

CD:ab

Enclosure

STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305

DEPARTMENT OF CHEMISTRY

May 2, 1973

Dr. H. Guyford Stever, Director
National Science Foundation
Washington, D. C. 20550

Dear Dr. Stever:

My very enjoyable visit with you last year in Palo Alto prompts me to write this letter in the hope that, in spite of your extraordinarily busy schedule, you will have an opportunity of reading it personally. I am writing to you in your dual capacity as Director of the National Science Foundation and Principal Government Science Advisor because I have become enormously concerned with the greatly deteriorating situation in university chemical research, especially as it pertains to the top institutions in this country.

Last week the Director of your Chemistry Section, Dr. Kent Wilson, and I were outside speakers, together with President McCoy of Du Pont and Glenn Seaborg of Berkeley, at the dedication of the new chemistry building of Purdue University. This should have been a joyous occasion, and yet the recurring theme of many of the speakers and faculty members was one of gloom and apprehension about the immediate and medium term future of chemistry. Dr. Wilson gave a talk which attempted to put the current NSF efforts in the best possible light, but I shall have to be quite frank and indicate to you, as I did to him, that his presentation only convinced me and many of the other participants that the situation is even more serious than many of us had believed.

On the face of it, the NSF budget for basic research in general and chemistry in particular does not seem to have suffered much this year and it is my firm belief that administrators within the NSF and the Office of Management and Budget think that the current budgetary situation is under reasonable control. I am afraid that nothing further from the truth is the case. According to Dr. Wilson, in the field of chemistry NSF is currently in a position to fund at the most twenty percent of new applications. This should be contrasted with the historical fifty percent or higher funding rate of approved NIH grants. However, one must remember that this twenty percent funding rate is occurring in the year in which all NSF and NIH postdoctorate fellowships have been abandoned, when all NIH predoctorate

Dr. H. Guyford Stever

May 2, 1973

Page 2

fellowships have been discontinued, and when the NSF is essentially winding down its own predoctorate fellowships. Since it is the top institutions in this country that have always had the largest number of such fellowship holders, this effect is only being noticed in the Harvards, Stanfords and Columbias of this country. To make matters even worse, until recently a larger proportion of university organic chemical research was funded by the NIH than by the NSF. I would estimate that eighty to ninety percent of this NIH funding has come through the Institute of General Medical Sciences. This is the institution which has been cut catastrophically this year in order to provide funds for the Cancer Program and other mission oriented programs. As a result, not a single new grant application has so far been funded this year by the Institute of General Medical Sciences of the NIH in spite of the fact that there is a big backlog of grant applications that have been approved by study sections and the appropriate council. The cumulative effect of the poor funding rate for new grants by the NSF, the abolition of essentially all fellowship support and the virtual unavailability of funds in the NIH Institute of General Medical Sciences all in one year has been devastating. I need not emphasize to you as a scientist that research, training and commitments to students and scientific collaborators cannot be turned off and on without notice. If, as a matter of national policy, we would like to reduce or wind down our research competence in the most highly qualified universities, then this should at least be done gradually and humanely. To do it in the present thoughtless and really brutal manner is almost unthinkable, and yet this is precisely what is happening. Somehow, I believe that it is being done out of ignorance rather than malice, and it is for this reason that I am writing to you with a very concrete proposal which, if implemented very quickly, may at least give us a short breathing spell during which the situation can be reconsidered or, at the least, give the opportunity to some of the major chemistry departments to wind down a substantial portion of their research in a less traumatic manner.

My suggestion is that an emergency allocation be made immediately to the NSF whereby it would be able to fund approximately fifty percent rather than twenty percent of meritorious new grant applications and, even more importantly, to enable the NSF to fund all of the currently approved and pending (but not funded) grant applications of the NIH Institute of General Medical Sciences. By accepting the fact that all of these latter applications have already gone through the entire screening mechanism of the NIH and have already been rated and

Dr. H. Guyford Stever

May 2, 1973

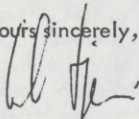
Page 3

approved by the council, it would not be necessary for the NSF staff to carry out any further scrutiny of these proposals. These applications have been pending since the last NIH Council Meeting last fall and, in fact, a new batch must clearly now be lying around without any prospect for any action.

I believe that this problem is either unique or particularly serious in chemistry, notably organic chemistry, because this is the discipline in which NSF should have played a major role in the past but never has because of insufficient funding. The reason that not much noise has been made about this in the past is that the NIH has filled this void very efficiently and many investigators were dependent almost exclusively upon the NIH, even though from a national policy standpoint such research should have been supported by the NSF. Many of my best known colleagues here at Stanford, at Columbia, Harvard and Berkeley receive seventy to ninety percent of their research support from the NIH (predominantly the Institute of General Medical Sciences). In my own case, during the last ten years the support of the NSF has been so small as to be practically insignificant and, if it had not been for the past generous support of the NIH, and especially the Institute of General Medical Sciences, I could have stopped research long ago and so could have many of my colleagues.

I simply cannot believe that it is a matter of national policy currently to reduce to a noncritical level the research and training competence in chemistry of the dozen or so leading institutions in this country. I would welcome your reply and sympathetic consideration.

Yours sincerely,



Carl Djerassi
Professor of Chemistry

CD:ab

cc: Sen. Alan Cranston
Sen. John Tunney

Senator KENNEDY. The subcommittee stands adjourned.

[Whereupon, at 12:36 p.m. the subcommittee was adjourned, to be reconvened at the call of the Chair.]

APPENDICES

APPENDIX A

TRANSFER OF FUNCTIONS OF THE OFFICE OF SCIENCE AND TECHNOLOGY
TO THE DIRECTOR, NATIONAL SCIENCE FOUNDATION
BY REORGANIZATION PLAN NO. 1 OF 1973

Dorothy M. Bates
Analyst, Science and Technology
Science Policy Research Division
Library of Congress
February 15, 1973

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APPENDIX A

Fact Sheet: Reorganization plan no. 1 of 1973
Message to the Congress of the United States of January 26, 1973, transmitting Reorganization plan no. 1 of 1973.
Reorganization plan no. 1 of 1973
NSF press release: Transfer of OST functions to Director of NSF, January 26, 1973

APPENDIX B

Selected References -- Transfer of Functions of the Office of Science and Technology to the Director, National Science Foundation by Reorganization Plan No. 1 Of 1973
--

CRS - 1

TRANSFER OF FUNCTIONS OF THE OFFICE OF SCIENCE AND TECHNOLOGY
TO THE DIRECTOR, NATIONAL SCIENCE FOUNDATION
BY REORGANIZATION PLAN NO. 1 OF 1973

Summary of Reorganization Plan No. 1 of 1973

Reorganization Plan no. 1 of 1973, which was transmitted to the Congress on January 26, 1973, 1/ if allowed to go into effect will shift existing operational and program functions for emergency preparedness and scientific and technological affairs from the Executive Office of the President into the line departments and agencies of the Government.

Section 1 of the plan transfers functions presently vested in the Office of Emergency Preparedness or the Director to the President.

Section 2 transfers functions vested in the Office of Science and Technology or its Director to the Director of the National Science Foundation.

Section 3 abolishes the following units of the Executive Office: the Office of Emergency Preparedness and the membership of the Director of the Office of Emergency Preparedness on the National Security Council; the Civil Defense Advisory Council; the National Aeronautics and Space Council, including the office of Executive Secretary to the Council; and the Office of Science and Technology, including the offices of Director and Deputy Director.

The Director of the Office of Management and Budget is directed by Sections 3(b) and 4 to make necessary provisions for winding up the outstanding affairs of the affected agencies; to arrange for transfers of personnel, property, records, and unexpended funds of those functions which are transferred to the President and the Director of the National Science Foundation; and to take further necessary measures to implement these transfers.

Section 5 provides that the plan shall be effective as provided by the Reorganization Act of 1949, section 906(a) of title 5 of the United States Code, or on July 1, 1973, whichever is later.

1/ Texts of the President's message to Congress transmitting the plan and of the plan itself and related documents are reproduced in Appendix A.

General procedure for Congressional action on reorganization plans

Under the Reorganization Act of 1949, as amended 2/, the President transmits a reorganization plan to the Congress together with a declaration that it is necessary to accomplish better administration, efficiency, economy, etc. Congress then has 60 days in which to act on the plan; this period is extended by any House or Senate adjournment of more than 3 days. Reorganization plans are referred to the appropriate committee in each House which under present rules is the Committee on Government Operations. The committee holds hearings on the plan and reports its recommendations. Unless a majority of either House rejects the plan by adopting a disapproving resolution within the 60-day period, the plan takes effect, and has the force and effect of law. In the case of Reorganization Plan No. 1, the effective date is at the end of the 60-day period or July 1, 1973, whichever is later. The 60-day period will expire well before July 1, 1973; the later date was set to allow time for an effective transition to be planned and executed.

To disapprove a reorganization plan, a disapproving resolution must be introduced by any member of either House. The resolution is referred to the Committee on Government Operations of that House which has 20 days after the introduction of the resolution to consider and report its recommendation concerning the plan. The disapproving resolution is then presented for consideration by all the members of that body.

No amendment of a Reorganization Plan by Congress, is permitted under the present statute. Congress has only the option of approving or rejecting a plan in its entirety. A negative vote on the disapproving resolution is a vote in favor of

2/ 5 U.S.C. 901-913 [1970 ed.], as amended by P.L. 92-179 of Dec. 10, 1971.

the plan; a favorable vote on a disapproving resolution by a majority in either House would prevent the plan from coming into force.

Hearings will be held on Reorganization Plan No. 1 of 1973

The chairman of the Subcommittee on Executive Reorganization and Government Research of the Senate Committee on Government Operations announced on February 1, 1973, that the Subcommittee will hold a hearing on Reorganization Plan No. 1 of 1973 on February 22, 1973.

The Legislative and Military Operations Subcommittee of the House Committee on Government Operations will hold a hearing on the reorganization plan on February 26, 1973.

No disapproving resolutions have been introduced in either House through February 8, 1973.

Rationale for Reorganization Plan No. 1 of 1973

The message to the Congress accompanying Reorganization Plan No. 1 of 1973 explained that the reorganization plan is part of a three-part program announced by the President on January 5, 1973 to streamline the executive branch of the Federal Government. 3/ The components of the program are:

1. A renewed drive to achieve passage of Administration legislative proposals to overhaul the major Cabinet departments.
2. The designation of three Cabinet Secretaries as Counsellors to the President with coordinating responsibilities in the broad areas of human resources, natural resources, and community development, and five Assistants to the President with special responsibilities in the areas of domestic affairs, economic affairs, foreign affairs, executive management, and operations of the White House.

It appears that these three Counsellors and five Assistants will serve as immediate links with the President for all facets of Government activity. Through them will be channelled matters from all the departments and agencies which require Presidential attention.

3. A sharp reduction in the overall size of the Executive Office of the President and a reorientation of that office to its original mission as a staff for top-level policy formation and monitoring of policy execution in broad functional areas.

Reorganization Plan No. 1 of 1973 would remove a total of 389 jobs from the Executive Office (OEP 323; OST, 50; and NASC, 16). This plan and

3/ U.S. President. Redirecting Executive Branch Management. Statement. . . January 5, 1973. Weekly Compilation of Presidential Documents, v. 9, Jan. 8, 1973; 5-10.

other recent and future actions should result in the reduction of the EXOP staff by approximately 60 percent (from 4,250 to 1,686) by the end of FY 1974.

It should be noted that removal of these offices from the EXOP will not cut all these positions from the Federal payroll. In all cases, it is contemplated that certain functions and some of the former staff will be transferred with the functions. OEP functions are expected to be delegated to HUD, GSA, and Treasury. NASA will take over the functions of the NASC. It is expected that at least some of the present OST staff will be picked up by the NSF.

The remainder of this memorandum will discuss only that part of the plan relating to OST and NSF.

"Streamlining the Federal science establishment."

The first paragraph in the President's message to Congress transmitting Reorganization Plan No. 1 of 1973 outlined how the Office of Science and Technology came to be established and given authority formerly vested in the National Science Foundation. 4/

4/ The following information provides additional historical details concerning the establishment of OST. The Office of Science and Technology was established by Reorganization Plan No. 2 of 1962, which went into effect on June 8, 1962. Part I of the Plan established the Office of Science and Technology and transferred from the National Science Foundation to the Director of the new office:

(1) So much of the functions conferred upon the Foundation by the provisions of section 3(a)(1) of the National Science Foundation Act of 1950 (42 U.S.C. 1862 (a)(1)) [which reads: 'to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences;'] as will enable the Director [of OST] to advise and assist the President in achieving coordinated Federal policies for the promotion of basic research and education in the sciences.

(2) The functions conferred upon the Foundation by that part of section 3(a)(6) of the National Science Foundation Act of 1950 (42 U.S.C. 1862(a)(6)) which reads as follows: "to evaluate scientific research programs undertaken by agencies of the Federal Government." [The complete text of section 3(a)(6) was "to evaluate scientific research programs undertaken by agencies of the Federal Government, and to correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research groups;"]

Part II of Reorganization Plan No. 2 of 1962 established a new Executive Committee of the National Science Board and a new office with the title of Director of the National Science Foundation. Part III of the Plan authorized the Director of the Bureau of the Budget to transfer such personnel, property, records, unexpended funds, etc. in connection with the transfer of the designated functions from the NSF as he shall determine.

In its report recommending that disapproving resolution H.Res. 595 not be passed, the House Committee on Government Operations noted that the National Science Foundation had not during its existence carried out its functions of evaluation and correlation of Federal scientific programs and cited two main reasons: "First, the Foundation has considered itself limited to the field of basic science research and education. This does not include technology and development involved in so much of the Federal programs. . . . A second reason is that to coordinate the work of other departments and agencies the coordinating office should have a rank and status that would easily secure the cooperation of those agencies. This is not now the case with the Foundation even with all of the important work it is doing."

When the National Science Foundation was established by an act of the Congress in 1950, its statutory responsibilities included evaluation of the Government's scientific research programs and development of basic science policy. In the late 1950's, however, with the effectiveness of the U.S. science effort under serious scrutiny as a result of Sputnik, the post of Science Adviser to the President was established. The White House became increasingly involved in the evaluation and coordination of research and development programs and in science policy matters, and that involvement was institutionalized in 1962 when a reorganization plan established the Office of Science and Technology within the Executive Office of the President, through transfer of authorities formerly vested in the National Science Foundation.

The President's message next gave the rationale for abolishing OST and transferring its functions back to NSF: It said:

With advice and assistance from OST during the past decade, the scientific and technological capability of the Government has been markedly strengthened. This Administration is firmly committed to a sustained, broad-based national effort in science and technology, as I made plain last year in the first special message on the subject ever sent by a President to the Congress. The research and development capability of the various executive departments and agencies, civilian as well as defense, has been upgraded. The National Science Foundation has broadened from its earlier concentration on basic research support to take on a significant role in applied research as well. It has matured in its ability to play a coordinating and evaluative role within the Government and between the public and private sectors.

The committee concluded, "In the light of these factors it seems quite appropriate that the evaluation and coordinating functions be put in an office such as contemplated by this reorganization plan. The new Office of Science and Technology will be located in the Executive Office of the President and its Director will also be an adviser to the President. This should give him the status and power necessary to screen proposed projects, to choose between competing programs, and recommend the cancellation of programs no longer feasible or practicable. This should result in making our scientific work more efficient and economical. Members of Congress have often deplored the duplication, overlapping, and waste in so many of our research and development programs. This plan offers the possibility of tremendous savings." U.S. Congress. House. Committee on Government Operations. Approving Reorganization Plan No. 2 of 1962 (Office of Science and Technology - National Science Foundation); Report to accompany H.Res. 595. Washington, U.S. Govt. Print. Off., 1962. (87th Congress, 2d session. House. Report no. 1635) 12 p.

I have therefore concluded that it is timely and appropriate to transfer to the Director of the National Science Foundation all functions presently vested in the Office of Science and Technology, and to abolish that office. Reorganization Plan No. 1 would effect these changes.

Next, the message explained the new responsibilities of the Director of NSF and the NSF staff. These are discussed below.

The final part of the message treated the abolition of the National Aeronautics and Space Council whose mission is regarded as largely accomplished.

New Responsibilities of the NSF Director and NSF Staff

Dr. Stever to be named Science Adviser. In addition to the transfer to him of responsibility for former OST functions, the President announced his intention to request the current Director of the Foundation, Dr. H. Guyford Stever, to take on the additional post of Science Adviser. In this capacity, Dr. Stever would "advise and assist the White House, Office of Management and Budget, Domestic Council, and other entities within the Executive Office of the President on matters where scientific and technological expertise is called for, and would act as the President's representative in selected cooperative programs in international scientific affairs, including chairing such joint bodies as the U.S.-U.S.S.R. Joint Commission on Scientific and Technical Cooperation." Dr. Stever told the press, however, that he would not be Science Adviser to the President. So the position of personal science adviser to the President which was created after Sputnik will now disappear from the scene.

Responsibility for military technology, etc. not transferred to Director, NSF.

In matters relating to national security, weapons development, and military technology, etc., the message states that the President will continue to draw on the capabilities of the Department of Defense and the machinery of the National Security Council. However, the Science Adviser may be called upon in special situations, "when appropriate."

Summary of NSF Director's responsibilities with respect to civilian research and development. Dr. Stever's responsibilities with respect to civilian research and development were spelled out in NSF press release 73-104 of January 26, 1973, entitled "Transfer of OST functions to Director of NSF" as follows:

The Director of the Foundation would, with respect to civilian research and development:

- Appraise the overall effectiveness of ongoing Federal and National R&D efforts to advance national goals through science and technology.

- Make recommendations on policy and program actions necessary to achieve these national goals through science and technology. The Director of the Foundation would form an Office of Science Policy to consider such matters. The Director would report to the President through George P. Shultz, Assistant to the President.

The NSF would continue OST emphasis on the science and technology base for national domestic R&D in such fields as energy, natural resources, health, social systems, transportation, communications, education, and participation in international programs in which science and technology are vital elements.

- The Director of the National Science Foundation, Dr. H. Guyford Stever, would serve as a focal point for the President in interaction with the academic and industrial science communities on broad matters of science policy, as well as in selected cooperative programs with the international science community. He would serve as Chairman of the U.S.-U.S.S.R. Joint Commission on Scientific and Technical Cooperation.
- A Science Policy Council within the Federal Government would be formed to consider policy problems in science and technology, which affect more than one Federal agency or which concern the overall advancement of the Nation's science and technology.

The Chairman of the Science Policy Council would be the Director of the National Science Foundation. Membership of the Council would be composed of policy level individuals from Federal departments and agencies.

Dr. Stever to Report to the President through the Special Assistant to the President for Economic Affairs. The press release quoted above, contained the first formal notice that Dr. Stever would report to the President on matters relating to his new policy role through George P. Shultz, Assistant to the President for Economic Affairs. Mr. Shultz is also Secretary of the Treasury. In addition, he is Chairman of the new Council on Economic Policy which was established in the Executive Office of the President in December 1972. It is not entirely clear whether Dr. Stever will be reporting to Mr. Shultz on all NSF matters, including its budget, or only as Science Adviser.

Possibility of the Director invoking executive privilege. In his role as Science Adviser and reporting to a Special Assistant to the President, there is a possibility that the Director of NSF will be less available to inform Congress concerning his activities than was the Director of the Office of Science and Technology.

When questioned whether he might feel obliged to invoke executive privilege on certain matters, Dr. Stever admitted that this was a possibility.

Conflicts of interest arising out of the dual role of the Director. It is presently unclear what may happen when conflicts arise between the Director's responsibilities as head of an independent agency and as Science Adviser. Dr. Stever noted that Mr. Shultz as Secretary of the Treasury and Special Assistant to the President for Economic Affairs would face similar problems.

Role of the National Science Board Unclear

It is considered significant that the reorganization plan transfers the functions of the Office of Science and Technology to the Director of the National Science Foundation, and not to the National Science Foundation per se. The legislation establishing the National Science Foundation defined the Foundation as consisting of a National Science Board and a Director. Neither the reorganization plan nor the President's message mentioned the National Science Board; what its role will be is not yet known. The Director of the Foundation stated at the press briefing of January 26, 1973, that members of the National Science Board had been briefed on the plan and that they support the proposed transfer.

NSF Staff to Perform Transferred Functions. As indicated in the President's message, the functions transferred from OST are expected to be performed by the already existing staff of the Foundation, which the Director may augment by drawing upon expertise from all the Federal agencies, as well as from outside the Government.

Office of Science Policy to be established in NSF. The NSF press release of Jan. 26, 1973 notes that the Director will establish an Office of Science Policy whose functions will include the appraisal of the overall effectiveness of Federal and National R&D efforts to advance national goals through science and technology and to make recommendations on policy and program actions necessary to achieve these goals through science and technology.

The NSF is requesting \$2 million for planning and policy studies during fiscal year 1974. This is the same amount which it expects to obligate during fiscal year 1973 and so shows no increase to accommodate the support to the new Office of Science Policy.

It is understood that no new money is being requested to carry out the new responsibilities. The Director has indicated that he expects studies in several

ongoing NSF programs (Science resources studies, science policy and planning analysis and program evaluation studies, national R&D assessment studies, experimental R&D incentives studies, and technology assessment studies) will be relevant. He noted that NSF has a great deal more in administrative support for the new functions than did the OST. He also indicated that approximately twenty of the additional positions NSF has been given in the FY 74 budget may be made available to take over the new activities.

Science Policy Council expected to replace Federal Council for Science and Technology

Dr. Stever told the press on January 26, 1973, that the Federal Council for Science and Technology is expected to be replaced on July 1, 1973, by the new Science Policy Council which he has been directed to establish and chair. He noted that the activity of the FCST would require reexamination, that the Science Policy Council would have many of the same functions of FCST, but that it will operate differently, and it will not be in the Executive Office.

Continuation of President's Science Advisory Committee

Whether the President's Science Advisory Committee will be continued when the Reorganization Plan goes into effect is not known at this time. The President's Science Advisory Committee has been a part of the White House since President Dwight D. Eisenhower enlarged and reconstituted the Science Advisory Committee of the Office of Defense Mobilization, effective November 22, 1957. Details were announced in a White House statement of November 29, 1957. The Director of the Office of Science and Technology has regularly been elected chairman of the non-governmental 18-member advisory committee.

Does the move represent a downgrading of science in the White House?

Many observers have interpreted the elimination of a science office from the Executive Office and the transfer of its functions to a line agency as representing a public downgrading of science and technology. An editorial in the New York Times pointed out that despite the important scientific and technical components of many of the major problems President Nixon faces daily, he has nevertheless removed from the Executive Office an immediate source of advice. "The practical effect of the President's action," the editorial noted, "is to handicap him in getting first-class scientific advice quickly when he needs it. His action also inevitably represents a public downgrading of science and technology. Yet the United States is powerful and prosperous today only because it has made such effective, large-scale use of scientific knowledge in all civilian and military fields." 5/

When questioned on this point, Dr. Stever replied, "It is not the intent of the President and his staff to downgrade science. Whether or not that is the effect can only be proven by how well we do. In some ways this arrangement has more capability than the previous one. NSF has a larger staff and also grantmaking and contracting authority for science policy studies. NSF expects to use this as added strength." 6/

In response to a question concerning the capability of the NSF to implement the plan, Dr. Stever stated firmly that if the people involved have the will to make it work, it will work. "Our job is to make it work," he said.

5/ Downgrading Science. New York Times, Feb. 7, 1973: 34

6/ NSF press briefing, January 26, 1973

APPENDIX A

Fact Sheet: Reorganization plan no. 1 of 1973

Message to the Congress of the United States of January 26, 1973, transmitting
Reorganization plan no. 1 of 1973

Reorganization plan no. 1 of 1973

NSF press release: Transfer of OST functions to Director of NSF, January 26, 1973

FOR RELEASE:

Jack Renirie
(202) 632-5728
Home: XXXXXXXXXXXXXXXX

IMMEDIATE
Mailed: January 26, 1973
NSF 73-104

TRANSFER OF OST FUNCTIONS

TO DIRECTOR OF NSF

In keeping with the President's announced intention of reducing the overall size of his Executive Office and making greater use of Departments and Agencies, the President has proposed to Congress to abolish the Office of Science and Technology and transfer its functions to the Director of the National Science Foundation.

Setting forth the Reorganization Plan, the White House said, "With a growing range of capability in the NSF, the President will now look to its Director as a principal advisor in science and technology matters."

In his message to the Congress transmitting the Reorganization Plan, the President further said, "It is also my intention, after the transfer of responsibilities is effected, to ask Dr. H. Guyford Stever, the current Director of the Foundation, to take on the additional post of Science Adviser. In this

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capacity, he would advise and assist the White House, Office of Management and Budget, Domestic Council, and other entities within the Executive Office of the President on matters where scientific and technological expertise is called for, and would act as the President's representative in selected cooperative programs in international scientific affairs, including chairing such joint bodies as the U.S.-U.S.S.R. Joint Commission on Scientific and Technical Cooperation."

The Director of the Foundation would, with respect to civilian research and development:

- Appraise the overall effectiveness of ongoing Federal and National R&D efforts to advance national goals through science and technology
- Make recommendations on policy and program actions necessary to achieve these national goals through science and technology. The Director of the Foundation would form an Office of Science Policy to consider such matters. The Director would report to the President through George P. Shultz, Assistant to the President.

The NSF would continue OST emphasis on the science and technology base for national domestic R&D in such fields as energy, natural resources, health, social systems, transportation, communications, education, and participation in international programs in which science and technology are vital elements.

- The Director of the National Science Foundation, Dr. H. Guyford Stever, would serve as a focal point for the President in interaction with the academic and industrial science communities on broad matters of science policy, as well as in selected cooperative programs with the international science community. He would serve as Chairman of the U.S.-U.S.S.R. Joint Commission on Scientific and Technical Cooperation.
- A Science Policy Council within the Federal Government would be formed to consider policy problems in science and technology, which affect more than one Federal agency or which concern the overall advancement of the Nation's science and technology.

The Chairman of the Science Policy Council would be the Director of the National Science Foundation. Membership of the Council would be composed of policy level individuals from Federal departments and agencies.

The dedicated efforts of the many outstanding scientists and engineers, who, as members and consultants of the President's Science Advisory Committee and the Office of Science and Technology, over the years, have worked to help shape the directions of science and direct the efforts of science and engineering to the solution of national problems are widely recognized and appreciated. It is expected that many of these outstanding individuals will continue to be called upon to render their valuable advice and services.

- END -

EMBARGOED FOR RELEASE
UNTIL 12:00 NOON, EST

January 26, 1973

Office of the White House Press Secretary

THE WHITE HOUSE

FACT SHEET

REORGANIZATION PLAN NO. 1 OF 1973

The President is today transmitting to the Congress Reorganization Plan No. 1 of 1973 which will achieve the following objectives:

1. The Office of Emergency Preparedness (OEP) will be abolished and its functions transferred to other line agencies;
2. the Office of Science and Technology (OST) will be abolished and its functions transferred to the Director of the National Science Foundation (NSF);
3. the National Aeronautics and Space Council will be abolished.

On January 5, 1973, the President announced a comprehensive program for the Executive Branch which includes a sharp reduction in the overall size of the Executive Office of the President, and a reorientation of that office back to its basic purpose of assisting the President in top level policy and management matters. This reduction will be achieved through budget or other administrative means or by the issuance of Executive Orders. Where necessary changes require consideration by the Congress, appropriate actions will be forwarded. This Reorganization Plan represents a major step in that direction.

Implementation of Reorganization Plan No. 1 of 1973 will achieve the following objectives:

- it eliminates three organizations in the Executive Office of the President;
- it reduces the numbers of employees in the Executive Office by 389 positions (from an estimated 4,250 to 3,861), and achieves an estimated \$2,000,000 in budget savings;
- it transfers necessary continuing functions to line departments and agencies where they can be better performed;
- it streamlines the Executive Office and contributes to making it more effective and responsive to Presidential needs.

The following specific actions will be taken:

1. Office of Science and Technology

This office will be abolished and its functions transferred to the Director of the National Science Foundation.

OST has performed with distinction since its creation in 1962, during the post-Sputnik period when major evaluation and coordination of science and technology programs was

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vital. Increasingly, the research and development capabilities in line departments and agencies have been upgraded and our R & D programs have stabilized. With a growing range of capability in the NSF, the President will now look to its Director as a principal advisor in science and technology matters.

2. The National Aeronautics and Space Council

NASC, under the leadership of the Vice President, has helped bridge a period of time when our Space programs were being defined and brought into being. We now, however, have effective resolutions of our space and aeronautics objectives and have achieved necessary coordination among the agencies concerned. We are, therefore, able to abolish the Council at this time with no transfer of its functions.

3. The Office of Emergency Preparedness

The Office of Emergency Preparedness will be abolished in a two-step process:

First, the present authority of OEP consists mainly of authorities delegated to it by the President, plus certain statutory functions assigned to the Director.

The Reorganization Plan will transfer those statutory functions not already vested in the President to him.

Second, after the Reorganization Plan becomes effective, the President will then delegate all of the functions now performed by OEP in the following manner:

- a. All OEP responsibilities having to do with preparedness for, and relief of civil emergencies and disasters would be transferred to the Department of Housing and Urban Development. This would provide greater field capability for coordination of assistance provided by Federal agencies with that furnished by states and local communities and would further the objective of creating a broad new Department of Community Development.
- b. OEP's responsibilities for measures to insure continuity of civil government operations in the event of major military attack would be reassigned to the General Services Administration (GSA), as would responsibility for management of national security stockpile objectives and policy. Coordination of these responsibilities would be provided by the National Security Council and the Council on Economic Policy respectively.
- c. Investigations of imports which might impair national security (Sec. 232 of the Trade Expansion Act of 1962) will be reassigned to the Treasury Department. These investigations result in reports making recommendations to the President for his action.
- d. The Oil Policy Committee will continue to function as it does now, except that the Deputy Secretary of the Treasury will be designated to replace the Director, OEP, as committee chairman. The Oil Policy Committee will function under the general supervision of the Assistant to the President (Dr. Shultz) concerned with economic affairs.

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Those disaster relief authorities which have been reserved to the President in the past, such as the authority to declare major disasters, would continue to be exercised by him under these arrangements. Certain emergency situations calling for rapid government response will be coordinated by the Executive Office of the President under the supervision of the Assistant to the President in charge of executive management.

The background and current resources of the affected agencies are varied and diverse. The Office of Emergency Preparedness is the successor to several preceding organizations dating from 1947, and it has an estimated FY 73 budget in excess of \$6.3 million and permanent employment of 323 persons. The Office of Science and Technology was established in 1962, also the successor to related previous organizations, and its estimated FY 73 budget is over \$2 million and permanent employment is 50 persons. The National Aeronautics and Space Council was created in 1958, and has an estimated FY 73 budget of \$500 thousand, with a permanent employment of 16 persons.

Reorganization Plans of this kind are provided for under special reorganization authority. The Plan will be considered for 60 days in both Houses of Congress, and will become legally effective after 60 days, unless either House formally disapproves. Actual change of agency responsibility will take place July 1, 1973, to allow time for an effective transition to be planned and executed after the period of Congressional review.

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Office of the White House Press Secretary

THE WHITE HOUSE

TO THE CONGRESS OF THE UNITED STATES:

On January 5 I announced a three-part program to streamline the executive branch of the Federal Government. By concentrating less responsibility in the President's immediate staff and more in the hands of the departments and agencies, this program should significantly improve the services of the Government. I believe these reforms have become so urgently necessary that I intend, with the cooperation of the Congress, to pursue them with all of the resources of my office during the coming year.

The first part of this program is a renewed drive to achieve passage of my legislative proposals to overhaul the Cabinet departments. Secondly, I have appointed three Cabinet Secretaries as Counsellors to the President with coordinating responsibilities in the broad areas of human resources, natural resources, and community development, and five Assistants to the President with special responsibilities in the areas of domestic affairs, economic affairs, foreign affairs, executive management, and operations of the White House.

The third part of this program is a sharp reduction in the overall size of the Executive Office of the President and a reorientation of that office back to its original mission as a staff for top-level policy formation and monitoring of policy execution in broad functional areas. The Executive Office of the President should no longer be encumbered with the task of managing or administering programs which can be run more effectively by the departments and agencies. I have therefore concluded that a number of specialized operational and program functions should be shifted out of the Executive Office into the line departments and agencies of the Government. Reorganization Plan No. 1 of 1973, transmitted herewith, would effect such changes with respect to emergency preparedness functions and scientific and technological affairs.

STREAMLINING THE FEDERAL SCIENCE ESTABLISHMENT

When the National Science Foundation was established by an act of the Congress in 1950, its statutory responsibilities included evaluation of the Government's scientific research programs and development of basic science policy. In the late 1950's, however, with the effectiveness of the U.S. science effort under serious scrutiny as a result of Sputnik, the post of Science Adviser to the President was established. The White House became increasingly involved in the evaluation and coordination of research and development programs and in science policy matters, and that involvement was institutionalized in 1962 when a reorganization plan established the Office of Science and Technology within the Executive Office of the President, through transfer of authorities formerly vested in the National Science Foundation.

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With advice and assistance from OST during the past decade, the scientific and technological capability of the Government has been markedly strengthened. This Administration is firmly committed to a sustained, broad-based national effort in science and technology, as I made plain last year in the first special message on the subject ever sent by a President to the Congress. The research and development capability of the various executive departments and agencies, civilian as well as defense, has been upgraded. The National Science Foundation has broadened from its earlier concentration on basic research support to take on a significant role in applied research as well. It has matured in its ability to play a coordinating and evaluative role within the Government and between the public and private sectors.

I have therefore concluded that it is timely and appropriate to transfer to the Director of the National Science Foundation all functions presently vested in the Office of Science and Technology, and to abolish that office. Reorganization Plan No. 1 would effect these changes.

The multi-disciplinary staff resources of the Foundation will provide analytic capabilities for performance of the transferred functions. In addition, the Director of the Foundation will be able to draw on expertise from all of the Federal agencies, as well as from outside the Government, for assistance in carrying out his new responsibilities.

It is also my intention, after the transfer of responsibilities is effected, to ask Dr. H. Guyford Stever, the current Director of the Foundation, to take on the additional post of Science Adviser. In this capacity, he would advise and assist the White House, Office of Management and Budget, Domestic Council, and other entities within the Executive Office of the President on matters where scientific and technological expertise is called for, and would act as the President's representative in selected cooperative programs in international scientific affairs, including chairing such joint bodies as the U.S.-U.S.S.R. Joint Commission on Scientific and Technical Cooperation.

In the case of national security, the Department of Defense has strong capabilities for assessing weapons needs and for undertaking new weapons development, and the President will continue to draw primarily on this source for advice regarding military technology. The President in special situations also may seek independent studies or assessments concerning military technology from within or outside the Federal establishment using the machinery of the National Security Council for this purpose, as well as the Science Adviser when appropriate.

In one special area of technology -- space and aeronautics -- a coordinating council has existed within the Executive Office of the President since 1958. This body, the National Aeronautics and Space Council, met a major need during the evolution of our nation's space program. Vice President Agnew has served with distinction as its chairman for the past four years. At my request, beginning in 1969, the Vice President also chaired a special Space Task Group charged with developing strategy alternatives for a balanced U.S. space program in the coming years.

As a result of this work, basic policy issues in the United States space effort have been resolved, and the necessary interagency relationships have been established.

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I have therefore concluded, with the Vice President's concurrence, that the Council can be discontinued. Needed policy coordination can now be achieved through the resources of the executive departments and agencies, such as the National Aeronautics and Space Administration, augmented by some of the former Council staff. Accordingly, my reorganization plan proposes the abolition of the National Aeronautics and Space Council.

A NEW APPROACH TO EMERGENCY PREPAREDNESS

The organization within the Executive Office of the President which has been known in recent years as the Office of Emergency Preparedness dates back, through its numerous predecessor agencies, more than 20 years. It has performed valuable functions in developing plans for emergency preparedness, in administering Federal disaster relief, and in overseeing and assisting the agencies in this area.

OEP's work as a coordinating and supervisory authority in this field has in fact been so effective -- particularly under the leadership of General George A. Lincoln, its director for the past four years, who retired earlier this month after an exceptional military and public service career -- that the line departments and agencies which in the past have shared in the performance of the various preparedness functions now possess the capability to assume full responsibility for those functions. In the interest of efficiency and economy, we can now further streamline the Executive Office of the President by formally relocating those responsibilities and closing the Office of Emergency Preparedness.

I propose to accomplish this reform in two steps. First, Reorganization Plan No. 1 would transfer to the President all functions previously vested by law in the Office or its Director, except the Director's role as a member of the National Security Council, which would be abolished; and it would abolish the Office of Emergency Preparedness.

The functions to be transferred to the President from OEP are largely incidental to emergency authorities already vested in him. They include functions under the Disaster Relief Act of 1970; the function of determining whether a major disaster has occurred within the meaning of (1) Section 7 of the Act of September 30, 1950, as amended, 20 U.S.C. 241-1, or (2) Section 762 (a) of the Higher Education Act of 1965, as added by Section 161 (a) of the Education Amendments of 1972, Public Law 92-318, 86 Stat. 288 at 299 (relating to the furnishing by the Commissioner of Education of disaster relief assistance for educational purposes), and functions under Section 232 of the Trade Expansion Act of 1962, as amended (19 U.S.C. 1862), with respect to the conduct of investigations to determine the effects on national security of the importation of certain articles.

The Civil Defense Advisory Council within OEP would also be abolished by this plan, as changes in domestic and international conditions since its establishment in 1950 have now obviated the need for a standing council of this type. Should advice of the kind the Council has provided be required again in the future, State and local officials and experts in the field can be consulted on an ad hoc basis.

Secondly, as soon as the plan became effective, I would delegate OEP's former functions as follows:

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- All OEP responsibilities having to do with preparedness for and relief of civil emergencies and disasters would be transferred to the Department of Housing and Urban Development. This would provide greater field capabilities for coordination of Federal disaster assistance with that provided by states and local communities, and would be in keeping with the objective of creating a broad, new Department of Community Development.
- OEP's responsibilities for measures to ensure the continuity of civil government operations in the event of major military attack would be reassigned to the General Services Administration, as would responsibility for resource mobilization including the management of national security stockpiles, with policy guidance in both cases to be provided by the National Security Council, and with economic considerations relating to changes in stockpile levels to be coordinated by the Council on Economic Policy.
- Investigations of imports which might threaten the national security -- assigned to OEP by Section 232 of the Trade Expansion Act of 1962 -- would be reassigned to the Treasury Department, whose other trade studies give it a ready-made capability in this field; the National Security Council would maintain its supervisory role over strategic imports.

Those disaster relief authorities which have been reserved to the President in the past, such as the authority to declare major disasters, will continue to be exercised by him under these new arrangements. In emergency situations calling for rapid interagency coordination, the Federal response will be coordinated by the Executive Office of the President under the general supervision of the Assistant to the President in charge of executive management.

The Oil Policy Committee will continue to function as in the past, unaffected by this reorganization, except that I will designate the Deputy Secretary of the Treasury as chairman in place of the Director of OEP. The Committee will operate under the general supervision of the Assistant to the President in charge of economic affairs.

DECLARATIONS

After investigation, I have found that each action included in the accompanying reorganization plan is necessary to accomplish one or more of the purposes set forth in Section 901 (a) of title 5 of the United States Code. In particular, the plan is responsive to the intention of the Congress as expressed in Section 901 (a) (1), "to promote better execution of the laws, more effective management of the executive branch and of its agencies and functions, and expeditious administration of the public business;" and in Section 901 (a) (3), "to increase the efficiency of the operations of the Government to the fullest extent practicable;" and in Section 901 (a) (5), "to reduce the number of agencies by consolidating those having similar functions under a single head, and to abolish such agencies or functions as may not be necessary for the efficient conduct of the Government."

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While it is not practicable to specify all of the expenditure reductions and other economies which will result from the actions proposed, personnel and budget savings from abolition of the National Aeronautics and Space Council and the Office of Science and Technology alone will exceed \$2 million annually, and additional savings should result from a reduction of Executive Pay Schedule positions now associated with other transferred and delegated functions.

The plan has as its one logically consistent subject matter the streamlining of the Executive Office of the President and the disposition of major responsibilities currently conducted in the Executive Office of the President, which can better be performed elsewhere or abolished.

The functions which would be abolished by this plan, and the statutory authorities for each, are:

- (1) the functions of the Director of the Office of Emergency Preparedness with respect to being a member of the National Security Council (Sec. 101, National Security Act of 1947, as amended, 50 U.S.C. 402; and Sec. 4, Reorganization Plan No. 1 of 1958),
- (2) the functions of the Civil Defense Advisory Council (Sec. 102 (a) Federal Civil Defense Act of 1950; 50 U.S.C. App. 2272 (a)) and
- (3) the functions of the National Aeronautics and Space Council (Sec. 201, National Aeronautics and Space Act of 1958; 42 U.S.C. 2471).

The proposed reorganization is a necessary part of the restructuring of the Executive Office of the President. It would provide through the Director of the National Science Foundation a strong focus for Federal efforts to encourage the development and application of science and technology to meet national needs. It would mean better preparedness for and swifter response to civil emergencies, and more reliable precautions against threats to the national security. The leaner and less diffuse Presidential staff structure which would result would enhance the President's ability to do his job and would advance the interests of the Congress as well.

I am confident that this reorganization plan would significantly increase the overall efficiency and effectiveness of the Federal Government. I urge the Congress to allow it to become effective.

RICHARD NIXON

THE WHITE HOUSE,

January 26, 1973.

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REORGANIZATION PLAN NO. 1 OF 1973

Prepared by the President and transmitted to the Senate and the House of Representatives in Congress assembled, January 26, 1973, pursuant to the provisions of Chapter 9 of Title 5 of the United States Code.

EXECUTIVE OFFICE OF THE PRESIDENT

Section 1. Transfer of functions to the President. Except as provided in section 3(a)(2) of this reorganization plan, there are hereby transferred to the President of the United States all functions vested by law in the Office of Emergency Preparedness or the Director of the Office of Emergency Preparedness after the effective date of Reorganization Plan No. 1 of 1958.

Sec. 2. Transfer of functions to the Director, National Science Foundation. There are hereby transferred to the Director of the National Science Foundation all functions vested by law in the Office of Science and Technology or the Director or Deputy Director of the Office of Science and Technology.

Sec. 3. Abolitions. (a) The following are hereby abolished:

(1) The Office of Emergency Preparedness including the offices of Director, Deputy Director, and all offices of Assistant Director, and Regional Director of the Office of Emergency Preparedness provided for by sections 2 and 3 of Reorganization Plan No. 1 of 1958 (5 U.S.C., App).

(2) The functions of the Director of the Office of Emergency Preparedness with respect to being a member of the National Security Council.

(3) The Civil Defense Advisory Council, created by section 102(a) of the Federal Civil Defense Act of 1950 (50 U.S.C. App. 2272(a)), together with its functions.

(4) The National Aeronautics and Space Council, created by section 201 of the National Aeronautics and Space Act of 1958 (42 U.S.C. 2471), including the office of Executive Secretary of the Council, together with its functions.

(5) The Office of Science and Technology, including the offices of Director and Deputy Director, provided for by sections 1 and 2 of Reorganization Plan No. 2 of 1962 (5 U.S.C., App).

(b) The Director of the Office of Management and Budget shall make such provisions as he shall deem necessary respecting the winding up of any outstanding affairs of the agencies abolished by the provisions of this section.

Sec. 4. Incidental transfers. (a) So much of the personnel, property, records, and unexpended balances of appropriations, allocations, and other funds employed, used, held, available, or to be made available in connection with the functions transferred by sections 1 and 2 of this reorganization plan as the Director of the Office of Management

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and Budget shall determine shall be transferred at such time or times as he shall direct for use in connection with the functions transferred.

(b) Such further measures and dispositions as the Director of the Office of Management and Budget shall deem to be necessary in order to effectuate the transfers referred to in subsection (a) of this section shall be carried out in such manner as he shall direct and by such agencies as he shall designate.

Sec. 5. Effective Date. The provisions of this reorganization plan shall take effect as provided by section 906(a) of title 5 of the United States Code, or on July 1, 1973, whichever is later.

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APPENDIX B

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BY REORGANIZATION PLAN NO. 1 OF 1973

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APPENDIX B

Science Report/Nixon reorganization raises questions about role of science in federal policy making

by Claude E. Barfield

A federal science advisory system that developed over the last 15 years has been swept away in a Presidential reorganization that raises questions about the future ability of the White House to obtain disinterested advice on scientific aspects of major public-policy issues.

Over the years, the system had provided an organized framework for channeling to the President the views of the nation's top scientists on issues ranging from expensive defense hardware projects to the supersonic transport aircraft, the nuclear fast breeder reactor and the chances of conquering cancer.

But in the past four years, it has not proved to be of great use to the White House, despite the increasing number of scientific issues of major economic consequence which have required a Presidential judgment.

Hearings now being held in Washington by the Environmental Protection Agency provide a current example of a major technological question requiring a government decision. At issue is the request of domestic automobile manufacturers for a delay in the requirement to install high-performance air pollution control devices on new cars, and the EPA-White House decision will have immense economic consequences for the companies and for the consumer.

Presidential action: President Nixon announced his plan to dismantle the science advisory structure on Jan. 26.

Two actions, outlined in Reorganization Plan No. 1 of 1973, would:

- abolish the White House Office of Science and Technology, and transfer its functions to the National Science Foundation;
- abolish the position of special assistant to the President for science, and transfer its functions to the director of the NSF.

In addition, the White House let it be known that it would abolish the prestigious President's Science Advisory Committee (PSAC), a group created in 1957 and composed of 18 top non-government scientists. Finally, the Administration plans to abolish, and then reconstitute in a different form, the Federal Council for Science and Technology, a federal interagency body established in 1959 to coordinate the government's scientific and technological activities.

The reorganization removes from the White House organization an office that was supposed to provide the

Two-Part Series

This is the first of two reports on the Nixon Administration's plans to reorganize the federal science advisory system.

President with an overview of federal R and D activities, scattered through dozens of federal agencies, advice on the allocation of federal R and D resources, and advice, where needed, on specific public-policy questions, such as the automotive pollution issue.

The advisory system's demise comes at a time of unprecedented demand for development and use of new technologies to meet domestic needs, especially in the fields of environment and energy, often at a high cost to society.

The President's decision raises a number of important questions about the federal science system:

- Should there be more coordination and control of the decentralized and diffuse federal research operations?
- Is there a need for some more structured priority-setting mechanisms at a time when federal R and D funding has leveled off, thus heightening interagency competition for research dollars?
- How can the government more successfully integrate scientific and technological considerations into top-level decision making?
- How can the President get inde-

pendent advice on technology-related questions, advice free from federal agency bias or interest-group pressure?

Administration rationale: Members of Congress and of the scientific community have expressed deep misgivings about what appears on the surface to be an estrangement of science from White House decision making.

To its critics, the Administration responds chiefly by arguing that the dismantling of the science structure makes sense in terms of efficient management of the executive branch.

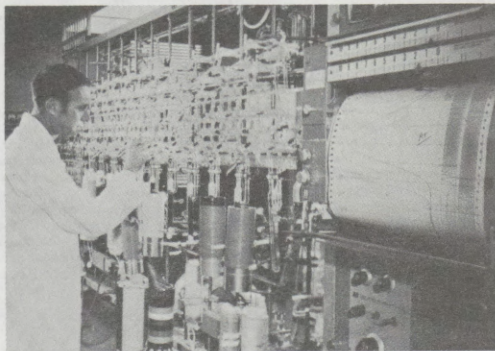
Administration leaders place the move in the context of an over-all effort to streamline the President's executive office and to remove from that office functions and agencies that are not crucial to Presidential decision making.

They say that the R and D capabilities of line departments and agencies has been upgraded in recent years and no longer needs close White House supervision, and argue that NSF is well suited to performing the functions previously lodged in the White House structure. Any requirement of independent advice of the kind provided by PSAC can be met through ad hoc, NSF-recruited panels of scientists, they say.

Edward E. David Jr., who was the last man to hold the science adviser's post, is a defender of the reorganization. David, who left the government on Dec. 29 to return to private industry, said: "I know some scientists, par-

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A scientist from an AEC radiation laboratory checks radiation levels resulting from an underground nuclear explosion to free natural gas

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ticularly those who have worked under the old system, are disturbed. Institutions are like children. People who bring them into being become fond of them and want to see them prosper; it's difficult for them to let go. But I think the new arrangements can be effective. And it's what the President wanted; that's the important thing."

NSF: Although the NSF is taking on new responsibilities that fall outside its area of traditional expertise, the fiscal 1974 budget gives it no new money and no new personnel to carry out these duties.

The agency traditionally has been the government's leading promoter of basic research in civilian fields; in fiscal 1974, some 83 per cent of its \$554-million research budget financed basic research in universities and other institutions. Only 17 per cent of the budget was targeted for applied research.

In contrast, only 15 per cent of the government's \$17.4 billion fiscal 1974 R and D budget is in basic research. Twenty-six per cent is spent on applied research, and the remaining 59 per cent on development of technologies that already have benefited from basic and applied research.

Although these figures show that the NSF will be stepping into unfamiliar terrain in any attempts to perform a policy-making function for all federal science activities, the agency's director, H. Guyford Stever, said on Jan. 26 that "NSF has the will and is capable of fulfilling the job." Stever said that "there are more resources in NSF than ever were assembled in OST" and that the agency would have a "clear channel of reporting and acting . . . a direct line to the Office of Management and Budget, and a direct line to Mr. Shultz for White House matters." George P. Shultz is assistant to the President for economic affairs, as well as Secretary of the Treasury.

Criticism: On the day the reorganization was announced, the Federation of American Scientists, whose 4,500 members include nearly half of the living U.S. winners of Nobel science prizes, issued a statement calling the move a "downgrading of science." The statement questioned the NSF's ability to serve "as a watchdog for the major science-related agencies," saying "only a collection of scientists in the White House can do that." The FAS also was highly critical of the abolishment of PSAC, which, it said, had been an "indispensable" Presidential



H. Guyford Stever

tool in "getting the facts and keeping the bureaucracy in line."

Philip B. Handler, president of the National Academy of Sciences, also expressed concern. "It's not the loss of 'our man in the White House' that I mourn," he said in an interview. "It's rather the seeming lack now of any independent mediating voice, above competing agencies and bureaucracies, to set forth scientifically sound options for policy."

Leading science specialists in Congress, including Rep. John W. Davis, D-Ga., and Sen. Edward M. Kennedy, D-Mass., likewise have criticized the President's decision.

Republican scientists: One reason for the demise of the White House science structure was the perception of Presidential aides that the scientific community at large was hostile to important Presidential policies, especially his approach to the Vietnam war.

And if the advisory system is reconstituted, it certainly will be with an eye to the advisers' politics. Indeed, the Science and Engineering Council, a group formed last year to support Mr. Nixon's reelection, already is exerting influence in science policy decisions.

The council was headed by William O. Baker, president of Bell Telephone Laboratories Inc., and Simon Ramo, chairman of the board of TRW Inc. Both men were consulted on the White House reorganization after the election, and they and other council members have had a considerable say in Presidential appointments for science- and technology-related posts. They also are exploring ad hoc means of giving advice to the White House on R and D questions.

Federal science system

The large and complex science establishment supported by the federal government today grew from the emergency needs of the Second World War and the continuing exigencies of the Cold War that followed.

Responding to the call from Washington in 1941, scientists flocked to government service in unprecedented numbers, and the military victory the United States won over Germany and Japan was in no small part a triumph of American scientific technology. The extraordinary scientific effort was best symbolized by the Manhattan Project that produced the world's first atomic bomb in 1945.

To coordinate the use of scientific personnel and resources, President Roosevelt in 1941 established the Office of Science Research and Development. It was the first centralized federal organization for science and technology. Its director, Vannevar Bush, had direct and continuous access to the President, and many of the scientists who worked for Bush went on to become members of a postwar, elite scientific federal policy-making establishment.

Bush's 1944 report to Roosevelt entitled "Science, the Endless Frontier," became the classic exposition of the rationale for the federal subsidies for scientific research and technological development.

OSRD was disbanded after the war, but in 1950, pursuant to a recommendation of the Bush report, Congress established the National Science Foundation, and gave it responsibility for support of basic research and for coordination and evaluation of federal R and D policies. NSF's first-year budget was \$225,000; its budget today is about \$640 million.

R and D growth: The federal science activities NSF was supposed to oversee grew rapidly in the 1950s and 1960s, especially after the Soviet Union placed its Sputnik satellite in earth orbit in 1957.

In 1953, federal R and D outlays totaled \$2.7 billion; in 1957, \$6.1 billion; in 1961, \$9.3 billion. In 1968 they reached a four-year plateau of about \$15 billion.

The percentage of the R and D budget devoted to civilian research also has grown steadily, although defense continues to dominate.

In 1953, 88 per cent of the R and D budget was devoted to defense work,

R and D Trends

The table below reflects trends in research and development expenditures by the federal government, industry and academic and other nonprofit institutions for the period 1953-72. Totals, in millions of dollars, are for calendar, not fiscal, years.

Year	Federal government	Industry	Universities and colleges	Other nonprofit institutions	Total
1953	\$ 2,759	\$ 2,239	\$ 151	\$ 58	\$ 5,207
1954	3,138	2,367	167	66	5,738
1955	3,509	2,513	185	72	6,279
1956	4,859	3,336	204	84	8,483
1957	6,119	3,460	230	103	9,912
1958	6,791	3,700	257	122	10,870
1959	3,059	4,057	290	134	12,540
1960	8,752	4,508	328	142	13,730
1961	9,264	4,749	371	168	14,552
1962	9,926	5,114	424	201	15,665
1963	11,219	5,449	485	218	17,371
1964	12,553	5,880	555	226	19,214
1965	13,033	6,539	615	252	20,439
1966	13,990	7,317	673	284	22,264
1967	14,420	8,134	753	306	23,613
1968	14,952	8,997	741	329	25,119
1969	14,917	10,008	900	354	26,179
1970	14,775	10,435	970	386	26,566
1971 (est.)	14,996	10,813	1,099	407	27,315
1972 (est.)	\$15,923	\$11,570	\$1,226	\$424	\$29,150

SOURCE: National Science Foundation

while 10 per cent went to civilian work and 2 per cent to space research.

In 1963, defense received 63 per cent of federal R and D funds; space 21 per cent (almost entirely for the Apollo program) and civilian programs 16 per cent. In 1969, defense was down to 59 per cent and space to 19 per cent, while civilian R and D was up to 22 per cent. In 1972, NSF estimates that the government spent 54 per cent of its R and D money on defense; 19 per cent on space and 27 per cent on civilian programs.

Organizational diffusion: As the dollar volume in federal R and D mushroomed during the past two decades, so too did the number of federal agencies spending the money.

The Defense Department remained the largest single recipient of federal R and D funds. In addition to NSF, the other two postwar high-technology agencies, the Atomic Energy Commission and the National Aeronautics and Space Administration, have drawn heavily on federal resources. At the same time, the multipurpose missions of the National Institutes of Health have received ever-increasing amounts of federal outlays.

Older federal departments such as Agriculture, Interior and Commerce have continued R and D programs in their specified areas and added new

responsibilities. Grouped within them are a number of smaller technology-related agencies including the National Bureau of Standards, the Geological Survey, the Bureau of Mines, the National Oceanic and Atmospheric Administration, the Office of Coal Research and the Agricultural Research Service.

Regulatory agencies, particularly the 60-year-old Food and Drug Administration and the recently created Environmental Protection Agency, are greatly dependent on scientific and technical information for their standard-setting and regulatory functions.

And finally, during the 1960s the newer civilian departments—HEW, HUD and Transportation—have struggled with uneven success to bring technological expertise to bear on major domestic problems.

In spending the \$17.8 billion in federal R and D funds during fiscal 1974, these agencies will support an extraordinary variety of projects.

Basic research money will be spent on studying solar magnetic storms that interrupt communications on earth, the movement of deep water on the ocean floors and the characteristic difference between normal human and cancer cells, among many other projects.

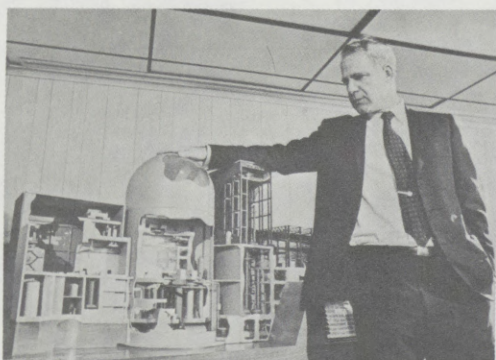
The federal budget will finance

targeted, applied research on such diverse matters as the use of nuclear fusion to produce electricity, solar energy, superconducting technologies for electric-power transmission, the use of enzymes for industrial processes, laser technology for medical surgery and instrumentation to monitor environmental pollutants.

Finally, the funds will support the government's extensive development activities, which often are conducted in alliance with private industry. Development projects include a demonstration nuclear-breeder reactor, construction of the space shuttle, a demonstration coal-gasification plant and a series of new weapons systems, including the B-1 bomber and the Trident submarine missile.

The work will be performed by many private and public institutions. In calendar 1972, the federal government distributed about \$8 billion to private industry, mostly for applied research and development; \$1.7 billion to academic institutions, mostly for basic research; and \$1.4 billion to federally funded R and D centers and nonprofit research institutions. In addition, it spent about \$4 billion for resident R and D.

Executive office organization: The growth of federal R and D spending and organizational diffusion produced



Former AEC Chairman James Schlesinger displays model of a fast-breeder nuclear power plant

periodic calls for centralization and coordination of federal science and technology activities in one department.

In the wake of Sputnik, Sen. Hubert H. Humphrey, D-Minn., in 1958 introduced a bill to create a Cabinet-level Department of Science and Technology. For the next four or five years, Humphrey and other members of the Senate Government Operations Committee pushed the concept of such a department, or at least the establishment of a commission to determine the need for major executive reorganization for science and technology.

Presidents Eisenhower and Kennedy opposed the Cabinet-level department, but both took steps to centralize and coordinate science policy making in the White House.

In late 1957, President Eisenhower announced the appointment of a permanent special assistant to the President for science and technology and the creation of a continuing President's Science Advisory Committee, to be composed of 18 non-government scientists and engineers.

In 1959, the interagency Federal Council for Science and Technology was established to provide coordination among the most important government agencies involved in science and technology. It was chaired by the President's science adviser, and included representatives from eight (later 11) departments and agencies.

In 1962, President Kennedy completed the White House structure for

science that Mr. Nixon now has dismantled. Under his Reorganization Plan No. 2 of 1962, Kennedy created the Office of Science and Technology, the director of which was subject to Senate confirmation.

In sending the plan to Congress, the President told Congress that OST would assume responsibility for policy planning, coordination and evaluation of all federal science and technology programs. The OST director was to be available to congressional committees, and thus would be able to furnish Congress with information on the Administration's scientific policies from an over-all, rather than a departmental, point of view.

In explaining why these functions were being taken away from NSF, Kennedy said: "... the Foundation, being at the same organizational level as other agencies, cannot satisfactorily coordinate federal science policies or evaluate programs of other agencies. Science policies, transcending agency, need to be coordinated at the level of the President, drawing upon many resources both within and outside of government. Similarly, staff efforts at that higher level are required for the evaluation of government programs in science and technology."

After 1962, the President's science adviser wore four hats. He served as assistant to the President for science and technology, director of the Office of Science and Technology, chairman of PSAC and chairman of the FCST. **Independent variables:** The central-

ization of science policy making in the White House theoretically meant that scientists had access to the highest levels of decision making. In practice, this access and the use made of the science policy making and advisory apparatus were dependent on a group of highly variable factors, including:

- the personal relationship between the President and his science adviser;
- the perception by the President and the White House staff of what the science adviser, OST and PSAC should or could be doing;
- the capacity of OST and PSAC to change over time and to provide meaningful aid in solving non-defense problems of emerging government concern—in the fields of environment and energy, for example;
- and finally, outside political factors affecting the relationship between the White House and the scientific community. In recent years, many scientists have opposed the President on the Vietnam war, and the scientific community in general has been upset about the impact of inflation on research and development, which has been an area particularly vulnerable to price increases.

Early years—Both non-government scientists and government administrators agree that the science adviser-OST-PSAC system was most productive from 1957 until 1966 or 1967. During those years, the variable factors were almost all favorable to the framework created as a result of Sputnik and Cold War competition, and the first three science advisers—James R. Killian Jr., George B. Kistiakowsky and Jerome B. Wiesner—all enjoyed an extraordinarily close relationship with their Presidents, Eisenhower and Kennedy.

Kistiakowsky said that both Presidents "were acutely aware of the need of independent advice, particularly on defense questions. Ike was a military man himself, and he just didn't trust the Pentagon without an outside check."

Many of the Presidential decisions in which the science adviser-OST-PSAC apparatus played an important role were made in these years. The science adviser and his allies successfully fought against Pentagon proposals for a nuclear-powered aircraft, the B-70 bomber and the Skybolt project (a nuclear-rocket program). OST and PSAC early on began focusing on the issues of population control, pesticides and the problems of the

environment.

Later years—None of the last three science advisers, Donald F. Hornig, Lee A. DuBridge and Edward David, developed a close personal relationship to Presidents Johnson and Nixon.

Hornig was a Kennedy appointee who came to the White House just after the assassination in 1963. After 1965, with most of the nation's scientific community in opposition to the Vietnam war, Hornig's position within the White House weakened substantially. And both DuBridge and David suffered to some degree from the same fate.

Said Philip B. Handler, president of the National Academy of Sciences: "It was unfortunate but President Johnson came to view the science adviser and PSAC as the closest face of the academic community that he felt had turned on him. The system had declined greatly by 1969, and President Nixon for reasons of his own didn't see fit to revive it."

Handler maintains that "despite the genuine misgivings and even disagreements with both Administrations by some PSAC members on the war, I never heard direct criticism of either President as a culprit or any attempt to betray him. . . . To the very end, the attitude was: 'How can we be helpful to the President?'"

Inflation—After 1967, the science adviser also was caught in a crossfire between the budget bureau and the scientific community as federal support for R and D leveled off and even began to decline in terms of real purchasing power.

Between 1960 and 1967, federal funds for R and D rose at an average of about 10 per cent annually; between 1967 and 1972, a reverse occurred and federal R and D support, adjusted to account for inflation, declined at an average of about 6 per cent annually.

During the tenure of President Nixon's first science adviser, Lee DuBridge, criticism from scientists coalesced and centered on the White House science-policy apparatus. Said DuBridge, who to a great degree was a casualty of the attack: "It was, I guess, natural that we should be blamed. But there were a number of complex factors at work, and I felt when I left Washington that the entire federal science-support system and organization needed reexamining." In an interview with *National Journal* on the day his resignation was announced



Lee A. DuBridge



Philip B. Handler

in 1970, DuBridge said that he personally thought that a Council of Science Advisers should be established in the White House, equal in status and power with the President's Council of Economic Advisers.

Centralization restudied: The tightening budget stringency and what James Kilian called an "accumulation of uncoordinated actions" by the federal government which brought "disorder and dismay to the house of science" raised anew fundamental questions about the structure of the federal science and technology system.

Daddario—During 1969, the House Committee on Science and Astronautics Subcommittee on Science, Research and Development, chaired by Rep. Emilio Q. Daddario, D-Conn., held extensive hearings on the question of the need for centralization of federal science activities.

Daddario, who left Congress in 1970 in a losing bid for the Governorship of Connecticut, was the leading congressional authority on science policy during the 1960s. Looking back on the hearings, he says now: "Even though the danger signals had been flying since 1967, we found the scientific community divided and uncertain about the necessity for wholesale restructuring and moving drastically from the existing decentralized, pluralistic system."

Despite the uncertainties within the scientific community, the Daddario subcommittee proposed the creation of a new agency—the National Institutes of Research and Advanced Studies (NIRAS)—built around an enlarged NSF. Added to the NSF core would have been a National Foundation on the Arts and Humanities, two new institutes of social sciences and ecology, a group of basic research projects no longer relevant to mission agencies and a number of graduate education programs from HEW. The agency would have had an initial budget of about \$2.3 billion.

Kennedy bill—Although Daddario's bill failed to move, Congress has shown itself increasingly restive and unhappy about the federal R and D establishment, particularly about the seeming inability of major civilian agencies—HUD, HEW and Transportation—to bring science and technology to bear on major domestic problems.

The reception given the National Science Policy and Priorities Act of 1972 (S 32) by the Senate last year clearly demonstrated that Congress is receptive to proposals for reorganizing the far-flung federal science and technology establishment. The bill, sponsored by Sen. Kennedy, passed the Senate 70-8, and quite likely would have passed the House by an equally impressive margin had the second session of the 92nd Congress not ended soon thereafter.

Like the Administration's reorganization, the bill would make NSF the government's central planner for science and technology. But the foundation would be given a much stronger mandate—as well as a new statutory base—to perform that function. In addition, the bill would create within NSF a new Civil Science Systems Administration with authority to spend \$800 million over a three-year period to fund design, develop and demonstrate technological ad-

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1972-74 R and D Expenditures by Agency

As the table below shows, about three quarters of the federal government's research and development expenditures is controlled by three hardware-oriented agencies—the Defense Department, the National Aeronautics and Space Administration and the Atomic Energy Commission. Figures are for fiscal years and in millions of dollars.

Agency	1972 actual	1973 estimated	1974 estimated
Defense (military functions)	\$ 8,117	\$ 7,873	\$ 8,333
NASA	3,373	3,008	3,066
HEW	1,513	1,670	1,873
Atomic Energy Commission	1,298	1,359	1,411
National Science Foundation	418	423	446
Transportation	274	290	359
Agriculture	349	360	343
Interior	210	262	255
Commerce	165	179	187
Environmental Protection Agency	133	146	164
Veterans Administration	66	71	75
HUD	47	43	61
Justice	13	30	46
All other	127	173	171
Totals	\$16,103	\$15,886	\$16,790

SOURCE: Office of Management and Budget

vances in such areas as pollution control, health care; transportation, communications and education. An aide to Kennedy predicts the legislation will pass the Senate again by mid-summer.

Congress also moved last year to increase its own ability to weigh scientific issues by establishing a new Office of Technology Assessment. Staff now is being recruited for the office, and Daddario is a leading candidate for the director's office.

Brooks—Harvey Brooks, one of the nation's most knowledgeable and influential spokesmen on science policy and organization, believes the case for some kind of centralization of federal science policy making has become much stronger in the last few years. Brooks is dean of Engineering and Applied Physics at Harvard and is a member of both the National Academy of Sciences and the National Academy of Engineering. A former PSAC member, he is currently on the National Science Board—the governing board of NSF—and the board has turned to him to prepare a memorandum regarding the consequences for NSF, the board and federal science of the recent reorganization.

Brooks, who is worried that the President's reorganization did not give NSF the power to carry out the mission he assigned it, said in an interview: "The American system,

with its emphasis on pluralism, decentralization and competition among sectors for R and D funds, performed pretty well until the mid-1960s. However, we've moved into an era where resources for R and D are limited, thus necessitating more careful planning and coordination at or near the highest government decision-making level. . . . In addition, a new and more difficult task of interweaving science policy with national social, economic and political policies would seem to call for a unified, coherent strategy."

Nixon and reorganization

A deep concern with government organization and structure has been a hallmark of the Nixon Administration in nearly every major area of government policy making. And given the problem that already had surfaced regarding the White House science policy-making and advisory apparatus it was natural that White House attention should turn to it early on.

Ironically, in light of the Administration's recent decisions, a Presidential task force in 1970 and a PSAC panel in 1971 both recommended augmenting the role of the science adviser and the OST in the White House by giving them broadened and much stronger budgetary, planning and management responsibilities. The first group—the Presidential Task

Force on Science Policy—was one of 17 advisory panels named by Mr. Nixon in 1969 and was chaired by Reuben F. Mettler, president of TRW Inc. The PSAC panel, chaired by Patrick E. Haggerty, chairman of the board of Texas Instruments Inc., studied questions of science-policy structure in detail for over a year, and turned over its report to the President's Advisory Council on Executive Organization headed by Roy L. Ash, president of Litton Industries Inc. and now the director of OMB.

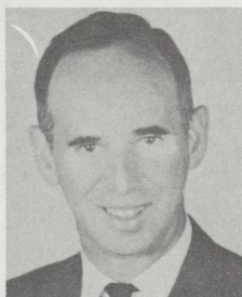
The Ash council, whose advice has been followed closely by the President in his sweeping government reorganization proposals, came to an entirely different set of conclusions. Its recommendations regarding the White House science-policy structure were never made public, but according to Ash and to Andrew M. Rouse, former staff director of the council, they called for abolition of the entire science-policy system in the Executive Office of the President. "In reality," said Rouse, "the Administration has just carried out the earlier council recommendations, and it used the same rationale in explaining its action."

The Ash council's conclusions, stemming from theoretical premises regarding efficient government management, were reinforced by the day-to-day practical experience of the White House and Domestic Council staff.

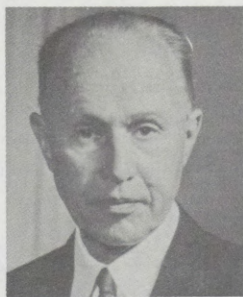
Inability to use: Looking back over the first four years of the Nixon Administration, several White House and Domestic Council staff members argued that they had not found OST advice of unique utility or packaged in a way they found helpful.

Said William E. Kriegsman, a former Domestic Council staff member (1969-1971) who had major responsibilities for science policy: "I think that if it had been expedient the White House would have dropped the science adviser and abolished OST two years ago when DuBridge resigned. DuBridge was a sweet guy with impeccable credentials and a desire to help; but when we asked OST for advice, they kept coming with answers that weren't usable or which didn't fit the political realities. The White House staff had to handle most of this work itself. . . . David tried hard to retrieve the situation and work within the system, but basically it was too late, I think."

Kriegsman's view was corroborated



S. David Freeman



George B. Kistiakowsky



Edward E. David Jr.

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by Richard M. Fairbanks, a Domestic Council staff member who since 1969 has dealt with natural resources and environment issues. Fairbanks, who recently was named an assistant director of the council staff, said: "We did find OST useful, but they were by no means the only independent source we depended upon in energy and environmental matters; and they were no more right on a number of issues than other agencies. Sometimes EPA was better, or Interior or the AEC. Maybe they could or should have, but the fact is they didn't constitute the most important option-analyzing source for us."

Unstated reasons—In addition to the publicly stated reasons given by the Nixon Administration regarding the reorganization, there are several unstated difficulties that undercut the science adviser-OST-PSAC system after 1969.

To some degree the OST staff, and to a much greater degree PSAC and its panel members, never could overcome the feeling of the top political operators in the White House that they were an alien, hostile force.

S. David Freeman, who headed the OST Energy Policy Staff from 1968 to 1971, is a Democrat who stayed on at both DuBridge's and David's request. Says Freeman: "The OST staff was an oasis of holdovers, and I think we did feel the need to bend over backwards to show that our advice was disinterested. But in retrospect, I don't think we ever overcame the sense of distrust by the political types around the White House. . . . Actually, I'm a great believer in the spoils system myself, and I wonder now if it

wouldn't have been better for OST if DuBridge had cleared the decks in 1969 in order to allay the resentment and fear. The institution might have had a better chance of surviving."

Even more damaging were clashes between PSAC panels and the Administration on several of the most important political issues that came up after 1969.

The most celebrated and corrosive disagreement erupted over the doubts raised by a PSAC panel, chaired by Richard L. Garwin of IBM, about the environmental effects of the supersonic transport. The panel's negative findings were supposed to remain confidential, but they emerged publicly at the height of the struggle over the SST in Congress and became a crucial factor in the debate.

The scientific community was overwhelmingly opposed to the Administration's decision to deploy the antiballistic missile system, and PSAC itself, after analyzing the issue at one of its meetings, verbally passed on to the White House its deep reservations both about the technical problems and the Cold War implications involved in the decision.

And a PSAC panel, in a report to Edward David during the fall of 1971, directly attacked the major arguments advanced by the Administration and NASA in favor of the space shuttle, giving Sen. Walter F. Mondale, D-Minn., the leading Senate antagonist of the project, bountiful ammunition for continued opposition. The shuttle study was supposed to be confidential (like the Garwin report), but was leaked to *National Journal*. (See Vol. 4, No. 33, p. 1295.)

Said Paul M. Doty, professor of chemistry at Harvard and a member of the NAS Committee on Science and Public Policy: "It seems pretty clear that the White House staff viewed PSAC as an institutionalized center for internal dissent—and after the incidents which occurred over the past few years, they just said 'Who needs them?'"

Privately and not for attribution, several White House staff members agreed that the substance of Doty's remarks was correct. Said one: "There was something of the feeling that some of the members were more politically than scientifically motivated."

David—President Nixon's last science adviser, Edward David, bore the burden of defending a system already badly compromised and weakened.

One former OST staff member who worked under David said: "Ed, from the time he came in, did everything he could to avoid antagonizing the top political men. The signals in our staff meetings were: 'Be careful and don't rock the boat.'"

Freeman said: "It's easy to sit in judgment with hindsight, but I think he'd have been better off with a kind of 'damn the torpedoes and full speed ahead' attitude that would always have called all the shots on the merits. Considering the recent decisions of the Administration, what Ed David really proved was that appeasement was not a more viable policy than trying to lead from strength when you've got the facts."

The White House attitude toward the role of the science adviser stood out clearly when it decided, in the summer of 1971, to mount a crash

412 drive to identify new technologies whose development the federal government could fund over the next decade.

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To lead the effort, the Administration turned to William M. Magruder who had spearheaded the SST drive in Congress for President Nixon, and he was brought in to work for John D. Ehrlichman, who was executive director of the Domestic Council staff. At the time, Ehrlichman explained the decision to *National Journal* by saying that the President used the OST "to provide specific and precise advice on matters of science and technology," and that the office was not equipped to make policy decisions on questions involving fiscal, social, political and other considerations. (See Vol. 3, No. 43, p. 2144.)

The failure of the Magruder operation to produce a technology program the White House could adopt further hastened the demise of the executive office science structure, in the view of Lawrence A. Goldmuntz, who served as liaison between Magruder and David in 1971.

Goldmuntz, who was executive director of the FCST at the time, said that "the personal, and bureaucratic rivalries and bad feeling were even worse than the press reported." But more important, in Goldmuntz's view, was the "surprise and disappointment" of the President and Ehrlichman at the study's results. "I think they believed somehow that we would be able to find a number of specific technologies to solve difficult problems—that somehow they could get a shot to the moon in the areas of transportation or energy or medical research," Goldmuntz said. "When it didn't turn out that way, there was an inevitable reaction against science and technology or at least a disenchantment with what it could do for this Administration over the short term."

1972 discussions: In December 1971, when the Administration suddenly backed away from any large-scale technological initiatives, Ehrlichman quietly turned to Edwin L. Harper, then the assistant director of the Domestic Council, to pick up the pieces and devise explanations of the program's results.

Harper also became the key Domestic Council figure in the construction—with OST—of the President's March 16, 1972, "message to Congress on science and technology."

Waldman—Beginning last spring,

Harper's assistant, Raymond J. Waldman, prepared several staff memoranda on executive office organization for science policy. In an interview, Waldman said: "The Magruder exercise had raised important questions about the role of the science adviser and his staff in the White House, and how they related to other elements like OMB and the Domestic Council. I was asked to do an operational study to try and figure what OST's important functions—if any—really were."

Waldman wrote a series of memoranda—the last in October—for Harper and Kenneth R. Cole Jr., who replaced Ehrlichman in January as director of the Domestic Council staff.

His findings largely reaffirmed the



Raymond J. Waldman

negative judgments of the Ash council in 1971.

During the spring, David briefed members of the Domestic Council staff on his own views concerning alternate organizational possibilities for federal science policy making.

Among the proposals that were debated over the past year and a half were the creation of a White House Council of Science Advisers, as recommended by both Hornig and DuBridge, expanding NASA into a civilian technology agency and the establishment of a new civilian advanced research agency, patterned on the Defense Department's highly successful Advanced Research Projects Agency (ARPA).

Final decisions: In the end, all of the alternatives debated were discarded and the original thinking of the Ash council, reinforced by the experience of the White House staff and the Waldman memoranda, won.

The decisions concerning the science adviser-OST-PSAC system were made in late November and early December in conjunction with the more general reorganization changes initiated by the President and his top advisers in meetings at Camp David, Md.

Among those taking part were Ash; Ehrlichman; Cole; Frederic V. Malek, the new deputy director of the OMB; and H.R. Haldeman, assistant to the President.

According to Charles F. Bingham of the OMB, "the discussion concerning the science adviser and OST presented no unique problems for the Presidential advisers." Said Bingham: "It was merely part of a larger debate on the streamlining of the Executive Office of the President—that is, what could they get along without." Bingham heads the government organization branch of OMB's Office of Management Systems. In that position, he has chief responsibility for the staff work to support the testimony regarding the reorganization plans and has accompanied Malek in his appearances before the Government Operations Committees in both houses.

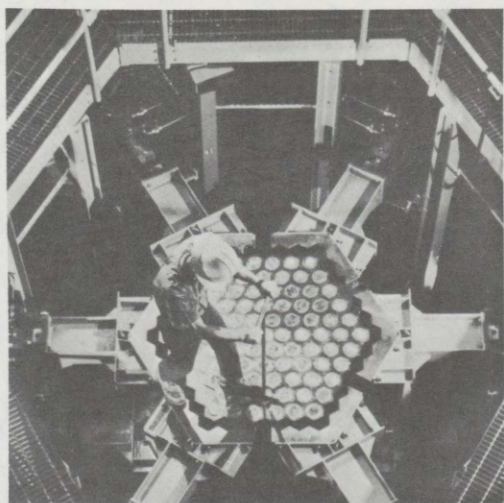
By early December, an initial decision had been reached to abolish the OST, PSAC and the position of special assistant to the President for science and technology.

Significantly, neither David nor H. Guyford Stever, director of NSF, was consulted or asked his opinion. (Since the abolition of his post, David has loyally defended the Administration, but as late as October, in discussing his opposition to Sen. Kennedy's NSF bill, he told *National Journal* that it was "important and necessary to have the coordinating and planning function for science policy in the executive office itself.")

Baker-Ramo committee—Though the top White House political officers failed to consult their own internal science-policy leaders, key members of a 27-member Science and Engineering Council, established during the Presidential campaign to work for Mr. Nixon's reelection, intervened and were listened to on the science-policy questions.

The council was headed by William O. Baker, president of Bell Telephone Laboratories Inc., and Simon Ramo, vice-chairman of the board of TRW Inc.

A Republican, Baker is a member of the governing council of the National Academy of Sciences and since



An engineer prepares a laser measurement test

1969 has been the key link between the Administration and the scientific academic community. In an interview, he said that "the council did not act as a unit; the input to the White House was on an individual and informal basis."

"We tried to explain to them," said Baker, "what were the implications of what they were planning and open up other options."

Baker conceded that it "was fair to say" that top White House officials knew very well what they wanted to get rid of but had not thought through very clearly what functions the OST and PSAC were performing that would have to be taken over somewhere in the federal government.

Members of the council were most disturbed at the fact that under the initial White House reorganization plan "there would have been no one place, man or institution who would represent the voice of science in the high councils of government," said Baker.

"We also pointed out," he said, "the political necessity and attractiveness of having someone to explain and communicate both to the scientific

community and to the nation at large just what was in the President's mind regarding science and technology."

In December, top White House officials offered David chairmanship of the AEC and the title of science adviser to the federal government. After considering the offer for several weeks, David turned it down.

Baker and others continued pressing for some kind of central focus; but as late as mid-January, when George P. Shultz, Secretary of the Treasury and special assistant to the President, appeared before the National Science Board to explain the Administration's resolve to transfer the duties of OST to the NSF director, the issue had not been resolved. Several NSB members quizzed Shultz closely about the lack of a central focus under the new arrangement.

After the NSB discussions the White House finally decided to bestow on the NSF director the title of science adviser.

Though he supports the reorganization plan fully, Baker is critical of the methods used to bring it about. "We warned the White House staff," he said, "that by operating behind

closed doors and then suddenly springing this without any discussion they would create a poisonous atmosphere. Dr. David had worked hard and had achieved a real rapport with scientists and engineers around the country; and this crude dumping was bound to produce misunderstanding and resentment. In some ways, it was just like the Magruder episode all over again."

Hope for future—Ironically, given the last-minute nature of the decision, it is Stever's new title and its implications that have occasioned the chief debate over the past month.

Members of the scientific community have seized upon it as a symbolic sign that science has not dropped entirely off the Administration's organizational charts. Administration officials, reacting to the criticism by Members of Congress and scientific organizations that "science has been downgraded," have stressed the importance of the title and the new role for the NSF director.

On Jan. 26, in an initial explanation of his new role to the press, Stever was tentative about its dimensions, by stressing that he was not the science adviser to the President. "I guess I am everybody's science adviser," he said.

But a month later, before the House Government Operations Committee, Frederic Malek posited a much more expansive role, stating: "Dr. Stever is really the science adviser to the entire Executive Office of the President, not just to the President himself. His role will be to advise the OMB... and the Council on International Economic Policy... who are formulating recommendations to the President that have something to do with science and technology."

Malek added later: "I can say from a personal point of view—having to cope myself with the complexities of a new job—that I am convinced even more of the need for sound scientific advice from Dr. Stever and his staff if we are going to make the kind of responsible decisions and give the President the advice he needs."

Administration rationale—The White House has advanced a number of arguments for the abolition of the science adviser-OST-PSAC system.

Basic to its thinking is a theory about the history and role of the system.

White House officials contend that the Presidential office science structure was conceived as an emergency measure to upgrade U.S. science in

William O. Baker: White House Bridge to Science

As relations between the Nixon Administration and the scientific community became tinged with hostility and distrust over the past four years, no man has been more important in maintaining communications between the two than William O. Baker, a long-time executive of Bell Telephone Laboratories Inc.

Baker, who was named president of the Bell Labs on Jan. 17, possesses impeccable credentials within the American scientific establishment and at the same time a Republican with close connections to the White House staff. He served as co-chairman in 1972 of the Science and Engineering Council for the Re-Election of President Nixon.

Biography: Baker, 57, has spent his entire professional career—34 years—at the Bell Labs. Before assuming the top position in January, he had been for 18 years vice-president for research and was also responsible for the labs' patent division.

He received a BS from Washington College in 1935 and a PhD in physical chemistry from Princeton University in 1938. In 1939, he went to work at the Bell Labs, concentrating his research on the macromolecules that form the basic elements of plastics. During the Second World War, Baker was responsible for the discovery of a synthetic polymer molecule called microgel that was fundamental to the production of synthetic rubber. After the war, he continued his work in the area of polymers and was elected to the National Academy of Sciences in 1961.

Baker began a long career of service to government during the Second World War, working with the Office of Scientific Research and Development. Since then, he has served on many advisory committees and boards, particularly in the defense area. He is a past member of the President's Science Advisory Committee, the National Science Board of the National Science Foundation and the Science Advisory Committee of the Defense Intelligence Agency.

He is presently a member of the governing council of the NAS; a member of the President's Foreign

Intelligence Advisory Board and a member of the Air Force Systems Command Board of Visitors.

Nixon Administration adviser: Baker had met and become friendly with the President some years ago, and, since 1969, the Administration has turned to him on various occasions for advice and for suggestions on appointments to scientific and technological posts within the federal government.

Thus it was Baker who suggested Edward E. David Jr., at the time a Bell Labs executive, when the Administration was looking around for a replacement for President Nixon's first science adviser, Lee A. DuBridge. It was Baker who came down to Washington in the summer of 1971 to smooth over relations between David and William M. Magruder, whom the White House had chosen to lead a crash drive to come up with a series of new technological projects for the federal government to develop and fund.

And during the past three months, it has been Baker—and other members of the Science and Engineering Council—to whom the Administration has turned for help, in the wake of the demolition of the White House science policy-making apparatus.

Baker views—Although he plays down his own role in the decisions on the current restructuring ("It has been wholly unofficial and only one of a number of inputs," he says), Baker does admit that "there is often a need for someone to serve as an interface between Washington and the scientific community."

"During the current reorganization," he said, "the White House operatives have tended to think purely in textbook management terms, without perceiving the scientific and technological imperatives that are a part of almost all political decisions today. On the other hand, scientists outside of Washington sometimes have a very dim view of how the system here really operates. . . . They think, for instance, that everyone in the White House has access to the President and that removing the science adviser means the end of the use of science in policy making."

Baker says he thinks the National

Science Foundation, which has assumed a broad advisory function under the reorganization, "can form the core of a new structure for science and technology in the federal government."

NSF will have to develop strong ties with the Office of Management and Budget, he says, because that agency "is now the most powerful in the government; it is even autocratic." At the same time, argues Baker, "OMB does not have the capability of judging the technological content of programs and will have to turn to NSF."

In his advisory role, the NSF director will report to the President through George P. Shultz, Mr. Nixon's assistant for economic affairs, and Baker expressed confidence that Shultz "is fully aware of the central underpinning science and technology constitute for American economic growth."

Baker himself undoubtedly will have easy personal access to Shultz through Kenneth W. Dam, who is the White House counselor's assistant. Dam and Baker established close connections while Baker was working on the President's Foreign Intelligence Advisory Board during the time Dam was OMB assistant director for national security programs. Each today has high praise for the other.

The Science and Engineering Council is forming a series of ad hoc advisory panels to undertake some of the duties the recently abolished President's Science Advisory Committee. The panels, Baker said "will nominally report through NSF but actually will consider themselves White House advisers." He said that "quite soon" there should be an announcement about an energy panel "putting together some of the best minds in the country;" and later other groups would be formed in such areas as environment, transportation, health, etc.

In conclusion, he predicted: "It's going to be an exciting and interesting time. I think the restructuring of the science policy apparatus can be done in a way that will serve the President, the scientific community and national goals and purposes."

the wake of Sputnik and because of the exigencies of the Cold War. That mission, they say, has been accomplished and there is no longer a need for a special science office in the White House.

In an interview Roy Ash put it this way: "The (science adviser-OST-PSAC) structure represents one of a whole list of problems that got put into the White House because it was perceived that there was an emergency or special situation. A couple of years ago, the Johnson Administration felt it had to have a protective agency for poverty programs—hence, the Office of Economic Opportunity. Today, the drug problem is to the fore, so we've set up a special group in the White House. All are necessary in their time, but when the emergency is over they tend to linger on without real function."

"The fact is," said Raymond Waldman, "that the position of science adviser was an anomaly in the White House. Why should science have a special representative there, when there is no one for welfare or education or public works?"

Waldman said that in his own management studies of OST last year, he found that in the areas of coordination, policy planning and management of the federal R and D program, OST had not contributed a great deal. "The need for an OST perspective just didn't seem that big," he said. Only on the matter of the close relationship that had grown between OMB and OST on funding decisions said Waldman, did he "end up with very mixed feelings" as to whether OST was vital.

General reorganization—White House aides also tie the demise of OST and PSAC to the Administration's broader management goals, as reflected in its total reorganization of White House staff and Cabinet functions.

"It is the intention of the President," said OMB's Bingman, "to have policy made by the assistants and counselors in the White House. Certainly, on many decisions they will have to have a scientific and technical input. But they can and will draw on a variety of sources to get this—including the NSF director, the NSF bureaucracy, line departments and agencies, and where needed, outside advice."

"You can't have advice singly on the subject of science," Malek told the House Government Operations Committee. "It has to be science as it relates to whatever the scientific application is."

Steuer is to report through Shultz, the President's chief economic counselor, said Malek, "because it is our feeling that the key impact of science and technology has to do with the economy and the development of the economy as a whole."

For scientific or technological matters that fall under the aegis of natural-resources or community-development counselors, he said, Shultz and his staff will arrange for Steuer's aid and advice.

Line agencies—Basically, the Administration sees science and technology as part of the operational functions of individual agencies and not an area of general policy making.

Malek said on Feb. 22 that one aim

of the reorganization was to move "operational functions back into line departments and agencies, thus leaving the executive office better able to carry out its original mission as a staff for top-level policy formation and monitoring of policy execution in broad functional areas."

The White House also argues that since 1962, when OST was established, the departments and agencies of the government have substantially upgraded their capacity for the management of R and D. Said Ash: "Today science and technology so permeates the whole of government that each agency has developed its own R and D capacity. There isn't needed a continuing definition of their roles in the Presidential office."

PSAC—Administration officials say they will adopt an ad hoc approach to securing the kind of outside scientific and technical advice previously provided by PSAC, and that this will give them better information sources. Bingman said: "The potential spectrum for scientific advice for policy-making is so broad that no one cast of characters—as PSAC represented—could possibly provide all the answers. You don't need a standing committee; indeed, a standing committee locks you in to the same advice from the same old stands and biases."

The Administration, said Bingman, does plan to tap into the scientific community through NSF and the National Academy of Sciences, on a case-by-case basis, as individual problems arise.

According to William Baker, plans are already afoot to reestablish some kind of informal advisory relationship between the Administration and the scientific and technological community. Members of the group of scientists and engineers that worked for President Nixon's reelection are moving to form a series of panels to advise the government in key domestic-policy areas. Baker said: "We hope to bring to bear on these issues some of the best brains in the country. Our first concern has been getting together a group on energy R and D alternatives, and there should be some announcement about that very soon in conjunction with the Administration's plans." He said other panels in such areas as transportation, health care and housing also are in the works.

"Probably, they will remain unofficial," he said, "with some loose connection with NSF." □

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Charles F. Bingman



William O. Baker

Science Report/Presidential revamping of science tasks upgrades National Science Foundation role

by Claude E. Barfield

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The National Science Foundation, a small agency which concentrates on financing basic research in academic institutions, suddenly has been told by President Nixon to advise the entire executive branch on a federal R and D budget totaling more than \$17 billion, most of it devoted to applied research and development.

This new role for the NSF was devised by White House reorganization specialists as part of a sweeping overhaul of the Executive Office of the President, an effort that included complete dismantling of the Presidential science-advisory structure that had developed over the past 15 years.

The move has produced profound misgivings among leaders of the scientific world, both as to the wisdom of abolishing the old institutions and as to the NSF's ability to handle its new assignment.

Many of these leaders say it makes little sense to give a second-rank agency with limited expertise in applied research and development responsibility for advising on technological projects undertaken by more powerful elements of the bureaucracy, including the Defense, HEW and Transportation Departments, the Atomic Energy Commission and the National Aeronautics and Space Administration. And they fear that the end of the old advisory system is ill-timed in light of the increasing number of pressing domestic issues that require sophisticated scientific judgments.

Reorganization: In reorganization moves announced in January, the President said he would abolish the position of special assistant to the President for science, the White House Office of Science and Technology (OST) and the President's Science Advisory Committee (PSAC), a prestigious 18-member group of nongovernment scientists.

In a last-minute decision, Mr. Nixon decided to designate the NSF and its director to pick up the functions performed by the machinery he was eliminating. The White House says that the NSF director, who has assumed the title of "science adviser," will henceforth be called upon to:

- conduct policy studies and make recommendations regarding federal science and technology policies;
- appraise and evaluate the effectiveness of national programs in science and technology;
- coordinate federal R and D programs;

Two-Part Series

This is the second of two reports in *National Journal* on the Nixon Administration's plans to reorganize the federal science advisory system. (For the first report, see Vol. 5, No. 12, p. 405.)

- advise all elements of the Executive Office of the President, including the Domestic Council, the Office of Management and Budget and the new counselors to the President;
- act as a link between public and private R and D efforts.

NSF Director H. Guyford Stever was not in on the discussions that led to the reorganization plan. He says he has spoken only a "few words" to the President since it was announced.

However, after a somewhat shaky initial appearance at a Jan. 26 news briefing to explain his new duties, Stever has moved to defend the plan with vigor, reassure the scientific community that science has not been downgraded and begin the process of creating mechanisms to carry out his broadened mandate.

Stever's plans for meeting the responsibilities thrust upon him by the White House still are in a very preliminary state, but some steps have been announced.

The NSF director will establish a small science-policy staff in his office. He has been given no extra money for personnel for this staff, and thus the positions will be created by leaving vacancies in the agency unfilled.

Stever also will assemble several task groups on national R and D problems, coordinated through his science

policy staff and composed of line-agency personnel, regular NSF employees and outside consultants.

Finally, he will give the NSF line organization the new responsibility of providing detailed studies and assessments of federal R and D programs and national problems related to science and technology.

In an interview, the NSF director said his "first priority will be to take a hard look at the civilian science area, to find out what civilian problems are the most pressing and where R and D can make a contribution. I want to talk to people from the academic community, industry and the government agencies. Then, we can organize the work here on a problem basis."

Energy and the environment are two areas where Stever wants to move quickly to bring to bear scientific and technical expertise for the benefit of the White House and line agencies.

"Energy policy involves a number of complicated political, economic and national security questions—but it also must have a strongly based across-the-board knowledge of R and D possibilities, opportunities—and traps," said Stever.

Reaction: Because the White House plan was announced only two months ago, with little warning, there still is much uncertainty as to its ultimate effects.

The scientific community, and Congress too, has little inclination to attempt to reverse the President's decision. Said William D. Carey of Arthur D. Little Inc.: "There's no sense lighting candles in an empty church. . . . Every President inherits a whole lot of monumental artifacts that don't respond to his needs or priorities—and after all, it's Mr. Nixon's White House." Carey served in the Budget Bureau for many years before joining Arthur D. Little in 1969. He is a recognized authority on science and government.

Even those with the strongest reservations say that the issues involved are too important to the nation for the scientific community to turn its back on the Administration. This attitude was summed up by James R. Killian Jr., President Eisenhower's first science adviser, who said: "It's true that some aspects of the recent changes worry a number of us deeply, but I think the predominant resolve is 'Let's make it work and help shore up the weaknesses.'"

Some prominent scientists, however,



H. Guyford Stever

believe that the Administration's decision to remove science policy making from the White House and place it in a second-line agency reflects a lack of understanding of the place of science and technology in political decision making.

Among them is Harvey Brooks, dean of Engineering and Applied Science at Harvard University and a leading expert on science policy and organization, who said: "In one real sense, the move is a downgrading of science."

Brooks recalled an occasion in mid-January when George P. Shultz, Secretary of the Treasury and assistant to the President for economic affairs, spoke to the National Science Board, the governing body of the NSF. It was clear then, Brooks said, "that he regarded OST and PSAC merely as hangovers from the crash drive after Sputnik to upgrade U.S. science. He did not regard OST or a scientific input as necessary for policy formulation at the White House today; science is considered just a part of the lower-level operations at the department and agency level."

"That view, I think, represents a misperception of the role of science in public policy. Other nations are more and more coming to see the urgency of ending the isolation of science from policy making and are making provisions to incorporate it at the very top levels of government. We seem by this action to have moved in the opposite direction." (In 1971, Brooks chaired a multinational panel of the Organization for Economic Cooperation and Development (OECD) which strongly recommended the integration of science into the social and economic planning of all countries.)

Philip Handler, president of the National Academy of Sciences, said he did not "think the reorganization should be painted all black," but that he "was apprehensive about some of the models used in explaining it."

Handler referred to the Administration's argument that science should no more occupy a special place in the White House hierarchy than welfare, education or agriculture, and said: "I fear there is a lack of understanding of the pervasive role of science and technology in all areas of public policy."

"What also bothers me is the lack of an objective voice in the executive office viewing agency proposals from a technical point of view. Dr. Stever's

role is still quite vague, and I suspect that the reorganization may have left the President naked before competing agencies with their own bureaucratic biases and blindspots."

National Science Foundation

Ten years ago, President Kennedy removed from the NSF the duties now being returned to it, implicitly acknowledging at the time that the agency had failed to accomplish these tasks.

Asked what had changed over the past decade, NSF Deputy Director Raymond L. Bisplinghoff replied: "NSF is, I think, a very different place than it was ten years ago. It has, so to speak, come out of the ivory tower and into the real world during that time span."

Nature of agency: By that, Bisplinghoff meant that the foundation had moved in recent years to expand its activities in the field of applied research-targeted efforts to achieve specific technologies.

But the NSF's budget still is heavily concentrated on the agency's original mission—support of basic research. This has raised doubts among many scientists about the capability of the NSF staff to provide useful advice to the White House, which has demonstrated more interest in applied research and development to meet national needs than in untargeted basic research.

The NSF began to broaden the range of its activities after Congress in 1968 passed legislation (82 Stat 360) broadening the agency's charter. The 1968 law, which Bisplinghoff said was of "major significance in expanding our capabilities and horizons," gave the agency a mandate to support applied research relevant to national problems. At the same time, the agency's status in the bureaucracy was upgraded: its director was given more authority and more pay, and five additional Presidential appointments (a deputy director and four assistant directors) were authorized.

It was not until 1971 that the NSF moved seriously to upgrade its applied research activities, with establishment of the Research Applied to National Needs (RANN) program. RANN now has a budget of \$80 million devoted to financing problem-oriented civilian research.

In 1972, at the direction of the White House, NSF also set up its National R and D Experimental In-

centives Program, which is designed to study and foster the process of technological innovation in private industry.

Congress appropriated \$18.5 million for this program last year, but OMB has allowed the NSF to obligate only about \$2 million. The impoundment was not made for budgetary reasons, OMB officials say, but rather because the NSF's planning and management have been badly flawed.

In a negative assessment of the experimental incentives program on March 16, *Science*, the magazine of the American Association for the Advancement of Science, said that "outsiders familiar with the program" believe the NSF staff "is not sufficiently dynamic, or politically attuned to do the job" and that the staff does not have "sufficient prior background in the innovation process or with . . . past government attempts to improve U.S. technological innovation."

These and other NSF ventures into the field of applied research have not been on a grand scale, and in fiscal 1974 only 17 per cent of the agency's research budget will finance applied research. (The research budget is \$554 million out of a total fiscal 1974 NSF budget of \$641 million.)

The remainder will be devoted to basic research, with the biggest single item, \$275 million, financing research grants to individuals in the physical, biological and social sciences, and in engineering.

Most of the NSF's 1,150 employees are involved in processing the grants and in other administrative chores.

Replies to criticism: During the past six weeks Stever and Bisplinghoff have moved to counter early criticism of the reorganization by scientific organizations like the Federation of American Scientists and congressional leaders in the science-policy field, such as Sen. Edward M. Kennedy, D-Mass., and Rep. John W. Davis, D-Ga.

Rebutting the charge that the movement of the science structure out of the White House represents a "downgrading of science," Stever said: "That is not what the President intended. I think a lot of people are making too much, symbolically, about a two-block move down the street. (NSF is located two blocks from the White House.)"

"Some of the overreaction, I think, stems from a lack of understanding of

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how the White House operates. There is the illusion that everybody over there has had ready access to the President. That just hasn't been the case. George Shultz has one of the strongest positions in the White House and I think that through the conduit of Shultz and his staff we will be in an excellent position to make our voice heard.

"A lot depends, finally," said Stever, "on how well we do our job—how useful we are to the White House and to other agencies in questions relating to science and technology."

Bisplinghoff noted: "We cannot dictate priorities or policies to other agencies; we can however, provide options and disinterested evaluation for Ash, or Shultz, or Butz or whoever."

Roy L. Ash is director of the OMB; Earl L. Butz is Secretary of Agriculture and counselor to the President; and George P. Shultz is Secretary of the Treasury and an assistant to the President. It is to Shultz that Stever reports.

As to possible complications stemming from his multiple roles as NSF director, science adviser and inheritor of OST's responsibilities, Stever pointed out that all of the President's new supercounselors, Shultz included, have similar problems. All head operating departments, while at the same time exercising policy-making and evaluative functions in the White House.

Said Stever: "I shall have to just make clear which hat I am wearing in each instance—and to separate out the judgments I make on budgetary matters for NSF, for instance, and other R and D budgetary advice I might be asked to contribute to Roy Ash and his staff."

Some critics of the changes have contended that a second-line agency like NSF will have no chance to exercise influence—particularly given the history of the reorganization and the clouded mandate it received in January—without some special word from the President himself.

But said William O. Baker: "If the reorganization plan itself does not make it perfectly clear that NSF is now the agency to be listened to on matters pertaining to science and technology in the federal government, there is no doubt in my mind that the President will act to put the point across."

Baker, who is president of Bell

Telephone Laboratories Inc., was co-chairman of a 27-member Science and Engineering Council for Mr. Nixon's reelection. He is a key link between the science community and the White House.

Scientists' views: The scientific community's mixture of optimism and skepticism about the President's science reorganization was nowhere more apparent than in comments made on the assignment of new roles to the NSF.

Edward E. David Jr., the last Presidential science adviser (he left the White House Dec. 29), was among the most sanguine. He said he did not "doubt that Guy Stever and his staff are up to the jobs they've inherited" and that he thought Shultz "will help greatly."

Another optimistic view was offered by Roger W. Heyns, president of the American Council on Education and vice chairman of the National Science Board, a 24-member group of nongovernment scientists which reviews NSF policies and grants. Heyns said he had "felt for several years that NSF should press for larger responsibilities. The President's action will mean profound changes for NSF and for the board, but it's time, I think, for us to get more into the mainstream."

Philip Handler said that "one clear plus under the new arrangement is the mandate to NSF to undertake major policy studies, particularly with regard to allocation of federal resources. OST never had the staff or funds or time to do this."

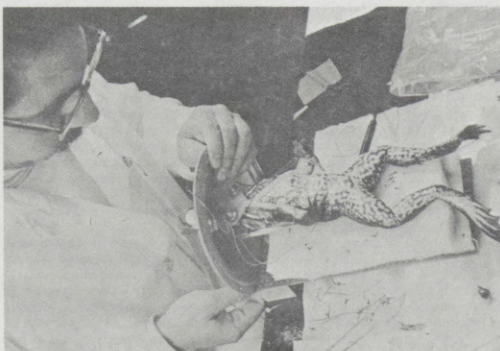
Very much divided in his reaction to the new arrangement was William D. McElroy, former director (1969-1972) of NSF and now chancellor of the University of California at San Diego. Of all NSF directors since the agency's creation in 1950, McElroy moved most naturally and easily in the political world of Congress, the White House and the bureaucracy.

"In some ways I think the change is to the good," said McElroy. "I think NSF has been greatly transformed over the last decade and is more capable today of setting out priorities for science and using its strong constituency in the universities to advise the government on policy options."

"However," he said, "they're going to have to have a hell of a lot more resources to perform these new tasks than they now have. Two years ago, the Administration was talking about a \$1-billion budget for NSF within three to four years. That is even more imperative now."

McElroy said he is worried that the NSF staff would be cut up when it attempted to set priorities and evaluate federal R and D programs. "There are many fine people at NSF," he said, "but they have no tradition or taste for the kind of political and bureaucratic infighting they will face if the Administration is serious in its plans for them. It's a tough world out there dealing with the big bureaucracies—they've all got a highly developed sense of turf, and don't brook interference lightly."

Others echoed McElroy's doubts



A scientist in Wallops Station, Va., tests a frog's adaptability to weightlessness

about the NSF staff's ability to assert itself in the political world of resource allocation—doubts stemming from the agency's history as a grant dispenser for academic science.

Said William D. Carey: "I found it surprising that the ball was lobbed into NSF's court. . . . They are still a very conservative agency when it comes to proposing national science priorities or judging the quality of the nation's scientific effort. They've just never developed enough self-confidence."

And Harvard chemistry professor Paul M. Doty, who served on an NSF advisory-planning committee from 1969 to 1972, said: "I saw the inside, and the quality of the staff, I guess, as close as anyone—it's pretty mediocre. There were a few strong points, but by and large, they're just not equipped to deal with the alleged new responsibilities for NSF." (Doty believes that the Administration's claims that it will use NSF as a sham, that they were made only to assuage the scientific community, "Stever's phone will never ring," he predicted.)

Potential conflicts arising from the NSF director's multiple roles, as head of an operating agency and as science adviser to the White House, also give rise to worries among leading scientists.

"The trouble," said Brooks, "is that you can never separate the various hats he's wearing. Suppose, for instance, Stever were asked to give advice on a new SST and through an advisory panel came out negatively. He would risk antagonizing powerful interests and jeopardizing NSF's budget and function. Two years ago, Sen. (Gordon) Allott (R-Colo., 1955-1973) raised hell about the technological-assessment funds in the NSF budget because he thought it was a means of killing the SST. Other Members of Congress will inevitably attack NSF if Stever renders advice adverse to their interests."

Independent advisory system

The federal government has used academic and industrial experts in science and technology as a source of independent advice since the beginning of World War II. In 1957, the advisory system was institutionalized, with establishment of the President's Science Advisory Committee, one of the organizations abolished by President Nixon in his recent reorganization of the federal science system.

Over the past three decades, U.S.

Presidents have felt a particular need for independent evaluations of projects promoted by the military establishment, and the PSAC and its subcommittees have had a notable influence in the defense area.

In recent years, the government increasingly has sought outside advice on civilian science and technology questions. Here, the advisory system has proved less useful, according to recent Administration statements.

Defense advice: Although its percentage of the federal research and development budget has declined steadily over the past two decades, the Defense Department remains by far the largest consumer of R and D funds. In an extremely tight fiscal 1974 budget, the Pentagon's R and D budget rose \$536 million from fiscal 1973, to \$8.5 billion. Defense work to be performed by other agencies (primarily the Atomic Energy Commission) brings the over-all military R and D budget to \$9.4 billion, or 53 percent of the \$17.4 billion the federal government projects it will spend on R and D in fiscal 1974.

Military programs in the works include the B-1 bomber, the Trident submarine missile, an expensive bomber-penetration decoy system, a site-defense system for the land-based Minuteman intercontinental missile, a close-support aircraft for the air force, a new strategic submarine-launched cruise missile and a new army tank. In addition, Pentagon-financed basic research in areas such as materials, lasers, radar and undersea sound detection are slated for sizable increases.

Administration arguments—In the document announcing the White House science reorganization, the Administration argued that the Pentagon has developed "strong capabilities for assessing weapons needs and for undertaking new weapons development." The Administration said that in special situations it would call upon the National Security Council and the NSF director (in his role as science adviser) for independent assessments.

In defense of the action, a National Security Council staff member argued that the military establishment "is no longer a monolithic organization; there are plenty of sources from which the President can receive differing viewpoints. In the first place, each of the services has its own R and D apparatus; then there's the Office of the Director of Defense Research and

NSF Leadership

Although the National Science Foundation concentrates heavily on basic research, its two top leaders have backgrounds in applied research and development. Both NSF Director H. Guyford Stever and Deputy Director Raymond L. Bisplinghoff are aeronautical engineers with strong ties to the federal government's space and defense programs.

Stever: Stever, 51, came to his current post as NSF director in February 1972, after serving for seven years as president of Carnegie-Mellon University, Pittsburgh, Pa. Before that, he had spent his entire academic career at the Massachusetts Institute of Technology. At MIT, he was professor of aeronautical engineering and from 1961 to 1965 chairman of the Departments of Mechanical Engineering, Marine Engineering and Naval Architecture.

Stever has served on advisory committees and boards for the Defense Department and NASA since the Second World War, including the science advisory board to the U.S. Air Force chief of staff (1947-1969); the Pentagon's technical advisory panel on aeronautics (1956-1962); and NASA's advisory committee on missile and spacecraft aerodynamics (1959-1965). In 1955-1956, he was chief scientist for the Department of the Air Force.

Bisplinghoff: Except for a brief stint at the University of Cincinnati (1941-1943), Raymond L. Bisplinghoff, 56, also spent his entire academic career (1946-1962, 1966-70), at MIT. He was successively associate professor and then professor of aeronautical engineering and dean of the School of Engineering.

From 1962 to 1966, Bisplinghoff was in federal government service as associate administrator for advanced research and technology in NASA.

He is a member of both the National Academy of Sciences and the National Academy of Engineering. Additionally, he has served as a consultant and an adviser to a number of aerospace and airline companies. He was appointed to his current position in 1970.

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Engineering (DDR&E) that reports directly to the Defense Secretary; and finally there's an outside Defense Science Board. There can also be independent assessments by the Central Intelligence Agency and the Arms Control and Disarmament Agency."

(All of the agencies he cited have been in existence for at least a decade, a period during which PSAC played an influential role in stopping some projects advanced by the military, notably including the proposed B-70 advanced bomber.)

The aide also said that the NSC, pursuant to its new responsibilities, "is exploring ways of independently tapping into the scientific community. We'll need a string of these people on call."

Outside dissent—Outside experts said the White House science reorganization could have particularly damaging consequences in the defense area. And few of those interviewed were impressed with the Administration's alternate plans for obtaining advice on military-technology issues.

The argument was put most strongly by President Eisenhower's science advisers, George B. Kistiakowsky and James Killian. Said Killian: "Under the new plan, despite what the Administration has said, there doesn't seem to be any way the President can get objective viewpoints that are not in some way encumbered with a vested interest."

And Kistiakowsky argued that "the nation and the President desperately need outside independent advice on defense matters. The questions of weapons systems—the B-1 bomber, Trident submarine, MIRV (missiles carrying multiple warheads)—are very much alive, and you cannot expect to get trustworthy information from the military."

Kistiakowsky expressed doubts that there were effective checks and balances and differing points of view within the Pentagon. He said, "the services grease each other's way; the Defense Science Board has always been heavily made up of scientists and engineers from companies dependent on defense contracts; and DDR&E in its first years represented an independent source, but now is almost completely under the thumb of the military."

Many of those interviewed also expressed doubts that the NSC staff would be able to offer an independent check on the military's claims. Among

them was Paul Doty of Harvard, a friend and former colleague of Henry A. Kissinger, assistant to the President (national security affairs), whom Kissinger has called on occasionally since 1969 as an independent channel to the scientific community. In an interview, Doty said that the capacity of Kissinger and his staff to act as a real check on the military was strictly limited.

He said: "Henry did interest himself in 1969 and 1970 in defense and disarmament questions, but then he got on the international circuit and since then just hasn't had the time. We've pressed him on a few important problems, but he's ended up saying 'I know they're important, and if I could just get three weeks alone to get on top of them I could help you.' But, it isn't going to work out I'm afraid."

Doty said that the "NSC staff has some very capable people but they are already overwhelmed with work. On a given problem DOD can simply swamp them with information against which there is no check."

Domestic advice: Even the stoutest defenders of the OST-PSAC system admit that in the area of civilian science and technology the task of providing useful advice to White House policy makers had proved difficult and exasperating.

From its origin in 1957 until the mid-1960s, PSAC was composed largely of scientists and engineers expert in defense and space issues and drawn mainly from the physical sciences. Many had worked together

in the World War II Office of Science Research and Development and, said Harvey Brooks, "Everybody knew everybody and we spoke almost in code."

In the 1960s, as the government began to deal more with science and technology problems in domestic affairs, the composition of the committee changed, at some expense to the old feeling of commonality and rapport. Said Brooks: "As other disciplines were added in the biological and social sciences, you did get more viewpoints but easy communication and an identity of purpose became more difficult."

PSAC members found that domestic problems they were asked to address often were closely associated with social and political judgments of a kind that made them more complex in many ways than the military projects PSAC had concentrated on before.

A young former OST staff member, who worked for Edward David, said that during the past two years he had attended meetings and discussions with present and former PSAC members, and that "it was striking how few of them were comfortable with or understood the problems associated with the application of civilian research to society. They were still very hardware oriented, and as Ed David learned, it was very hard to mix rocket scientists and sociologists and get people talking on the same wave length."

Although the President "has



An aerial view of the National Accelerator Laboratory, Batavia, Ill., used to study the nature and behavior of nuclear and subnuclear particles

chucked away his institutional advisory structure," said William Carey, "he hasn't closed off other options. I don't personally think it has been proven that a built-in advisory system is superior to the ad hoc approach the Administration seems about to take. The public task forces—mixing scientists, economists, lawyers and industry types—for instance, that Johnson and Nixon have used, may be a better method. It is a rare thing indeed for an advisory committee composed solely of scientists and engineers to be capable of assessing the political values or risks of the advice it is transmitting—or of packaging the advice in language or terms usable by the President."

David—Acutely aware of the problems both PSAC and the OST staff had experienced in providing the White House useful advice in civilian areas, David had actively been exploring ways to upgrade the advisory system in these fields during the last six months of his tenure.

Before the President's science reorganization decisions were made, David had been planning to restructure part of the OST staff along problem-solving lines, following the model established by the office's energy-policy division.

Lawrence A. Goldmunz, former executive director (1970-72) of the Federal Council for Science and Technology, with whom David consulted, said "the idea was to link a number of skills around a problem focus—to put together a lawyer, an economist, a social scientist and somebody expert in the hardware related to the problem."

In a speech given on Dec. 13, two weeks before he resigned, David identified several civilian R and D program areas which he said "required a strategic plan" and that spanned "several agencies of government and so the management and planning have to have a centralized focus, rather than being lodged in one agency."

"Further," said David, "the funding of these programs has already increased to a level where some over-all accounting is required. By accounting I mean what direction are these programs going, why they are going there and what progress are they making?" The program areas included energy, health, transportation, natural resources, education and social systems.

"The most representative one," said David, "... is energy. The energy dilemma is not only a tech-



Lawrence A. Goldmunz

nological problem, it's an economic problem, a social problem, legal, political, environmental and even to some degree a moral problem. Reconciling these various factors, which fall outside of science, with science and engineering possibilities is the crucial issue in national programs of R and D."

David also identified technical advice for regulation and standard-setting—particularly in the environmental field—as a second major task for federal science policy making during the next decade.

He has often stated his belief that Congress, in passing the Clean Air Act Amendments of 1970 (84 Stat 1676), required stringent automotive-pollution controls without regard to the availability or the cost of technology to meet standards set in the law, and without benefit of adequate scientific advice from any source. He alluded to the problem in his Dec. 13 speech, predicting that automotive pollution-control measures would cost the public \$100 billion between 1975 and 1985 and saying that where such "a monumental expense" was involved, "some rationalization of regulation is going to be necessary."

He concluded: "The nation needs strategies for achieving the qualities of life, in this case the quality of air. . . . I hate to say it, but I think we do not yet have that strategy in effect nor for that matter in view."

The speech could be interpreted as a warning to the White House that banishing science from the top levels of decision making could have deleterious consequences. But David loyally says now that he thinks that

"the new mechanisms the President has established will create a focus to bring together all the elements I listed in my speech."

The budget process

"When most people talk about federal science policy," said Lee A. DuBridge, President Nixon's first science adviser, "what they really mean is 'Where's the money going?'"

Decisions involving the federal government's large R and D budget (\$17.4 billion in fiscal 1974) was in fact one of the most important areas in which the science adviser and the OST played a part. And DuBridge's comment points to what may be the greatest loss in the abolition of OST: the close working relationship that had developed over the years between its staff and the staff of the President's budget office.

Although OMB benefited from the scientific expertise the relationship afforded it, there are no current plans to increase the budget agency's staff to make up for the loss. Charles F. Bingham, who heads the government organization branch of OMB's Office of Management Systems, said: "Over the years there's been a continuing debate as to whether the budget bureau should develop a specialized staff. The prevalent opinion still holds that the bureau should retain general rather than technical or special skills."

OMB-OST liaison: The liaison between OMB and the OST goes back to the late 1950s, when President Eisenhower's science advisers began to gather a small staff that grew throughout the 1960s with the creation of OST and a gradual increase in its membership. (At the end of 1972 OST had 22 professional staff members.)

Said William Carey, who had a major responsibility for R and D programs in the budget bureau until he left the agency in 1969: "The OST-OMB partnership was always an unequal one, with the budget bureau dominant at all times. But at least all the time I was around, OST people played an important part in the definition of questions, the analysis of options and even in the balloting on the outcome."

Individual relationship—OMB-OST teamwork was rooted in the day-to-day relations between individual budget bureau examiners and their staff counterparts in OST. "What we tried to do," DuBridge said, "was to have individual OST staff members pro-

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vide the technical expertise and back-up for key budgetary R and D decisions—in effect, to form a kind of technical arm of the budget bureau.”

“By and large,” said S. David Freeman, who headed OST’s energy-policy staff from 1968 to 1971, “I think most of the budget bureau people felt that the OST staff tried hard to give objective, impartial advice and not fall into the role of advocates for certain programs.”

The setting of long-range priorities for expenditure of federal R and D money never was OST’s strong suit; there simply were too many immediate problems that the White House asked the staff to analyze. The result was that OMB tended to use OST advice on a handful of important issues each year. Carey said that he and others had pressed within OMB for an increase in the OST’s staff, “but it never came off.”

Breeder and shuttle—The two largest civilian R and D programs now being funded by the federal government—the nuclear fast-breeder reactor and the space shuttle—provide examples of major White House decisions in which OST played a large role.

In his 1971 energy message to Congress, President Nixon raised to top priority the \$3.4-billion breeder-reactor program. Just two years earlier, a major debate had taken place within the budget bureau on whether to cut back drastically or drop the program. Recalled David Freeman: “It was a crucial time. You had a new Administration and a new budget director looking for places to save money. The policy-planning staff of the budget bureau came forward with a number of arguments, including challenges to the safety of the project, to its cost/benefit ratio, the contention that the country didn’t need it, in the energy mix and that we ought to rely on the private market to develop it.

“The OST staff countered with arguments that the breeder was feasible, that its cost/benefit ratio was indeed quite good and that the project was so large that private industry couldn’t carry it alone.”

Freeman said he is not “sure how the issue would have come out had we not been there, but I think we did have an impact.”

President Nixon’s January 1972 decision to go forward with NASA’s \$5.1 billion space-shuttle development program was also preceded by a heated and complex debate.



Raymond L. Bisplinghoff

Navy Capt. Russell D. Drew, who had been OST’s space expert since 1967, became a key figure during negotiations late in 1971 on the proper nature and cost of the shuttle system. At the time, NASA was pressing for a sophisticated design costing more than \$14 billion. Factions in OMB wanted to drop the project entirely. Drew had followed the shuttle issue closely since NASA first proposed it and, said a White House aide, “he became the real honest broker among contending factions.”

Getting information—Freeman said the OMB liaison also was quite important in giving the OST influence within the federal bureaucracy, facilitating its efforts to secure information on R and D efforts from mission agencies.

“Working as a White House staff member is always a game of poker,” he said. “You develop a network of contacts in various agencies but their cooperation is heavily dependent on how they perceive your power. It was important when we called that the agencies never really knew exactly how much clout we had. They didn’t know how badly we could hurt them, and also there was always the possibility we could help them, particularly with the OMB.”

Director’s sessions—Individual consultations between OST and OMB staff members probably constituted the most important part of the White House science structure’s role in federal-budget policy making.

But in addition, the science adviser occupied an unusual position in the budget process: he was the single outside participant allowed in the final

round of budget negotiations (the director’s review) in November and December. (This practice grew up in the 1960s and continued, “without statutory base, until OST was abolished. In only one year, the first of the Nixon Administration, did the science adviser not participate in these sessions.”)

“This was an important privilege for the science adviser, and one that no Cabinet officer had,” said William Carey. “Particularly with the fragmented federal structure for science and technology it was important that he be there when the final decisions were made.”

Problems for OMB: Some present and former government officials who have worked on federal R and D budget policy believe that OMB will not be able to perform as capably in the area as it did with the OST’s assistance.

Among them is Lewis M. Branscomb, who was director of the Commerce Department’s National Bureau of Standards from 1969 to 1972 and now is vice president and chief scientist at International Business Machines Corp. Said Branscomb: “The capability most conspicuously lost by the reorganization was that of getting a judgment—from a group not tied to competing agencies and programs—about the technical and management possibilities and traps in federal R and D programs. The typical OMB examiner, while usually competent and diligent, is now much more likely to be taken in by slick operators and highly varnished budget presentations.”

An OST staff member who worked under David said: “The real problems are going to emerge in dealing with new programs. OMB examiners and the higher ups are quite good at educating themselves over the years on the issues related to older programs, but they have neither the scientific expertise themselves nor, and this is more important, do they have the knowledge that would allow them to tap the right men in various agencies to give them the straight story on new programs.”

Freeman expressed doubt that the NSF could assume the role the OST had played in the budget process. He said: “There is a real sense of unity that develops among White House staff members. The two-block separation will be a formidable barrier for NSF, because they’ll be thought of as outsiders and not the President’s own men.” □

APPENDIX C

[From Chemical and Engineering News, March 5, 1973]

Solar energy could play big role in U.S.

Solar energy can be developed to meet sizable portions of future U.S. energy needs. This latest boost for solar energy technology comes from the Solar Energy Panel, a group organized jointly by the National Science Foundation and the National Aeronautics and Space Administration in January 1972. The panel has now issued its report on solar energy potential.

The panel consists of nearly 40 scientists and engineers in solid-state physics, chemistry, microbiology, power engineering, architecture, photovoltaics, and thermal sciences. It also includes economists, environmentalists, and sociologists.

Charged with assessing the potential of solar energy as a national energy resource and the state of technology in the various solar energy application areas, the panel has reached a number of conclusions. Among them:

- Enough solar energy is received to make a major contribution to future U.S. heat and power requirements.

- For most applications, the cost of converting solar energy to useful forms of energy is now higher than that of conventional sources, but through increasing prices of conventional fuels and increasing constraints on their use, the conversion will become competitive in the near future.

- A substantial development program can achieve the necessary technical and economic objectives by the year 2020. Then solar energy could economically provide up to 35% of the total building heating and cooling load; 30% of U.S. gaseous fuel requirements; 10% of liquid fuel needs; and 20% of the electrical energy requirements.

- If solar development programs are successful, building heating could reach public use within five years, building cooling in six to 10 years, synthetic fuels from organic materials in five to eight years, and electricity production in 10 to 15 years.

In making its assessment, the panel notes that average yearly incidence of solar energy in near-earth space is 130 thermal watts per sq. ft. and on the ground in the continental U.S. an average of 17 thermal watts per sq. ft. The 17 thermal watts per sq. ft. results in an average 24-hour energy supply of 410 thermal watt-hours per sq. ft., about twice the amount needed to heat and cool an average house.

The panel notes that converting the 17 thermal watts per sq. ft. into electricity at a 10% conversion efficiency would result in an average daily electric output of about 1.14 million kwh. per square mile. Thus, the panel says, at this rate total U.S. energy consumption in 1969 could have been supplied by the solar energy incident on 0.14% of the U.S. land area.

With this energy potential in mind,

the panel recommends that the Federal Government take a lead role in developing a research and development program for practical application of solar energy. It has identified three broad applications as most promising from technical, economic, and energy quantity standpoints and recommends an R&D program aimed at all three simultaneously. The three include economical systems for heating and cooling of buildings, economical systems for producing and converting organic materials to liquid, solid, and gaseous fuels or to energy directly, and economical systems for generating electricity.

The panel cites numerous conversion methods by which solar energy can be used for heat and power—thermal, photosynthesis, bioconversion, photovoltaics, winds, and ocean temperature differences. To apply these methods to the three broad application areas, the panel has recommended an R&D program composed of short-term (three years) and long-term (10 to 15 years) approaches. It has also worked out recommended levels of funding for a

15-year long-term R&D program for such applications.

For R&D related to thermal energy for buildings, the panel recommends \$100 million over the 15-year period. For renewable clean fuel sources, the program is composed of photosynthetic production of organic materials and hydrogen, at \$60 million, and conversion of organic materials to fuels or energy, at \$310 million. For electric power generation, solar thermal conversion would receive \$1.13 billion, photovoltaic conversion \$780 million, wind energy conversion \$610 million, and ocean thermal gradients \$530 million.

The panel envisions that R&D transitions will progress from feasibility studies to component development to prototype or pilot plant and to demonstration models or plants. It assumes that industry would share some of the costs for demonstration plants.

In its work, the panel also considered the environment. Large-scale use of solar energy as a national resource, it concludes, would have minimal effect on the environment.

**Charge injection converts optical image to video signal**

An experimental TV camera built around a new solid-state imager views the imaging device, held by its developers, General Electric engineers Gerald J. Michon (left) and Hubert K. Burke. The device, a $\frac{1}{8}$ -inch-square, photosensitive silicon semiconductor chip, uses a technique called charge injection to create an electrical video signal from an optical image. The chip carries 32 rows, each with 32 pairs of metal-oxide-silicon (MOS) capacitors. As light strikes the chip, each pair of capacitors collects an electrical charge proportional to the intensity of light striking it. Integrated circuits built into the perimeter of the chip scan the rows, and on signal, each pair of MOS capacitors releases its charge into the silicon base of the chip. Measurement of charge strength produces an area of appropriate shading on a TV screen. GE has under development an imager with nine times the present resolution—a chip with 100 rows of 100 capacitor pairs.

[From Science Magazine, March 16, 1973]

Solar Energy: Proposal for a Major Research Program

Despite growing interest in solar energy, little real research has been done. In contrast to fusion research, which has had the high-powered backing of a tightly knit segment of the physics community, solar energy research has been largely the hobby of a few isolated investigators. Careful assessments of solar energy's potential contribution to the U.S. energy supply and comprehensive proposals for its development have been lacking.

A report by a National Science Foundation-National Aeronautics and Space Administration panel released last month goes part way toward remedying this neglect (1). Solar energy, the panel asserts, is in principle a significant national resource. Its development will require a large commitment of money and research effort, and even so, the cost of solar technology may delay its use in many applications. Nonetheless, the report claims, by the year 2020 solar energy could provide 35 percent of heating and cooling in buildings, 30 percent of the nation's gaseous fuels and 10 percent of its liquid fuels, and 20 percent of electrical needs.

The NSF/NASA report was prepared as part of a national energy study for the now-defunct Office of Science and Technology. Optimistic in tone, it assesses various methods for converting sunlight to useful energy and finds no technical barriers to their application. The report outlines the research needed to bring the requisite technologies into existence and appeals for the funds to carry out the work. It also attempts to ascertain the impact of these technologies on the U.S. energy system. Special attention is given to three applications of solar energy: the thermal needs of buildings, production of artificial fuels, and generation of electricity.

The report notes that the cost of solar heating is competitive now with the cost of heating by fossil fuels in some parts of the country and could supply as much as 80 percent of the heat needs in sunny climates (Fig. 1). A 10-year R&D program costing \$100 million is proposed to bring about commercial availability of solar heating and cooling equipment. Energy storage and auxiliary energy sources would be needed.

Methods to produce artificial fuels

from organic materials could also be developed within 10 years, according to the report. Both organic wastes—farm residues, animal wastes, and urban sewage—and materials which might be grown specifically for energy production—plants, algae, and trees—could become renewable sources of fuels. The solar energy captured in these materials would be further converted into fuels by pyrolysis, fermentation, chemical reduction, or mechanical methods. Depending on the material and the process involved, solid, liquid, and gaseous fuels could be produced, and the report recommends a \$172 million R&D effort to develop these processes. Additional funds are recommended for research into improved photosynthetic production of organic materials and their combustion.

Generation of electricity with solar energy at costs competitive with nuclear power will take longer, the report suggests, and will require more expensive R&D efforts. Photovoltaic and thermal conversion of sunlight both require large man-made collectors that are invariably the most costly component

of these systems, but they offer relatively straightforward approaches to solar power. Less efficient but distinctly feasible are the natural collecting mechanisms that give rise to winds and temperature differences in the oceans. The report proposes more than \$1 billion to develop and construct a solar thermal demonstration plant and more than \$0.5 billion for each of the other three systems.

In contrast to these enormous sums, the \$5 million now being spent on solar energy research seems minuscule. But even with this modest effort some progress is being made. Photovoltaic power supplies for remote use—on an offshore drilling platform, for example—are being produced and sold commercially in competition with battery units. Construction has begun on a demonstration house at the University of Delaware that will be powered by photovoltaic cells. New engineering estimates by Aerospace Corporation put the cost of electricity from solar thermal power plants in 1990 closer to economic competitiveness with nuclear power.

The total solar energy program proposed by the NSF/NASA panel comes to a whopping \$3.5 billion. Even excluding the costly demonstration plants, the R&D budget still amounts to \$1.5 billion, a sum that may be hard to justify. Whether or not the total is excessive, it is comparable to the Atomic Energy Commission's \$650 million proposal for an expanded fusion research effort in the 1970's and the \$680 million price-tag for geothermal research suggested in the Hickel report (2). (Both estimates exclude demonstration plants and, for fusion, equipment to demonstrate scientific feasibility.) As these amounts illustrate, the cost of developing new energy sources will be high. Nonetheless, increased support would seem to be in the national interest.

—ALLEN L. HAMMOND

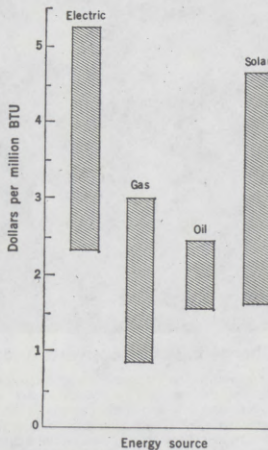


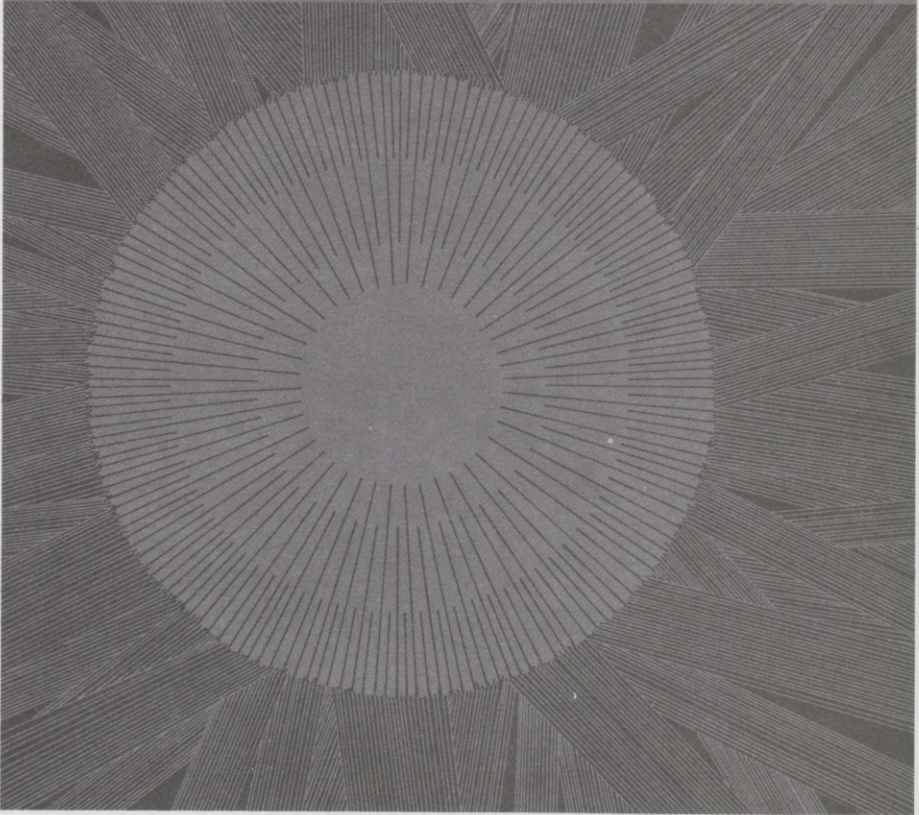
Fig. 1. Costs of space heating. [Source: University of Maryland]

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2. W. J. Hickel et al., *Geothermal Energy* (University of Alaska, College, 1972).

APPENDIX D

**SOLAR ENERGY AS A NATIONAL
ENERGY RESOURCE
NSF/NASA SOLAR ENERGY PANEL**



AN ASSESSMENT OF SOLAR ENERGY
AS A NATIONAL ENERGY RESOURCE

PREPARED BY THE

NSF/NASA SOLAR ENERGY PANEL

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Mr. William Woodward, Co-Chairman
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Dr. Frederick H. Morse, Technical Coordinator
Dr. Lloyd O. Herwig, Executive Committee

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INTRODUCTION

The Solar Energy Panel was organized jointly by the NSF and NASA in January 1972, and comprised of nearly 40 scientists and engineers possessing expertise in solid state physics, chemistry, microbiology, power engineering, architecture, photovoltaics, and the thermal sciences as well as several economists, environmentalists, and sociologists (see Appendix B). The Panel was charged with assessing the potential of solar energy as a national energy resource and the state of the technology in the various solar energy application areas, and with recommending necessary research and development programs to develop the potential in those areas considered important. The scope of the Panel's activities was defined to include all applications of direct solar energy, as well as power from wind, ocean thermal differences, and useful energy from replenishable organic materials. This report presents the findings of the Panel.

Current projections [1] of the total U.S. energy demand, see Figure 1, show a growth from approximately 64×10^{15} BTU in 1969 to nearly 300×10^{15} BTU in the year 2020. A significant portion of this increase is projected to be derived from nuclear energy, with the rest being supplied by fossil fuels some of which are being rapidly depleted. In view of the Nation's and the world's growing concern with environmental and health/safety factors as well as our anticipated increasing dependence on imported petroleum and gaseous fuels, it is important to evaluate the potential impact of solar energy utilization, since it is an inexhaustible source of enormous amounts of clean energy [2].

The average yearly incidence of solar energy in space and on the ground in the continental U.S. is:

In near-earth space	130 thermal watts/ft. ²
On the ground (average)	17 thermal watts/ft. ²

The 17 thermal watts/ft.² results in an average daily (24 hour) energy supply of 410 thermal watt-hours/ft.². This value is approximately twice the amount needed to heat and cool an average house. Converting the 17 thermal watts/ft.² into electricity at a 10% conversion efficiency would result in an average daily electric output of approximately 1,140,000 kilowatt-hours per square mile. In 1969, the Potomac Electric Power Company sold a daily average of 30,000,000 kilowatt-hours to 425,000 customers in an area encompassing 643 square miles. Within 27 square miles or about 4% of the above PEPCO serviced area devoted to a solar electric generation system, PEPCO could in principle provide the necessary electric power. Under the same assumption of a 10% conversion efficiency and U.S. average solar incidence, in 1969 the total electric energy consumed in the U.S. could have been supplied by the solar energy incident on 0.14% of the U.S. land area.

There has been little Federal support of solar energy utilization other than for powering artificial satellites. Commercial and philanthropic support of solar power generation has been almost negligible. Programs in Australia, the USSR, France, and Israel have all substantially exceeded U.S. effort. In principle, solar energy can be used for any energy need now being met by conventional fuels [3]. Three broad applications have been identified by the panel as most promising from technical, economic, and energy quantity standpoints. These are: (1) the heating and cooling of residential and commercial buildings, (2) the chemical and biological conversion of organic materials to liquid, solid, and gaseous fuels, and (3) the generation of electricity. The Applications chapter of the report is organized into three primary sections corresponding to these broad application areas. Within each section, one or more methods or processes for

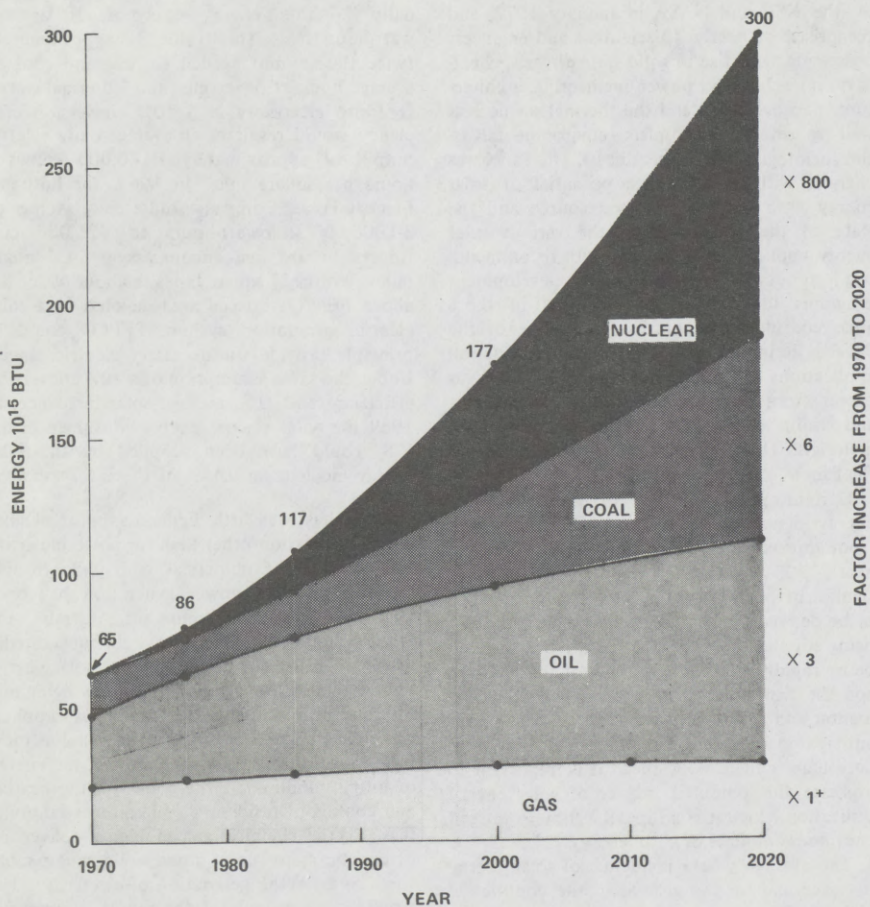


FIGURE 1. PROJECTED U.S. ENERGY DEMAND BY SOURCE [1]

converting solar energy to the desired form are presented in the following format:

- Description of Concepts
- Status
- Limiting Factors and Recommended Approaches
- Goals and Projected Impacts
- Short Range (3 year) R&D Program Recommendation
- Long Range (10-15 year) R&D Program Recommendation
- Phased Program Plan

The Panel is confident that solar energy can be developed to meet sizable portions of the Nation's future energy needs. This report is

intended to document this confidence. It must be recognized, however, that severe time limitations prevented a thorough and critical formulation and review of the technology, economics, relative prospects, and development tasks in each concept. Closer study is expected to eliminate certain areas from further attention, while some new and promising approaches may be added. A more detailed, in-depth examination of these and other methods for converting solar energy to useful forms is high on the agenda of our recommended research and development program. An introduction to the potential and uses of solar energy may be found in references [4] & [5].

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- Solar energy is received in sufficient quantity to make a major contribution to the future U.S. heat and power requirements.

- There are numerous conversion methods by which solar energy can be utilized for heat and power, e.g., thermal, photosynthesis, bioconversion, photovoltaics, winds, and ocean temperature differences.

- There are no technical barriers to wide application of solar energy to meet U.S. needs.

- The technology of terrestrial solar energy conversion has been developed to its present limited extent through very modest government support and some private funding.

- For most applications, the cost of converting solar energy to useful forms of energy is now higher than conventional sources, but due to increasing prices of conventional fuels and increasing constraints on their use, it will become competitive in the near future.

- A substantial development program can achieve the necessary technical and economic objectives by the year 2020. Then solar energy could economically provide up to (1) 35% of the total building heating and cooling load; (2) 30% of the Nation's gaseous fuel; (3) 10% of the liquid fuel; and (4) 20% of the electric energy requirements.

- If solar development programs are successful, building heating could reach public use within 5 years, building cooling in 6 to 10 years, synthetic fuels from organic materials in 5 to 8 years, and electricity production in 10 to 15 years.

- The large scale use of solar energy as a national resource would have a minimal effect on the environment.

RECOMMENDATIONS

It is recommended that:

- The Federal government take a lead role in developing a research and development program for the practical application of solar energy to the heat and power needs of the U.S.

- The solar energy R&D program provide for simultaneous effort on three main objectives: (1) economical systems for heating and cooling of buildings, (2) economical systems for producing and converting organic materials to liquid, solid, and gaseous fuels or to energy directly, (3) economical systems for generating electricity.

- Research and development proceed on various methods for accomplishing the above objectives and that programs with phased decision points be established for concept appraisal and choice of options at the appropriate times.

- For those developments which show good technical and economic promise, the Federal government and industry continue development, pilot plant, and demonstration programs.

- Environmental, social, and political consequences of solar energy utilization be continually appraised and the results employed in development program planning.

SUMMARY

The following information is tabulated to facilitate an overview of the Solar Energy Panel's findings:

Table 1. Status of Solar Utilization Techniques.

Table 2. Summary of Major Technical Problems.

Table 3. Impact of Solar Energy Applications on the Reference Energy System.

Table 4. Summary of Overall Program Funding.

Comments From the Solar Energy Panel's Consultants

TABLE 1. PRESENT STATUS OF SOLAR UTILIZATION TECHNIQUES

The checkmarks in this table indicate the approximate state of development for the various utilization techniques. The extreme right hand check indicates the progress as of 1972 but some work may still be required in the other areas. For example, water heaters are commercially available but combined water heating, heating and cooling systems are still in a state of development.

TABLE 2. SUMMARY OF MAJOR TECHNICAL PROBLEMS

This table identifies the major technical problems to be overcome. As an example, before any of the photovoltaic systems can become applicable on a large scale, solar arrays costing about \$1.00 per square foot will have to be developed. Before the space power station can be feasible, major advances are required in the deployment of huge lightweight structures in space, and low cost synchronous orbit transportation. In all

applications substantial cost reductions are important problems.

TABLE 3. IMPACT OF SOLAR ENERGY APPLICATIONS ON THE REFERENCE ENERGY SYSTEM

This table shows the expected impact that solar energy could have if developed to commercial utilization. The impact is compared with the Reference Energy System's annual consumption figures for the particular application, an estimate in percent of the expected market, the annual savings in fossil fuels based on \$1 per million BTU and an estimate of the significance of the impact based on the specific application and the total U.S. energy needs. A minor impact is considered to range from 0 to 5%, a modest impact from 5 to 10%, and a major impact is equal to or greater than 10%. For example, if by 2020, 30% of the Nation's methane needs are met by the bioconversion of organic wastes, then this would represent a major impact on the gas consumption market and a minor impact on the total U.S. energy consumption (4.2%). At \$1.00 per million BTU, assumed for natural gas costs, the value of the product is \$12 billion per year.

TABLE 4. SUMMARY OF OVERALL PROGRAM FUNDING

The funding recommended by the Panel for the total 15 year program is shown in this Table. Since some systems will terminate at phased decision points in the R&D program, the items have not been totaled. Specific decisions justified by the progress made in a preceding phase are required before progressing to the next phase. In general, the transitions will progress

Table 1. Present Status of Solar Utilization Techniques

Application	Status					
	Research	Development	Systems test	Pilot plant demonstration	Prototype plant	Commercial readiness
Thermal energy for buildings						
Water heating	X	X	X	X	X	X
Building heating	X	X	X			
Building cooling	X	X				
Combined system	X	X				
Renewable clean fuel sources						
Combustion of organic matter	X	X	X	X		
Bioconversion of organic materials to methane	X	X	X	X		
Pyrolysis of organic materials to gas, liquid, and solid fuels	X	X	X	X	X	
Chemical reduction of organic materials to oil	X	X	X			
Electric power generation						
Thermal conversion	X					
Photovoltaic						
Residential/commercial	X					
Ground central station	X					
Space central station	X					
Wind energy conversion	X	X	X			
Ocean thermal difference	X	X	X			

X indicates effort is underway but not necessarily complete.

from feasibility studies, to component development, to prototype or pilot plant, to demonstration models or plants. It is assumed that some of the funds designated for demonstration plants will be cost shared by the industry and thus reduce the government investment.

COMMENTS FROM THE SOLAR ENERGY PANEL'S CONSULTANTS

To include the concerns from the various other disciplines which would interface with the

development of any new energy source, the Solar Energy Panel had representatives from the economic, environmental, psychological, sociological and industrial interests. A summary of their comments follows:

Economic

On close examination, the possibilities for the economic use of solar power, given reasonable R&D support, appear much better than generally realized. In regard to the level of R&D, if the nation is to obtain the maximum benefits

Table 2. Summary of Major Technical Problems

Application	Major technical problems to be solved
Thermal energy for buildings	Development of solar air-conditioning and integration of heating and cooling.
Renewable clean fuel sources	
Combustion of organic materials	Development of efficient growth, harvesting, chipping, drying and transportation systems.
Bioconversion of organic materials to methane	Development of efficient conversion processes and economical sources of organic materials.
Pyrolysis of organic materials to gas, liquid and solid fuels	Optimization of fuel production for different feed materials.
Chemical reduction of organic materials to oil	Optimization of organic feed system and oil separation process.
Electric power generation	
Thermal conversion	Development of collector, heat transfer and storage subsystems.
Photovoltaic	Development of low-cost long-life solar arrays.
Systems on buildings	High temperature operation and energy storage.
Ground station	Energy storage.
Space station	Development of light-weight, long-life, low-cost solar array; transportation, construction, operation and maintenance; development and deployment of extremely large and light-weight structures.
Wind energy conversion	Integration of large wind conversion system with suitable energy storage and delivery systems.
Ocean thermal difference	Large low pressure turbines, large heat exchangers, and long, deep-water intake pipe.

for its energy R&D expenditures, then R&D expenditures on various sources of energy and processes should be carried to the point of equal marginal productivity of the incremental research dollar for each source and process. On the basis of this, as well as other, criteria, it appears that an objective allocation of R&D funds would call for substantially increased R&D support for a number of solar energy opportunities. There are also international benefits in making a viable solar technology available to the world as well as balance of payments and national security benefits in limiting our almost inevitable dependence on foreign energy sources.

Environmental

Solar energy utilization on a large scale could

have a minimal impact on the environment if properly planned. It is important, therefore, that a policy of research and review for environmental effects be made an integral part of the R&D process. Continuous feedback into the development program is critically important to prevent the undue expenditure of funds for processes that could ultimately prove unacceptable from a public point of view. One of the major obstacles to public acceptance of new technologies is the fear that there are unknown side effects that have not been adequately investigated or disclosed.

The most environmentally benign solar energy systems might be those of small scale that would fit into space already occupied by buildings. When considering large land based systems, great

Table 3. Impact of Solar Energy Applications on the Reference Energy System⁽¹⁾

System	Year	Annual consumption ⁽²⁾ (10 ¹⁵ BTU)	Percent of total energy consumption in USA	Estimated percent of market captured	\$10 ⁶ Annual savings in fossil fuel @ \$1.00/10 ⁶ BTU	Significance ⁽⁶⁾ of impact on reference energy system by 2020
Thermal energy for buildings	1985	(3)17	15	<1		Major on building industry Minor on total energy consumption
	2000	(3)21	12	10	2,100	
	2020	(3)30	10	35	10,500	
Conversion of organic materials to fuels or energy						
Combustion of organic matter	1985	37	32			Major on electric utility Modest on total energy consumption
	2000	76	43	1	760	
	2020	160	53	10	16,000	
Bioconversion to methane	1985	(4)27	23	1	270	Major on gas consumption Minor on total energy consumption
	2000	(4)31	18	10	3,100	
	2020	(4)41	14	30	12,300	
Pyrolysis to liquid fuels	1985	(5)50	44			Major on oil consumption Minor on total energy consumption
	2000	(5)63	36	1	630	
	2020	(5)80	27	10	8,000	
Chemical reduction to liquid fuels	1985	(5)50	43			Major on oil consumption Minor on total energy consumption
	2000	(5)63	36	1	630	
	2020	(5)80	27	10	8,000	
Electric power generation						
Thermal conversion	1985	37	32			Modest on electric utility industry Modest on total energy consumption
	2000	76	43	1	760	
	2020	160	52	5	8,000	
Photovoltaic						
Systems on buildings	1985	(3)9	9			Major on building industry Minor on total energy consumption
	2000	(3)15	9	5	750	
	2020	(3)21	6	50	10,500	
Ground stations	1985	37	32			Major on electric utility industry Modest on total energy consumption
	2000	76	43	1		
	2020	160	52	10	16,000	
Space stations	1985	37	32			Major on electric utility industry Modest on total energy consumption
	2000	76	43	1	760	
	2020	160	52	10	16,000	
Wind energy conversion	1985	37	32			Major on electric utility industry Modest on total energy consumption
	2000	76	43	1	760	
	2020	160	52	10	16,000	
Ocean thermal difference	1985	37	32			Major on electric utility industry Modest on total energy consumption
	2000	76	43	1	760	
	2020	160	52	10	16,000	

Notes: (1) Each of the above impact estimates assumes the successful development of practical economically competitive systems. However in each case a judgement has been made resulting in estimates that are less than the maximum possible. The estimates are not necessarily additive since not all systems will be carried to commercial readiness.

(2) Nonrenewable fuel consumed to generate the electric power as projected in the energy reference systems and resource data report, AET-8, Associated Universities, Inc., April 1972 [1].

(3) Nonrenewable fuel consumed to generate the projected electric power requirements for buildings, AET-8 [1].

(4) Methane consumed to meet projected energy needs, AET-8 [1].

(5) Oil consumed to meet projected energy needs, AET-8 [1].

(6) Minor, 0-5%; Modest, 5-10%; Major, >10%.

Table 4. Summary of Overall Program Funding*

Applications	Long Range R&D Program (15 years) \$ M
Thermal energy for buildings	100
Renewable clean fuel sources	
Photosynthetic production of organic materials and hydrogen	60
Conversion of organic materials to fuels or energy	310
Electric power generation	
Solar thermal conversion	1130
Photovoltaic conversion	780
Wind energy conversion	610
Ocean thermal gradients	530

*See Appendix A for additional funding information.

care must be taken to find suitable areas that would not be of unique ecological or recreational importance or cause serious alterations in local climate or weather.

One can indeed imagine designing "optimum size" environmentally oriented communities which would meet most of its energy needs from direct solar energy and the solar derived fuels from the local waste treatment plant.

Industrial

Before solar energy becomes a major source of clean energy for our nation, it will require the involvement of industrial ingenuity and productive know-how to produce economic hardware and services. Some of the difficulties in achieving industry participation are: (1) most companies are looking for short term projects

for their new enterprises with return on their investments in 2 to 3 years; (2) long range projects present great risk, and investment capital is very scarce unless there is a high probability of return in a major line in their business; and (3) companies will undergo major change only under crisis (they will take chances but cannot take failure).

To overcome these problems several things are needed. (1) The item needed must be defined very carefully so that the direction is clear and feasibility shown. (2) The Government must make a long range commitment to assure that the interest will not wane in a couple of years. (3) The incentives must be substantial so that future profit is sufficiently assured over a period of time that makes industrial investment pay off. Further, industries must feel that the system is socially acceptable so that the public will look upon it favorably. Solar energy utilization fits into this pattern extremely well.

Sociological

Research on the social conditions which foster solar energy technology protects against the truncating of a technological policy by the social responses it engenders. Analysis of social problems accompanying solar energy technology development requires a shift of focus from the physical world to the world of social activity. There is a need for more social scientific work to define the social (including economic, political, and cultural) problems presented by solar energy utilization. The establishment of National priorities for the use of solar among other energy forms should recognize the social impacts of the utilization of each energy form.

APPLICATIONS

THERMAL ENERGY FOR BUILDINGS

INTRODUCTION

Buildings may be heated and cooled with solar energy by use of some type of solar receiver or collector in which a fluid, such as water or air is heated. The system includes an insulated storage tank or rock bin and an auxiliary heat supply unit of some type to supplement or substitute for the solar source when it is insufficient to meet the demand. A heat-operated air conditioner provides cooling when supplied with solar or auxiliary energy, and various pumps, controls, and facilities are needed for circulating air from the conditioned space to either the heating or cooling unit. Figure 2 is a schematic diagram of one system employing water as the heat collection fluid. As seen, hot water for household use may also be supplied by a system of this type. Numerous alternate designs are possible.

The solar collector is one of the most important, and most expensive, element in the system. A sketch of one type is shown in Figure 3. Solar radiation is transmitted by the glass covers and absorbed by the blackened metal sheet. This causes the temperature of the metal sheet to increase, so that water circulated through the tubes is heated. Water temperatures of 100 to 200°F are commonly obtained, depending on conditions. Heat losses are minimized by the rear insulation and overlying glass covers.

A practical location, and suitable area, for the solar collector is the house roof. The collector should be south-facing for maximum efficiency, and it may be supported on the roof, on a frame work above the roof in building walls particularly in the high Northern latitudes. Storage may be conveniently located in a house at

ground level or in a basement. In a temperate, sunny central U.S. location, a 1,500 square foot house could be provided about three-fourths of its heating and cooling needs with a 600 to 800 square foot collector and 2,000 gallons of hot water storage. Greater attention to energy conservation in house design can significantly reduce the heating and cooling requirements, by more effective insulation, roof and wall orientation, window arrangement, surface properties for radiation control, solar transmission and shading.

STATUS OF RESIDENTIAL SOLAR HEATING AND COOLING

The three residential solar applications, water heating, space heating, and space cooling differ substantially in status of development, so they are discussed individually below. It is evident, however, that combinations of the three functions in integrated heating, cooling, and water heating systems will have the best prospects for economical use. The status of the integrated system is outlined after the discussion of each component.

Water Heating

Solar water heaters are commercially manufactured in Australia, Israel, Japan, USSR, and on a small scale in the U.S. The aggregate business of these enterprises is probably several million dollars per year. Solar water heaters are standard items of equipment in households in particular areas (e.g., northern Australia); areas of use are growing slowly. Application in the

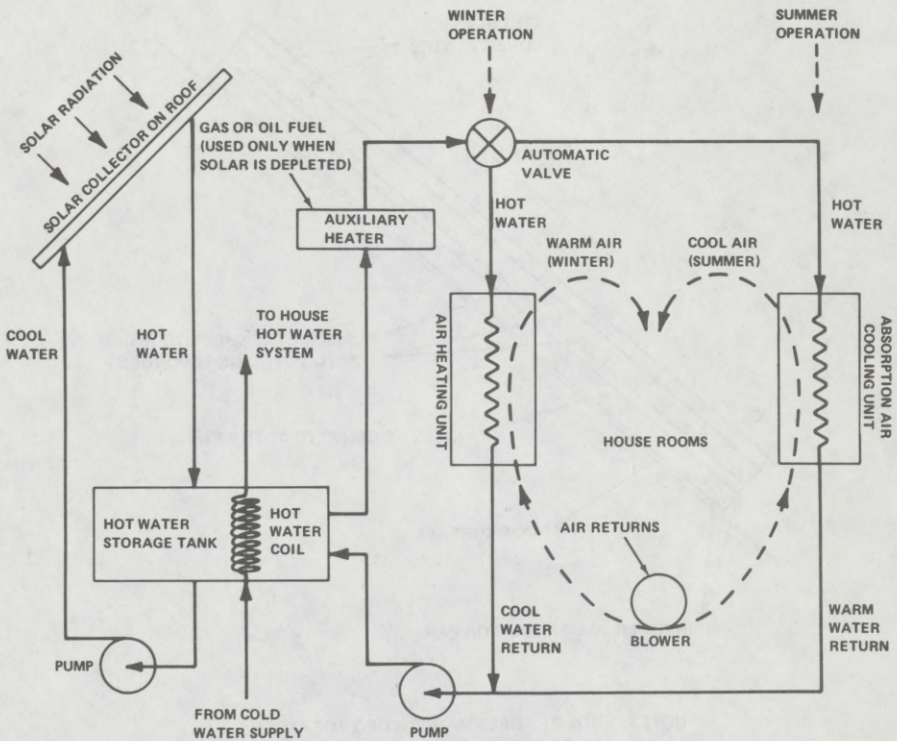


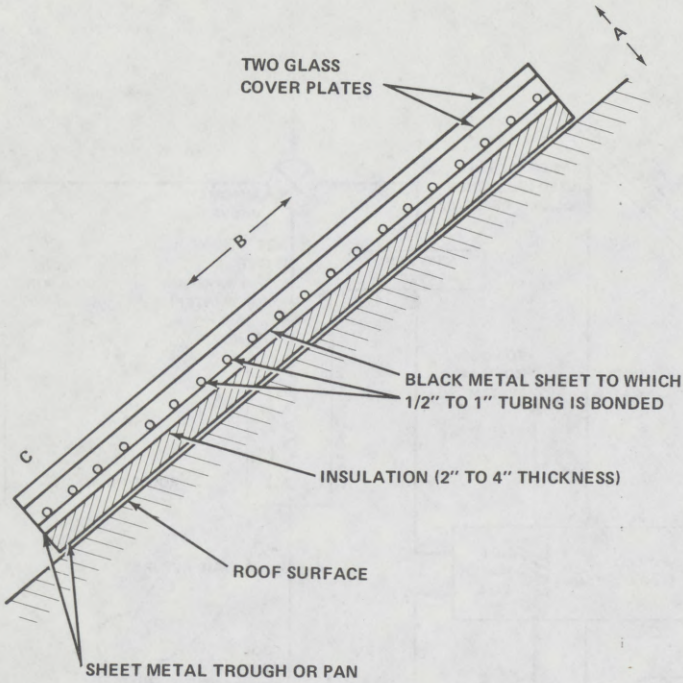
FIGURE 2. RESIDENTIAL HEATING AND COOLING WITH SOLAR ENERGY: SCHEMATIC DIAGRAM OF ONE ALTERNATIVE

U.S., once common in Florida but then diminished by the availability of natural gas, is now beginning to increase. In addition to household applications, institutional installations are beginning to appear in Australia, for schools, hospitals, etc. [6].

The technology of solar water heaters is well developed; further product engineering (particularly of collectors) and larger scale manufacturing would result in cost reductions and increased utilization.

Space Heating

Approximately 20 experimental solar heated structures have been designed, built, and operated. Various combinations of collector types, heat storage techniques, heat transfer media, and auxiliary energy supplies have been used. Some of these buildings were laboratories, and some were also designed as residences; only one fully instrumented and evaluated system has been in continuous use, so long-term experience with solar heating systems is limited.



NOTES: ENDS OF TUBES MANIFOLDED TOGETHER
ONE TO THREE GLASS COVERS DEPENDING
ON CONDITIONS

DIMENSIONS: THICKNESS (A DIRECTION) 3 INCHES TO 6 INCHES
LENGTH (B DIRECTION) 4 FEET TO 20 FEET
WIDTH (C DIRECTION) 10 FEET TO 50 FEET
SLOPE DEPENDENT ON LOCATION AND ON
WINTER-SUMMER LOAD COMPARISON

FIGURE 3. SOLAR COLLECTOR FOR RESIDENTIAL HEATING AND COOLING
DIAGRAMATIC SKETCH OF ONE ALTERNATIVE
(elevation-section)

The performances of several of these heating systems were fully measured and evaluated, and the results were published [6]. The capabilities of the various designs have thus been well established. Subsequent economic studies have shown that in a wide variety of U.S. climates, solar heating is less expensive than electric heating, and in a few locations, it is nearly competitive with gas or oil heating [7]. Table 5 and Figure 4, based on one of these analyses, clearly demonstrates that solar heating, even without supplemental savings from cooling, can be a practical alternative to conventional heat sources.

Workable heating systems have evolved from these experiments. However, they are not fully

engineered, both from the point of view of selecting the best systems or optimizing the design of those systems. Also, solar collectors, energy storage units and heat transfer systems are in an early stage of component development and engineering. Though technical feasibility is assured, economic feasibility is being approached for major regions of the U.S. Further R&D is needed to reduce costs and develop better systems.

Air Conditioning

A few experiments have been conducted in the U.S., Australia, and the USSR to study the operation of absorption refrigeration systems

Table 5. Costs of Space Heating (1970 Prices) In Dollars Per Million BTU Useful Delivery [7].

Location	Optimized solar heating cost in 25,000 BTU/degree-day house, capital charges @ 6%, 20 years		Electric heating, usage 30,000 kwh/year	Fuel heating, fuel cost only	
	Collector @ \$2/ft. ²	Collector @ \$4/ft. ²		Gas	Oil
Santa Maria	1.10	1.59	4.28 ¹	1.52	1.91
Albuquerque	1.60	2.32	4.63	0.95	2.44
Phoenix	2.05	3.09	5.07	0.85	1.89
Omaha	2.45	2.98	3.25 ³	1.12	1.56
Boston	2.50	3.02	5.25	1.85	2.08
Charleston	2.55	3.56	4.22	1.03	1.83
Seattle-Tacoma	2.60	3.82	2.29 ^{2,3}	1.96	2.36
Miami	4.05	4.64	4.87	3.01	2.04

Notes: ¹Electric power costs are for Santa Barbara, Electric power data for Santa Maria were not available.

²Electric power costs are for Seattle.

³Publicly owned utility.

Solar heat costs are from optimal design systems yielding least cost heat.

Electric power heat costs are from U.S. Federal Power Commission, All Electric Homes, Table 2 (1970). Conventional heat fuel costs are derived from prices per million BTU reported in P. Balestra, The Demand for Natural Gas in the United States, Tables 1.2 and 1.3 (North Holland Publishing Co., 1967). The 1962 costs were updated to 1970 by use of national price indexes on gas (121.1 in 1970 versus 112.8 in 1962) and on fuel oil (119.22 in 1970 versus 101.2 in 1962) as adjustment factors on each fuel price in each state. Bureau of Labor Statistics fuel prices indexes obtained from Gas Facts. Fuel prices were converted to fuel costs by dividing by the following national average heat (combustion) efficiencies: gas, 75%; oil, 75%. Heat efficiencies are from American Society of Heating, Refrigerating and Air Conditioning Engineers, Guide and Data Book 692-694 (1963 ed.).

All solar heat costs based on amortizing entire solar system capital costs in 20 years at 6 percent interest. Capital investment based on current prices of solar water heaters at \$4 per sq. ft. plus current costs of other components, and on anticipated near-term solar collector price of \$2 per sq. ft.

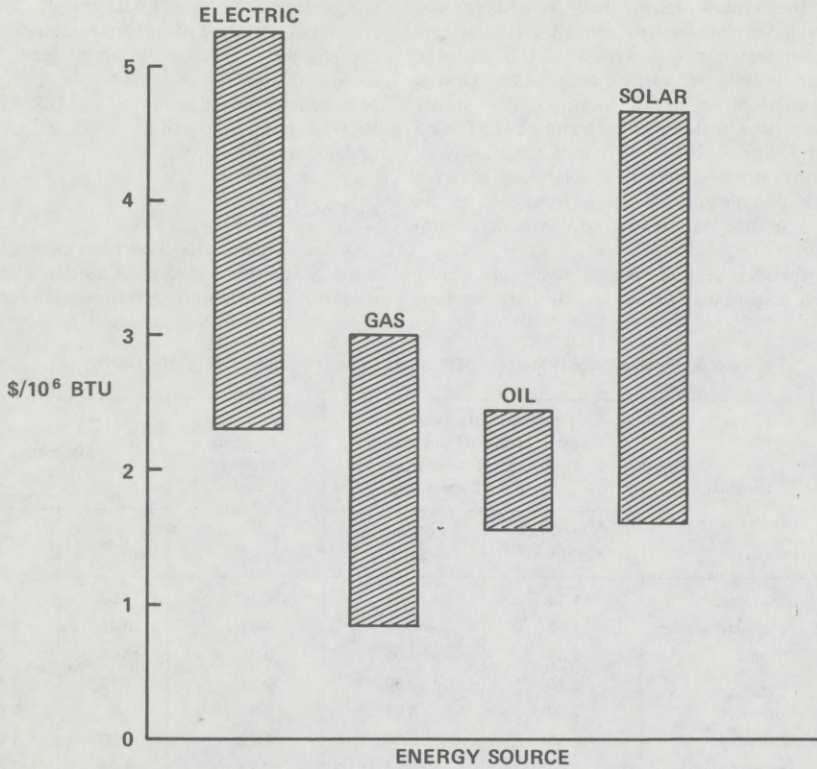


FIGURE 4. COSTS OF SPACE HEATING

using heat from solar collectors [6, 8]. These experiments show that the concept is promising, and no major technical barriers to successful development are seen. Other cooling methods, by use of dehumidifying agents with solar regeneration, jet compression with solar input, are also possibilities on which a very few experiments have been performed. It is evident that there are numerous technological options to be explored; these include many types of cooling equipment [9] and cycles, alternative methods of providing energy storage and auxiliary energy input, and combinations of these components in systems. Economic projections based

on the preliminary experiments done to date and not reflecting major developments in components or systems are promising.

Combined Systems

Although no experiments have yet been performed, the same major components, solar collectors and energy storage units, can be used to supply hot water, space heating, and air conditioning. Most of the solar heated experimental houses have included means for heating water; only one has included air conditioning other than by nocturnal radiation or by use of

heat pumps. The economics of combined systems, with their higher use factor on capital intensive equipment, can be expected to be much better than that of either heating or cooling alone.

There remain, however, numerous design and operating problems which require solution before practical systems can be marketed and used.

LIMITING FACTORS AND RECOMMENDED APPROACHES

The principal factor limiting the adoption of solar heating in favorable sections of the U.S. is the lack of well-engineered and economically manufactured and distributed solar heat collectors. The key problem is the development, optimization, production design, and manufacture of such units. The difference in the cost of heat supplied by solar collectors relative to conventional sources is disappearing and no longer appears to be a major problem. Marketing may however, require innovative concepts for general acceptance by builders and home owners.

The key problems impeding wide utilization of solar cooling and combined systems, in addition to questions analogous to those for heating, are economical cooling subsystems, evaluation of alternatives, designs and product engineering, construction and operating experiences. These are technical development problems whose solutions can be assured by reasonable effort. As with heating alone, high capital investment may impede initial adoption, but full appraisal of costs shows that fuel savings will more than offset first-cost disadvantage when systems become commercially available.

The approaches to wide utilization of combined systems are indicated by the character of the problems. Support is needed for engineering development and design studies, testing and improving well conceived systems, optimization studies, and production engineering design, followed finally by full demonstrations and trial public use.

There is no doubt that among all the possible uses for solar energy, residential heating and cooling has the highest probability of success.

There are the least uncertainties both in the technology and the economics of these domestic applications. There is, moreover, a very high benefit/cost ratio in that the total funds needed for the development of a viable enterprise will be only a small fraction of the annual value of fuel savings, or of equipment sales, or of some other measure of benefits to the economy.

GOALS AND PROJECT IMPACTS

The goal of research on solar heating and cooling is fully developed and engineered systems suitable for wide public use. Research toward this end must have the following aims:

- Efficient and economical solar collector designs.
- Heat storage materials and containers, low in cost and dependable in performance.
- An air cooling unit efficiently operable by heat from the solar collector-storage system.
- Economical system designs for house heating, cooling, and water heating, supplied with optimum combinations of solar and auxiliary energy.

Achievement of the broad objectives listed above, through various specific projects involving research, engineering development, system design, economic analysis, production engineering, component and system testing, and full scale demonstration, will place this application in trial public use well within a decade. A suitable and achievable practical goal is a 10 percent penetration of the market for new building heating and cooling installations by 1985.

The impact of successful solar heating and cooling development may be forecasted in several ways as indicated in Table 6. The maximum potential use of solar heating and cooling would involve virtually all new houses and commercial buildings. Assuming solar energy could supply an average of 80 percent of the heating and cooling requirements in 90 percent of all new houses and single-story commercial buildings, 4.5 percent or 8.4×10^{15} BTU per year of the Nation's year-2000 energy requirements may be

Table 6. Impact of Heating and Cooling of Building by Solar Energy

	Water heating		Solar heating		Solar cooling		Combined thermal systems	
	1975 1980	1980 1985	1980 1985	1985 1990	1980 1990	1985 2000	1980 1990	1985 2000
Time scale								
New buildings (1%) (10%)								
Total buildings (1%) (10%)								
Resource effect								
Fuels	1.2% U.S. energy budget with 100% installation							
Materials	10%/house increase in glazing.							
Environment	Ultimately ⁽¹⁾ 30-80 percent of fuels and electricity normally used for space heating/cooling can be saved.							
Land	Use of average additional 1,000 ft. ² glass/house + other materials. No shortage of materials.							
Noise	3D zoning; sun rights.							
Visual	None							
All others	Minimal							
Economics	None ⁽²⁾							
Capital	None ⁽²⁾							
\$/MBTU heat	\$200-\$400 ⁽³⁾							
Solar	unit cost							
\$/MBTU heat	\$3-\$6 ⁽⁶⁾							
Conventional	\$2-\$4 present							
d/Ton-hr. solar cooling	\$3-\$5 1990 estimated							
d/Ton-hr. conventional cooling	\$2.50-\$4.50 1990 estimated							

Notes: (1) Percent of energy used for space heating and cooling (2) Percent of total U.S. energy

1990 7
2000 50-80

- (2) Except for indirect positive benefits due to decreased use of other resources.
 (3) 50 ft² collector; 100-200 gallon hot water tank; thermal transfer, controls.
 (4) 500 ft² collector, \$2-\$4/ft², plus controls and storage cost.
 (5) Including \$1,500 cost of cooling unit.
 (6) \$200-\$400 unit cost. 15% year discount—\$60/year; 1,200 BTU/ft² day incident; E = 50%—3,000 kWh delivered/year.
 (7) Including cost of heat supply to cooling unit.
 (8) Electrically operated compression systems and heat-operated systems using natural gas.

saved. The corresponding figures for 2020 would be 8 percent and 23×10^{15} BTU per year.

A more probable impact, considering the time required for a new development to achieve wide use and the greater suitability and economy of the system when used in new rather than old buildings, is 10 percent of new buildings constructed in 1985, 50 percent in 2000, and 85 percent in 2020. As percentages of *total* buildings, these figures become approximately 1 percent, 12 percent, and 31 percent, respectively. Corresponding energy savings are 0.12, 2.1, and 10.5×10^{15} BTU/year.

Equivalent annual values of probable fuel savings at these three intervals are \$180 million, \$3,600 million, and \$16,300 million. Gas and oil costs are estimated at a present average price of \$1.50 per million BTU delivered to residential customers.

The probable sales of solar heating and cooling equipment should reach an annual gross value of \$0.75 billion by 1985, \$4.5 billion by 2000, and \$9 billion by 2020. This new billion dollar industry will involve heating and cooling equipment manufacturers, their material suppliers, and their customers. Heating and cooling contractors, their employees, and other services will participate.

Some of the intangible benefits of this development will be the alleviation of problems related to inadequate gas supplies in some areas of the country, the reduction of excessive and expensive electricity peak loads and associated power system failures during very hot weather, and the extension of oil and natural gas supplies further into the future.

RECOMMENDATION FOR SHORT RANGE RESEARCH AND DEVELOPMENT (YEARS 1-3)

The short range goal of R&D effort in residential solar heating and cooling should be a fully workable prototype system suitable for test operation in favorably situated residences. This can be achieved within three years of the start of a program so oriented. It cannot be expected that the system will be the most economical or most efficient or most convenient

that is possible, because more time and development will be required for such advantages to be realized.

Component design and system design studies, optimization studies, cost analyses, and prototype construction and testing of components and the integrated system are the main requirements of the three-year R&D program. The studies must involve solar collectors, heat storage units, heat exchangers, absorption refrigeration equipment, auxiliary heat supply facilities, control instruments, and various sub-assemblies and full assemblies of these components.

RECOMMENDATIONS FOR DEVELOPMENT IN 4TH TO 10TH YEARS

After initial performance testing of a functional unit, the residential solar heating and cooling system should be subjected to a rigorous program of improvement and optimization. Three interrelated objectives are increased: efficiency, reduced cost, and greater simplicity and practicability of application to general use. Most of the effort should be placed on concepts previously investigated, but there should be some work on promising alternatives, especially those involving cooling methods.

The types of projects requiring support in this phase of development are the same as those listed for the initial program, plus engineering design and testing to increase effectiveness of components and complete systems, production design and engineering study (ideally in cooperation with manufacturers) to reduce equipment cost, and architectural and construction analyses to achieve practical applicability to residential use. Prototype testing and demonstration operation of complete systems will be a substantial portion of the total effort during this period. A public information and education program should be included in the demonstration phase of development. Commercial production and sale of residential and commercial solar heating and cooling systems should commence before the end of this ten-year period.

PROGRAM PLAN FOR THERMAL ENERGY FOR BUILDINGS

Table 7 contains a recommended program of development to achieve practical use of solar energy in the heating and cooling of buildings. Tasks previously discussed are indicated here in abbreviated form. Sub-division of tasks to the extent herein is necessarily subject to modifications as work proceeds and results are obtained. Some tasks may require more effort than indicated, others less. The program must therefore have sufficient flexibility for modification as needed.

There should be continuous objective evaluation of the results of the program in order that planning of subsequent work or program termination can be timely and effective. In addition to this continuous decision process, there should be certain planned milestones or decision points. The first of these is set at 3 years from program commencement. At that

time, technical and economic data, some of which will be provided by prototype system operation, will provide a firm basis for planning the next development steps or for discontinuing the development. Abandonment is not anticipated, but many factors, some not even related to solar energy, may alter the present favorable prospects of this application.

Another decision point is indicated at the end of the fifth year, prior to starting a substantial demonstration program. Information available at that time will permit confident appraisal of the market for solar heating and cooling, the impact of this application, and the requirements and orientation of a demonstration program.

The funding level estimated for the entire 10 year program is \$100 million. If the total program is carried through approximately as outlined, it is fully expected that at its conclusion, residential heating and cooling with solar energy will be in general public use.

Table 7. R&D Summary and Milestones for Solar Heating and Cooling of Buildings

Task	Year									
	1	2	3	4	5	6	7	8	9	10
Collector										
Storage										
Cooling										
System design										
System construction and testing										
Production engineering										
Architectural										
Demonstration ⁽¹⁾ (including public information)										

Notes: (1) In cooperation with commercial builders and developers.

▲ Technical and economic viability decision.

△ Demonstration decision.

RENEWABLE CLEAN FUEL SOURCES

The natural conversion of solar energy into plant materials by photosynthesis and the further conversion of this stored energy into more concentrated forms such as natural gas, petroleum and coal is the basis of the world's fossil fuel supply.

Because these fossil fuel reserves are being depleted rapidly, it is essential that consideration be given to means for providing large additional supplies of high quality, concentrated fuels by using forces similar to those which produced our fossil fuels. The managed production of plant tissue (e.g., trees, grasses, water plants, fresh water and marine algae) with more efficient use of solar energy and required nutrients carried out on suitable land and water areas could provide starting organic materials.

The plant materials which constitute the product of photosynthesis have a comparatively low heat content per unit weight. The conversion of this plant material into higher heat content fuels (gases, oils, solids) similar to those making up the fossil fuel reserves is therefore essential for effective storage and efficient use as clean, contemporary fuels.

This section considers methods for production of various forms of stored energy via photosynthesis and also considers a number of promising methods for conversion of organic materials produced by photosynthesis into commonly used fuels. Figure 5 presents a summary of typical processes and products.

PHOTOSYNTHETIC PRODUCTION OF ORGANIC MATERIALS AND HYDROGEN

Introduction

As indicated in Figure 6, the successful utilization of a moderate portion of the area (land and water) under the control of the United States for conversion of solar energy into stored chemical energy via photosynthesis could provide the entire electrical energy needs of the country.

The large scale photosynthetic production of

plant material at solar energy conversion efficiencies, e.g., 3-5%, greater than usually observed in ordinary agricultural operations, 0.1%, would supply materials that could serve directly as fuels for production of part of man's energy needs or that could be subsequently converted into other forms of higher quality fuels. Concepts to be considered here are directed toward production of large amounts of land-grown products, e.g., trees or grasses, and also large amounts of water-grown products, e.g., algae or water plants. Because the ultimate purpose of growing the plant material is to provide a source of material that can be converted to heat energy by combustion or to enriched fuels by application of appropriate conversion processes, other available organic materials that can be converted in the above ways will also be examined. These latter materials comprise the large amounts of solid wastes—agricultural, animal, industrial, and urban—which are presently creating grave environmental problems and which actually represent a rich energy resource.

LAND PLANTS

In natural ecosystems, land plants such as trees and grasses show a net productivity ranging from about 4 to 26 tons of dry plant material per acre per year. Under intense cultivation the yields of certain crops have been reported to be about 40 tons of dry material per acre per year. Assuming an average yearly insolation of about 2.4×10^{10} BTU per acre per year and an average heat of combustion of the dried plant materials of 16×10^6 BTU/ton, the efficiency of solar energy conversion ranges between about 0.3% and 3.0%.

If, through advanced management practices including exploitation of modern developments in plant genetics, plantations were operated to produce continuous crops at greater than 3% solar energy conversion, less than 3% of the land area of the U.S. would produce stored solar energy equivalent to the anticipated U.S. electric energy requirements for 1985.

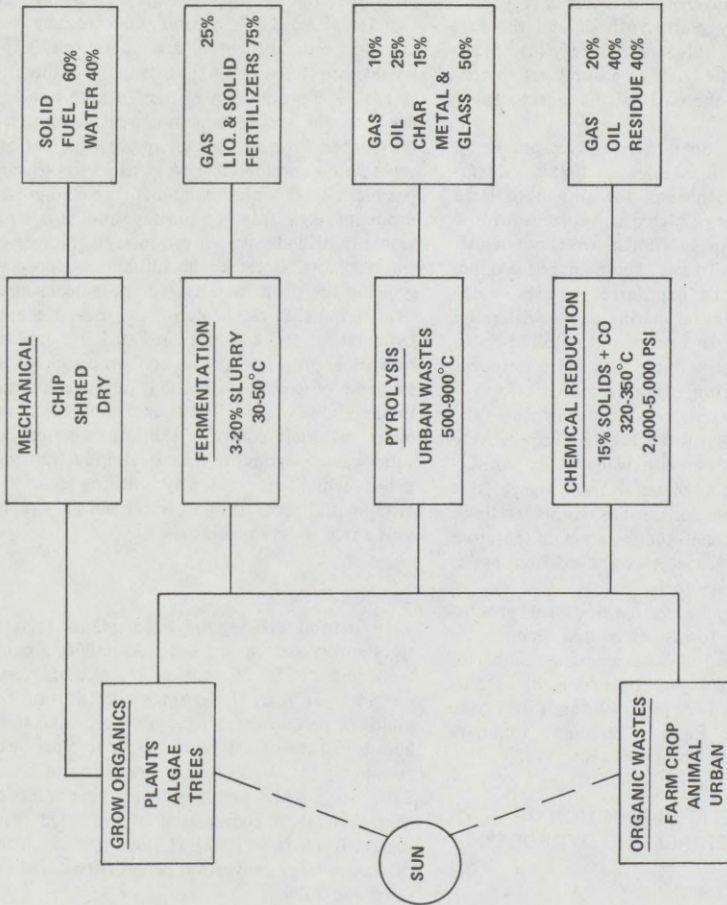


FIGURE 5. PRODUCTION OF FUELS FROM SOLAR ENERGY

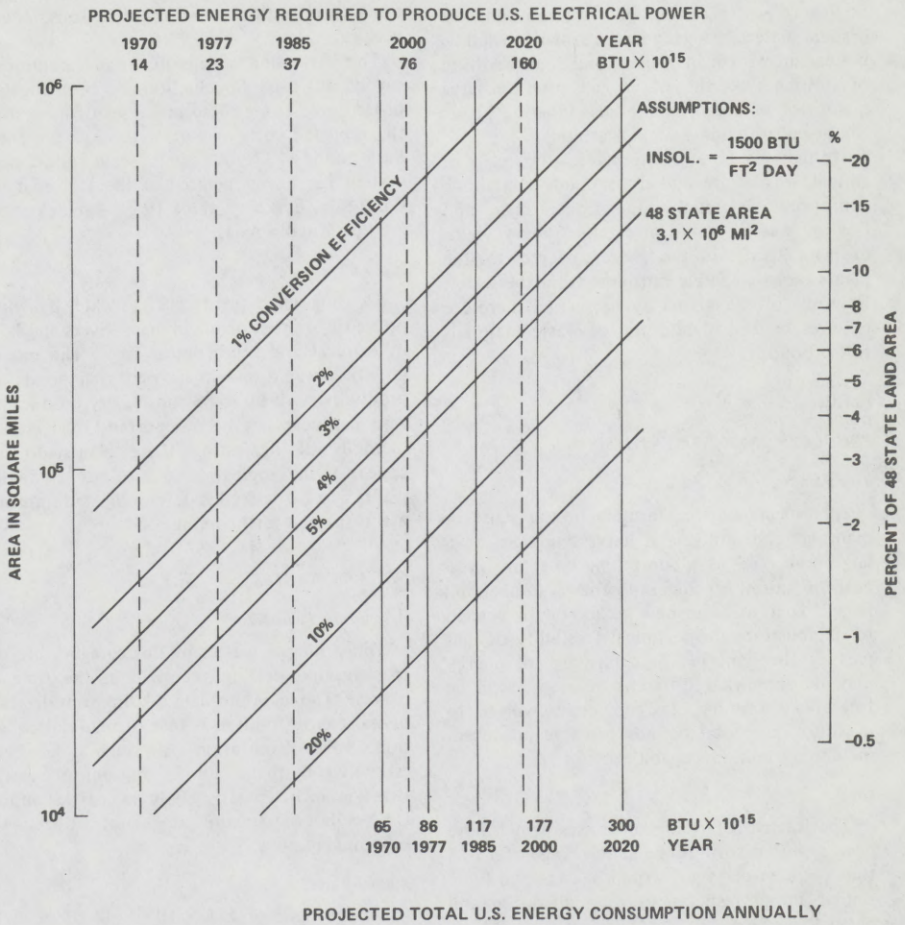


FIGURE 6. AVAILABILITY OF SOLAR ENERGY VS. LAND AREA

WATER PLANTS

The fixation of solar energy in the form of plant tissue grown in, or on the surface of, bodies of water can supply large amounts of organic material. Algae may be grown in shallow ponds and with management and some addition of nutrients to the water can produce large quantities of organic materials. Floating plants can be cultivated in a similar fashion.

If high levels of nutrients in the form of animal wastes are added to ponds containing appropriate bacterial populations, algae and floating water plants can produce heavy yields of plant tissue. In the process of growth, the plants remove soluble nutrients from the water. Removal of the plants by harvesting therefore requires continued addition of waste materials to the ponds.

Status

PRODUCTS OF PHOTOSYNTHESIS

Tree Farming

All aspects of tree farming in the sense of planting, cultivating, and harvesting trees on a large scale and as a continuing crop, are presently practiced for such industries as lumber and paper. Therefore, no new technology is needed to demonstrate the technical feasibility of that part of the concept. Tree farming for energy may be somewhat different because it will be total plant farming. The objectives will be to maximize the total pounds per acre produced, including trunk, limbs, and roots [10].

Grasses

The intensive farming of grasses, which have been reported to produce in the range of 13-15 tons per acre per year, would be expected to be similar in all respects to the cultivation and harvesting of hay.

Algae Culture

Extensive studies have been carried out over many years relating to the culture of specific algae strains as a potential high protein food source. The growth of algae for the purpose of removing nutrients in sewage oxidation ponds is

a common procedure. Recent reports [11,12] have indicated continuing yields of 20-30 tons of dry material per acre per year with peak production at the rate of about 50 tons per acre per year.

The harvesting of this material is commonly carried out using flocculation and centrifugation procedures. Using these processes of harvesting, the reported costs of a dried product are about \$.05/pound [13]. A small scale pilot plant system has been operated at the University of California, Berkeley, since 1959. Larger systems are operating in Asia.

Water Plants

Floating water plants, such as water hyacinth, presently are pest plants in many rivers and lakes in tropical and semitropical areas. The rate of growth is rapid and in nutrient-rich ponds net productivity of up to 85 tons of dry product per acre per year has been reported [14]. Present methods of harvesting these plants do not appear to be sophisticated but interest in the plants as a cattle feed is developing and improvements may be forthcoming.

ORGANIC WASTES

Agricultural Plant Wastes

The principal wastes in this category are the crop residues left in the field at the time of harvest. The main problem relating to utilization of most crop residues is that of material collection and transportation. Although it has been estimated that the annual amount of wasted straw is sufficient to satisfy all of the annual U.S. cellulose demand, it is not utilized for economic reasons.

Animal Wastes

On the basis of 118×10^6 head of cattle in the U.S. [15,16], the expected dry organic waste would amount to about 13×10^7 tons per year. Much of this waste is found on open range and is not recoverable. If it is assumed that 10-20% of the cattle are maintained in restricted area feed lots, the total waste from which energy recovery can be considered amounts to 13×10^6 to 26×10^6 tons of dry organic

material per year. Lesser amounts of wastes are also available from other types of animals raised in confined areas. It is therefore estimated that about 2×10^7 tons of dry waste per year would be available for use. Since local concentrations of these wastes may be very large, the cost as a raw material could be the cost of transportation to a processing site less some credit for accepting the waste.

Urban Solid Wastes

Urban waste generation may be assumed to approximate 5 pounds per person per day [17]. Of this approximately one-half is dry organic material obtained from waste paper, kitchen wastes, and garden or lawn wastes. Although this amounts to about 10^8 tons of dry organics per year over the entire population, the portion generated in cities where severe disposal problems exist approximates 2 to 4×10^7 tons per year. As with the animal wastes the cost of this material as an energy source could be the transportation charges to the conversion site less a credit for accepting the waste.

Summary

It is considered that the total animal and urban solid wastes available under conditions not involving potentially prohibitive collection costs may amount to 4 to 6×10^7 tons of dry organic material per year. The average heat content of this material may be 16×10^6 BTU per ton. Therefore, an annual energy supply amounting to 0.6 to 1.0×10^{15} BTU is available. This represents approximately 6% of present energy requirements for electrical generating plants.

Limiting Factors and Recommended Approaches

PRODUCTS OF PHOTOSYNTHESIS

Tree Farming

Considering a tree crop as a source of raw material for conversion to energy or to an upgraded fuel, the technical problems fall primarily in the area of cost reduction. At the present time, the cost of wood chips produced from lumbering wastes is reported to be about \$20 a ton at a production site. Assuming a

similar cost at the "forest plantation" site, an additional cost for transportation of the chips to the point of use must be considered.

If utilization of the tree crop is envisioned as fuel for a 1,000 MW power plant, the required fuel supply is assumed to be obtained from an area of 400-500 square miles and would require transportation over distances of 10 to 15 miles. Handling of the fuel during drying operations incurs additional costs. These processing charges suggest fuel costs at the power plant in the range of \$1.50 to \$2.00/ 10^6 BTU.

There appear to be no significant social problems associated with this concept. Environmental problems would involve particulate emissions and low-level sulphur dioxide emissions. These would be handled by adequate controls on the combustion unit.

In this concept, the main problems are to find cheap land, increase the solar conversion efficiency, and develop low cost methods of harvesting, processing, and transporting the material. Specifically the cost of dried wood fuel delivered to the power plant site must be competitive with alternate fuels at the time the plant goes on line. To accomplish this goal innovative procedures for harvesting, size reduction, drying, and transporting of the fuel may be required to develop commercial feasibility.

Similar costs of the wood chips would be associated with their conversion to fuels with higher energy content. The resulting fuel would obviously have a still higher cost.

Grasses

Reduction of costs attached to cultivation, harvesting and transportation appear to be the primary problem areas. There may also be significant problems connected with plant pests. No estimates of costs for this crop are immediately available but costs for hay should provide a guide.

Algae Culture

Some technical problems which have been recognized include development of unwanted algae predators and pathogens in algae cultures, accumulation of non-algae turbidity, and algae separation. Some problems of an economic

nature are large land use and associated costs, cost of pond construction and maintenance, and harvesting costs. Estimates using present technologies indicate costs of \$0.05 a pound for dry algae mass. New harvesting techniques are needed to bring about large decreases in costs.

Water Plants

Technical problems associated with growth and harvesting of floating water plants include those of predation by animals; elimination of nuisance insects; and development of innovative harvesting procedures to minimize expenditure of energy for harvesting and transporting them.

Studies are required which will lead to improvements in the efficiency of conversion of solar energy to stored chemical energy in plant tissue for each of the several classes of plants considered suitable for use as fuels or as sources of new supplies of high quality fuels.

System studies are required to establish firmly the step or steps in the plant growth and harvesting which make the largest contributions to the total cost. Harvesting presently appears to be the highest cost item and primary effort should be directed towards innovative developments in this area.

Studies of optimum transportation methods for candidate plant materials should be carried out.

ORGANIC WASTES

Technical problems related to use of organic waste materials as energy sources are largely due to the variable composition and tendency towards degradation of the wastes. These properties make themselves apparent during storage and transport.

Goals and Projected Impacts

The goals and R&D requirements for processes involving the production of organic materials by photosynthesis to serve as energy sources or as raw materials for enriched fuels production are described in Table 8. The potential impact of these materials on the energy supply system is presented in Table 9.

Recommendations for R&D

Continued improvements are needed in solar energy conversion to plant material and in harvesting and transportation processes. A phased program plan for new fuel and energy sources is shown in Table 10.

Emphasis should be directed toward possible large scale utilization of marine areas for photosynthesis of new plant material and for conversion of plant material to high quality fuels. The funding level estimated for the entire 10 year program is \$30 million.

ADVANCED CONCEPT-BIOPHOTOLYSIS OF WATER TO PRODUCE HYDROGEN GAS

Concept Description

The direct formation of hydrogen gas using the photosynthetic apparatus of green plants or blue-green algae has been proposed. Under the stimulation of light, the photosynthetic apparatus in chlorophyll and other accessory pigments can raise the oxidation-reduction potential of the electrons released from water to a level as much as 0.3 volt more negative than the hydrogen electrode. Thus it is thermodynamically possible to couple the reducing potential of these electrons with an enzyme (hydrogenase) to bring about the reduction of hydrogen ions to form hydrogen gas. The hydrogenases may exist either endogenously in algae or exogenously in bacterial sources. A particular problem is the need to accomplish the reduction to hydrogen gas in the normal presence of oxygen. Several possibilities can be investigated for accomplishing the required coupling of photosynthetically reduced substances and appropriate hydrogenase activity. In effect, the normal processes of photosynthesizing cells in fixing carbon are interrupted and diverted to provide hydrogen gas as the reduced product. This process represents essentially a photolysis of water.

The requirements for such an aqueous system would be (1) light, (2) a stabilized photosynthetic apparatus capable of generating reductants from water, (3) a suitable electron

Table 8. R&D Requirements for Development of New Fuel and Energy Sources

Steps to economic feasibility	Major technical problems	Time scale
1. Improve solar energy conversion in fresh water algae, marine algae, and floating plants by maintaining required nutrients in ample supply.	1. Improvement in crop yield.	Steps 1-6 Research 1973-1976
2. Develop new harvesting procedures for algae.	2. Cost of harvesting.	Steps 7-9 Development 1977-1988
3. Optimize algae-bacteria symbiosis.	3. Cost of transportation.	
4. Develop new harvesting procedures for floating water plants.		Step 10 Commercial after 1988
5. Attempt improvement in solar energy conversion in land plants.		
6. Decrease cost of harvesting of land plants.		
7. System selection and system components development.		
8. Pilot plant, 500 lb./day.		
9. Demonstration plant, 25 ton/day.		
10. Commercial plant, 1,000 ton/day.		

carrier such as ferredoxin, and (4) a ferredoxin-coupled hydrogenase under conditions to convert hydrogen ions to molecular hydrogen.

This concept is being pointed out in spite of its relatively speculative nature because of recent developments that suggest its accomplishment and the extremely important ramifications of producing hydrogen directly. The use of hydrogen obtained in this process to produce electric power via the H_2-O_2 fuel cell offers the possibility of providing very clean and very efficient power sources dependent largely on solar energy.

Status

The thermodynamic feasibility of this process for producing hydrogen gas has been established. An efficiency as high as 10% has been observed for the photosynthetic portion of the process. The combination of the process components to

produce a working system has not been demonstrated.

Limiting Factors and Recommended Approaches

TECHNICAL

Besides the large amount of multidisciplinary basic research and development work necessary to demonstrate the ability to actually produce hydrogen by biophotolysis of water using solar energy, engineering studies will need to be conducted to determine the technical feasibility of capturing the solar energy in the photosynthetic apparatus in a closed system in a manner permitting recovery of the hydrogen formed.

ECONOMIC

If the economics of the technical process for hydrogen production referred to above are favorable, other costs, such as raw materials, will

Table 9. Impact of New Energy and Fuel Sources.

Time Scale	Plant growing	Solid wastes
1%	2000	1985-2000
10%	2020	2000-2020
Resource Effect		
Fuels	Conserves fossil fuels.	Conserves fossil fuels.
Environmental Effects		
Land use	Large areas required for land plant growth.	Some storage area required.
Air	Beneficial—O ₂ added, CO ₂ removed.	
Water	Large areas required for water plant growth.	Some storage required.
Waste		Beneficial, eliminates waste disposal problem.
Thermal	None.	None.
Economics (Projected)		
Primary or Secondary Energy Source	\$1.50-\$2.00/10 ⁶ BTU (Assumes development of successful harvesting process).	1.00/10 ⁶ BTU.

be negligible. Hydrogen as a fuel can be transported economically and its use in H₂-O₂ fuel cells provides an efficient means for electric power generation.

SOCIOLOGIC

The cycle of converting water to hydrogen fuel and of using this fuel in H₂-O₂ fuel cells resulting in water as the combustion residue has great attraction for preserving the environment and for recycling of materials.

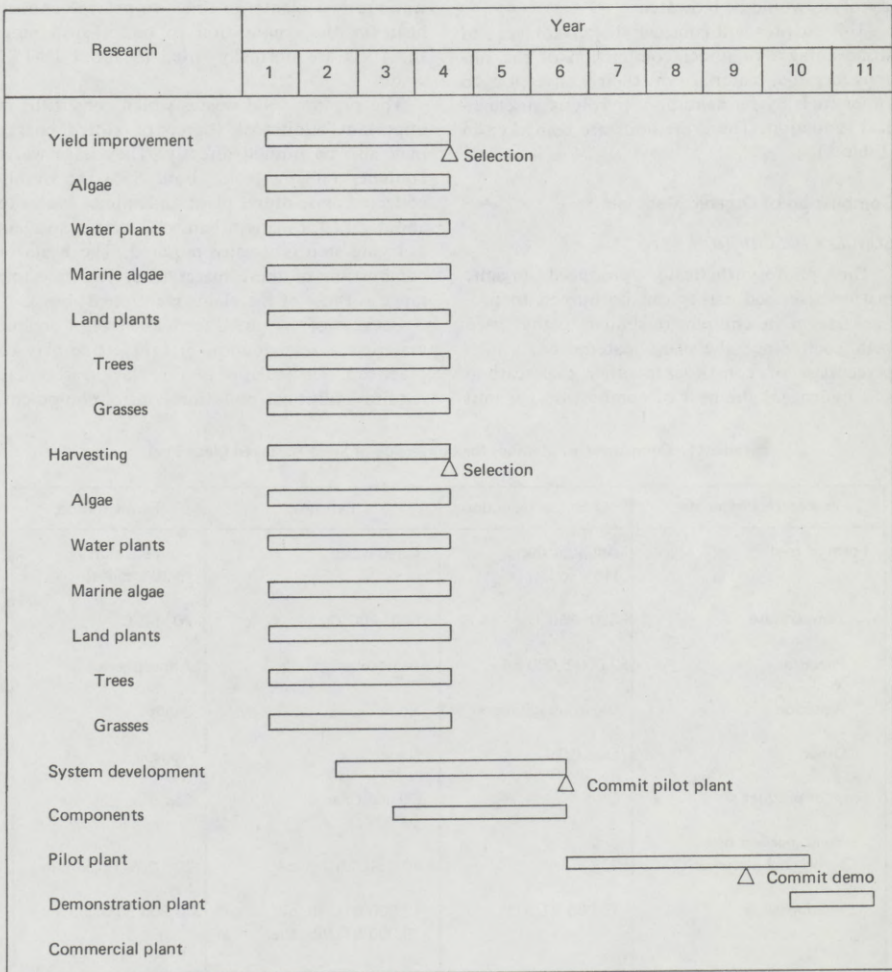
Although this is a speculative area of technology, the benefits to be gained from development of an economic process for producing large quantities of hydrogen are very large. A modest level of support should be provided for these types of concepts that can lead to important

breakthroughs. The estimated funding for a 15 year program is \$30 million.

CONVERSION OF ORGANIC MATERIALS TO FUELS OR TO HEAT ENERGY

Each of the organic materials described in the preceding section can be converted directly into thermal energy by combustion or can be converted to more concentrated fuels by a number of biological or chemical processes. The choice of conversion method is frequently dictated by the physical nature of the material. For example, certain freshly harvested plants having a very high water content would be most profitably converted to a concentrated storable fuel by a biological process that operates in an

Table 10. Phased Program Plan for New Fuel and Energy Sources.



aqueous medium. In other cases where the material is relatively dry or is resistant to biodegradation, direct combustion to heat energy or conversion to concentrated fuels by pyrolysis would be indicated.

This chapter will consider the advantages and disadvantages of direct combustion of the various organic materials or their conversion to other fuels by fermentation, pyrolysis, or chemical reduction. These methods are compared in Table 11.

Combustion of Organic Materials

CONCEPT DESCRIPTION

The photosynthetically produced organic matter described earlier can be burned to produce steam in equipment similar to that used with coal. Since the plant material has a high percentage of constituents other than carbon and hydrogen, the heat of combustion per unit

weight is significantly smaller than coal. Also the plant material, if freshly harvested, would contain water to the extent of about 47% in the case of most trees and of about 95% for some water-grown plants. In order to provide enough heat for the combustion to be self-sustaining, the fuels are normally dried to about 10-15% water.

The organic solid wastes which constitute an important additional source of stored energy may also be burned directly. They have water contents ranging from about 85% for freshly collected agricultural plant and animal wastes to about 20% for many urban solid wastes, so again a drying step is usually required. The heats of combustion of these materials are in the same range as those of the plants mentioned above.

Because of the varied form and size of organic materials, size reduction or briquetting may be practiced. Particulates in the stack gases may require additional pollution control equipment,

Table 11. Comparison of Methods for Conversion of Solid Wastes to Clean Fuel

Process requirements	Chemical reduction	Pyrolysis	Fermentation
Form of feed	Aqueous slurry (15% solids)	Dried waste	Aqueous slurry (3-20% solids)
Temperature	320°-350°C	500°-900°C	20°-50°C
Pressure	2,000-5,000 psi	Atmospheric	Atmospheric
Agitation	Vigorous agitation	None	Slight
Other	Uses CO	None	None
Form of product	Oil	Oil and Char	Gas
Yield (percent of original material)	23%	40% oil; 20% char	20%-26% (maximum)
Heating value	15,000 BTU/lb.	12,000 BTU/lb. oil* 9,000 BTU/lb. char*	23,800 BTU/lb.
Percent of original heat content recovered in product (assume 8,000 BTU/lb. dry waste)	37% (corrected for CO use) 65% anticipated	82% (60% if char not included)	60% (77% maximum)

*All of gas and 1/3 of char used to supply heat.

and certain of the materials contain significant levels of sulfur.

STATUS

Power production by combustion of urban solid wastes is already practiced on a commercial scale [18], principally in Europe, and most technical problems have been solved. There have been reports of corrosion problems and of uneven boiler operation due to variable composition but they are not considered serious.

Although not used for large scale power production, wood in the form of chips or sawdust is used extensively for power production in lumbering and related industries.

Animal wastes are used regularly in India to provide at least a part of the relatively small heat requirements.

The technical feasibility of power production from varied organic materials has been established, but the economic feasibility is uncertain. The efficiency with which power can be generated and the costs associated with pollution control, corrosion, fuel collection, processing and transportation must be examined.

LIMITING FACTORS AND RECOMMENDED APPROACHES

Economic

The actual cost of the fuel at the power plant is probably the key factor in establishing the viability of this concept. In the cases of use of urban solid wastes and concentrated animal wastes produced at large feed-lots there could be a credit paid for removal of the wastes.

Technical

The non-uniformity of the fuel and the relatively low heat content due to presence of water and inerts can lead to uneven operation of steam producing plants. The nature of the fuels may also result in problems involving pollutants and particulates which must be removed from stack gases [19].

GOALS AND PROJECTED IMPACTS

Although quite large quantities of urban, animal, and agricultural wastes are produced in the U.S. every year, the amounts available in

restricted areas and in sufficiently high concentrations to suggest probable economic utilization is thought to be between 4 and 6×10^7 tons of dry organic material. The average heat content of this material is assumed to be about 15×10^6 BTU per ton.

If all this material were burned to produce steam and subsequently electric power, the power generating capability would be in the range of 5,000-10,000 Mw(e). This is a relatively small percentage of the electrical power consumption in the U.S. in recent years, however a potential supply of this magnitude should not be neglected.

For the above reasons it becomes important to consider the impact of the combustion of plant materials grown specifically for the purpose of providing a continuing large volume supply of stored chemical energy.

For example, selected tree crops can be grown on a large farm and harvested on a continuing basis. The product can be reduced in size, dried, and transported to an electric power plant site (1,000 Mw) and used for fuel. The ash resulting from the combustion can be returned as a fertilizer component to the farm. The tree-fired electric plant would be centered in a forested area where the land could not be used profitably for other crops. This land would be harvested and replanted to provide a continual regenerating fuel supply. Because this process would result in the mining of a lesser amount of coal, benefits which can be foreseen include a reduction in strip mining and of the acid waste problems accompanying such mining, and a reduction in the emissions of sulfur dioxide resulting from the combustion of high sulfur coals.

The R&D requirements for further development of the process of direct combustion of organic material is described in Table 12. The potential impact of the process on the energy supply system is described in Table 13.

RECOMMENDATIONS FOR R&D

Studies of solid waste collection, drying, and transportation should be carried out to develop lower cost, more effective procedures for obtaining benefit from large amounts of potential

Table 12. R&D Requirements for Combustion of Organic Matter.

Steps to economic feasibility	Major technical problems	Time scale
Plants/trees		
1. Feasibility study.	1. Large energy expenditure in chipping operation.	Steps 1-5 Research 1973-1976
2. Develop new harvesting methods.	2. Efficient drying.	Steps 5-8 Development 1977-1988
3. Develop new techniques for size reduction, drying and storage of the prepared fuel.	3. Transportation of fuel to plant site.	Step 9 Commercial After 1988
4. Improve total crop yields.	4. Efficient removal of sulphur oxides and particulates from stack gases.	
5. Develop sulphur removal techniques.		
6. Component development.		
7. Pilot plant—1 MW.		
8. Demonstration plant—50 MW.		
9. Commercial plant—500-1,000 MW.		
Organic solid wastes		
1. Feasibility study.	1. Combustion of wastes of variable composition and energy content.	Steps 1-3 Research 1973-1976
2. Develop combustors for agricultural waste.	2. Reduction of moisture content of wastes.	Steps 4-6 Development 1977-1988
3. Develop collection, drying, and transportation techniques.	3. Efficient removal of sulphur oxides and particulates from stack gases.	Step 7 Commercial After 1988
4. Laboratory experiments.		
5. Pilot plant—1 MW.		
6. Demonstration plant—50 MW.		
7. Commercial plant—500-1,000 MW.		

energy. Studies of whole plant farming to increase the solar conversion efficiency are required. Detailed systems analysis and economic and optimization studies should be undertaken to evaluate system concepts for growing and preparing organic materials for direct combustion for electric power generation. These studies should be primarily oriented to identifying process steps making the largest contributions to the total cost, and to suggest procedures for improving the economics. The expected funding for the 15 year program is \$140 million.

Bioconversion of Organic Materials to Methane

CONCEPT DESCRIPTION

Most organic materials in the presence of some moisture and in the absence of oxygen are subject to natural fermentation in which a large percentage of the carbon content of the material is converted into a mixture of methane and carbon dioxide. Figure 7 is a schematic of a unit for converting solid waste to methane by anaerobic fermentation. The conversion occurs

Table 13. Impact of Combustion of Organic Matter on Energy System

Time scale	Plants/trees	Solid organic wastes
Initial (1%)	2000	2000 (possibly 1985)
Significant (10%)	2020	2020 (possibly 2000)
Resource effect		
Fuels	Conserve fossil fuels.	Conserve fossil fuels.
Materials		Reduce waste disposal problems.
Environment		
Land use	Large areas required for drying wood chips.	Some land areas required for drying and waste storage.
Air	Some sulfur oxide and unburned hydrocarbon emissions.	Combustion produces air pollutants.
Water	Same as for fossil fuel combustion.	Same as for fossil fuel combustion.
Visual		
Waste	Ash returned to soil.	Ash returned to soil.
Thermal	Same as for fossil fuel combustion.	Same as for fossil fuel combustion.
Other	Possible negative popular reaction to growing forests for burning.	Decreases supply of soil conditioning organics.
Economics		
Fuel cost (\$/MBTU)	\$1.25-\$2.00 (estimated).	\$1.00-\$2.00 (estimated). ¹

¹Based on reasonable truck and rail haul distances and costs. No charge for wastes. No subsidy for agricultural wastes.

at or around normal atmospheric pressures and at temperatures ranging from about 15°C up to about 50°C. The process operates with organic solid concentrations as low as a few percent and as high as 60-70%.

The volatile products of the fermentation are methane, carbon dioxide, trace amounts of hydrogen sulfide, and nitrogen gas. The volatile products as produced contain from 50 to 70% methane with carbon dioxide representing almost all of the residual. The heat of combustion of this crude product therefore ranges between 500 to 700 BTU/cu. ft. of gas and the gas can be burned directly for electric energy production. The gases can also be treated readily to remove carbon dioxide and hydrogen sulfide; and, the pure methane remaining can be pressurized for introduction into existing natural gas pipelines.

The heating value of this methane is about 1,000 BTU/cu. ft.

In general between 4.5 to 6.5 cu. ft. (STP) of methane can be obtained from the conversion of 1 pound of dry organic materials or from $9-13 \times 10^3$ cu.ft./ton. This corresponds to a heating value of $9-13 \times 10^6$ BTU/ton and represents 60-80% of the heating value of the original organic materials.

If the entire amount of solid wastes believed to be economically recoverable were subjected to anaerobic fermentation to methane, a total of between 3.6 and 7.8×10^{11} cu. ft. of methane would be expected. This would represent a recovery of 3.6 to 7.8×10^{14} BTU/year or approximately 2-3% of the yearly consumption of methane in the United States.

Under conditions where the starting organic

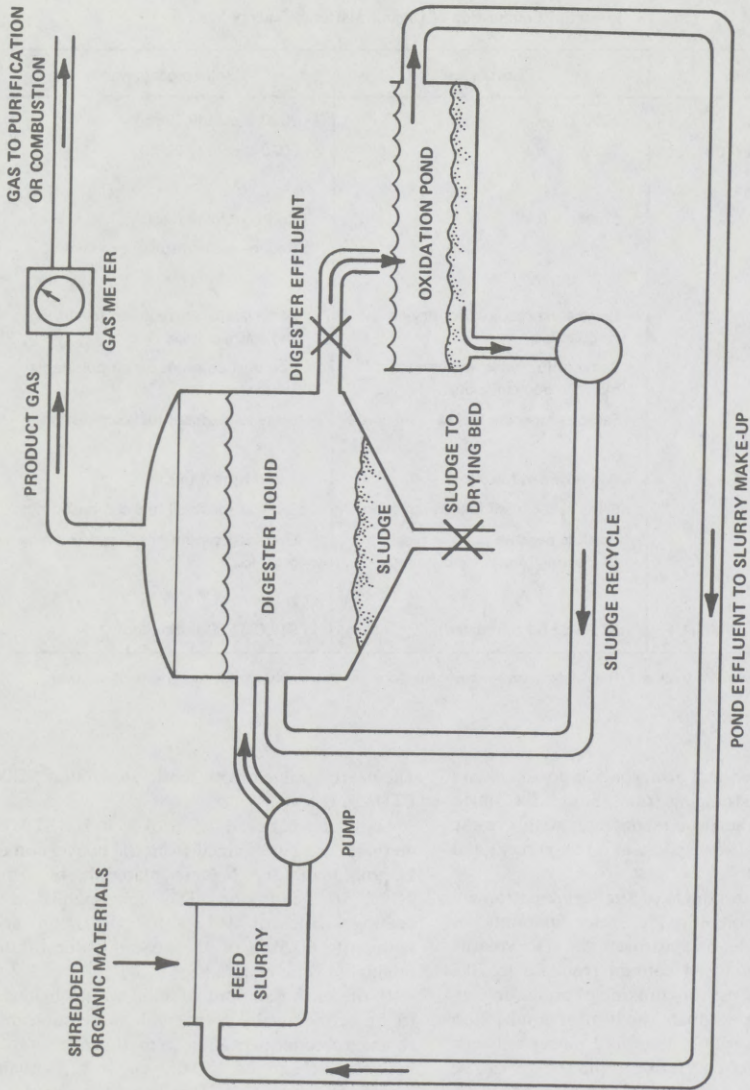


FIGURE 7. CONTINUOUS UNIT FOR CONVERTING ORGANIC MATERIAL TO METHANE BY ANAEROBIC FERMENTATION

material has a high water content the energy required for drying prior to combustion may equal or exceed the heat content of the organic material so a process such as fermentation, where drying is not required, becomes an efficient means for recovering the heat energy.

STATUS

The anaerobic fermentation process has been in use for many years for reducing the volume and weight of domestic sewage solids through conversion to liquid and gaseous products. In general the amount or composition of gas produced is of secondary interest since solids reduction is of principal concern. Many of the larger installations, processing up to 100 tons of sewage sludge per day, have used the generated gases for supplying their power requirements.

The use of anaerobic fermentation for the primary purpose of fuel production through conversion of organic materials such as urban organic wastes, agricultural wastes, animal wastes, and plant crops (including algae or floating plants) specifically grown for the purpose of such conversion is in its infancy.

Laboratory scale studies have been carried out at a number of locations using domestic solid wastes and animal wastes [20,21]. The studies have progressed to the point where most of the ground work leading to small pilot installations have been completed. The small pilot installations would accommodate solids up to 200 lb/day with expected gas production up to 1,000 cu. ft. methane per day.

Studies have also been carried out in which algae grown in sewage ponds and floating water plants (water hyacinth) grown on many tropical and semitropical bodies of water have been converted to methane by the fermentation process [13,22]. Bacterial populations have been developed which permit the fermentation process to be conducted in a marine environment.

Economic evaluations of the fermentation of solid wastes to methane have been made. Because a credit can be allowed for receiving the solid wastes from municipalities, the methane production costs using this raw material appear

to be competitive with imported liquified natural gas. Preliminary estimates of methane costs produced by fermentation of algae grown on sewage ponds suggest costs between \$1.50 and \$2.00/10⁶ BTU.

Similar estimates of costs of produced methane from all materials which are grown and harvested are to be expected and point up, in particular, the need for substantial improvements in harvesting techniques.

In addition to the obvious mitigation of the sewage disposal difficulties, advantages of the use of conversion of organics to methane by fermentation include the low energy requirements of the system, i.e., atmospheric pressure and temperatures from 20°C to about 50°C; the production of a single hydrocarbon gas which is easily purified; and, the relatively high recovery of the heat content of the feed in the form of methane. Disadvantages include the large size of installations and relatively slow rate of reaction, resulting from the necessary very mild operating conditions.

The process equipment, although of large size, is not complicated and is not excessively costly.

LIMITING FACTORS AND RECOMMENDED APPROACH

The technical feasibility of the process has been demonstrated. Full scale development can be undertaken after pilot scale operations have demonstrated optimum operating conditions for maximum conversion of organic material to methane; and, after established viable methods for ensuring operation of a living biological system exposed to numerous challenges have been developed.

GOALS AND PROJECTED IMPACT

The technical feasibility of bioconversion of organic material to methane has been established for many years. The immediate goal should be to establish the economics of the process using organic materials resulting from photosynthesis and organic wastes. This requires fermentation process optimization and construction and operation of pilot plants. The potential impact of this process is described in Table 14. The process has the potential to supply all our gas needs.

Table 14. Impact on Energy System of Fuel Production by Bioconversion of Organic Materials to Methane

Time scale	Methane production by fermentation of solid wastes	Methane production by fermentation of algae/floating plants
1% impact 10% impact	1985 1995	1985 1995
Resource effect		
Fuels	Could ultimately supply 2-3% of US gas needs.	If methane is produced from algae/F.P. 100% of US gas needs in 2020 could be supplied using 5% of the area of the U.S. (2% Solar Energy Conversion Efficiency).
Materials	Insignificant—only construction materials required.	
Environment		
Land use	Approximately same as present waste disposal land use.	5% of U.S. land area to produce 100% of year 2020 U.S. gas needs.
Air	Minimized air pollution from waste depositories and fossil fuel combustion.	
Water	Locally possible significant; nationally small.	Significant: surface areas of ponds and lakes may be covered with algae or floating plants.
Thermal	No thermal discharges involved.	No thermal discharges involved; for protein production from algae thermal pollution which would have accompanied farm energy production would be eliminated.
Visual	Significant improvement over garbage dump/burning facilities.	Low profile aesthetic appearance beautifies landscapes with artificial lakes; lake surfaces will be covered with vegetation.
Waste	There is approximately 60+% weight reduction in solid wastes; Solids equivalent to about 40% of the initial waste weight appear as sludge. Presently discarded.	Utilizes solid or liquid wastes on large scale instead of continuing present disposal problems.
Other		
Economic	A new multi-billion dollar protein food and methane fuel industry would be created if high protein cells in digester sludge are recovered and excess fresh water or marine algae are grown.	
Fuel cost	About same as imported LNG; could be less.	Higher than for solid wastes. Must reflect cost of producing algae or floating plants.

However, the amount of gas that will be supplied by this process will depend on the gas cost and the availability of land and/or water area for growing the organic feed.

A first estimate of the cost [23] of using waste as the organic feed is shown in Table 15. The costs are based on a 1,000 ton organic per day plant and are cited for each system component in terms of cost per 10^3 cu. ft. methane produced.

One configuration of system components, as indicated by asterisks on the table, indicates a cost of pure methane at pipeline pressure of $\$0.45/10^3$ ft.³ CH₄, or $\$0.45/10^6$ BTU assuming 10^3 BTU/ft.³ methane. The costs were developed using 1967-1969 dollars. The credit for receiving the waste from the municipalities was taken as representative of the East Coast of the U.S. and amounted to $\$5.25/\text{ton}$. There are numerous arrangements of components which could lead to even lower methane production costs but their utilization depends on specific geographic and other factors.

Table 15. Cost Estimate for Bioconversion of Organic Waste to Methane
(Based on a 1,000 ton/day plant).

	Cost per 10^3 ft. ³ methane	Credit per 10^3 ft. ³ methane
* Acceptance of solid waste from municipality		\$0.880
* Transfer station	\$0.184	
* Size reduction	\$0.317	
* Salvage transportation (alternatives)		\$0.125
Rail haul 50 miles	\$0.166	
100 miles	\$0.213	
* Truck haul 50 miles	\$0.897	
100 miles	\$1.460	
Barge 50 miles	\$0.133	
100 miles	\$0.146	
Pipeline (10% slurry) 50 miles	\$0.352	
100 miles	\$0.600	
* Transfer station digestion (10^3 ft. ³)	\$0.146	
* Conventional Low cost	\$0.274	
* Sludge disposal	\$0.156	
* Gas purification	\$0.250	
* Gas pressurization to pipeline pressure	\$0.025	
	\$0.025	

No firm estimates of costs have been obtained for the conversion of other organic materials to methane. The use of animal manures and of plant wastes as biodegradable materials has been successful but process costs will depend strongly on transportation and gathering costs. The same uncertainties apply to the conversion of plants grown specifically for the purpose. The costs of harvesting, drying, transportation, and other processes using present techniques are too high to permit an economic process. Innovative low cost cultivation and harvesting procedures are essential.

RECOMMENDATIONS FOR R&D

The R&D recommendation for conversion of organic wastes is presented in Table 16. The R&D for the conversion of grown organic materials is much the same as that for organic wastes. Additional studies are required to establish which grown organic matter is best and to develop economic techniques for growing, harvesting, and processing organic materials for bioconversion. The expected funding for a 15 year program is \$60 million.

Pyrolysis of Organic Materials to Gas, Liquid, and Solid Fuels

CONCEPT DESCRIPTION

Pyrolysis is a process of destructive distillation, carried out in a closed vessel in an atmosphere devoid of oxygen. This process has long been applied commercially to wood for the recovery of organic by-products such as methanol, acetic acid and turpentine in addition to the residual charcoal. Any organic material may be subjected to this treatment with the expectation that there would be obtained gas, liquid and solid products all of which could serve as fuels. In addition, materials which are difficult to dispose of, for example, plastic and tires, can be converted to fuel or other useful products by this process. The gases are usually a mixture of hydrogen, methane, carbon monoxide, carbon dioxide, and the lower hydrocarbons. The liquids are oil-like materials, and the solids are similar to charcoal. Operating

Table 16. R&D Requirements for Bioconversion of Organic Wastes to Methane

Steps to economic feasibility	Major technical problems	Time scale
1. Minimize cost of waste transport.	1. Find better waste transport means.	Steps 1-3 Research 1977
2. Maximize efficiency of conversion to gas.	2. Minimize cost of methane fuel generated.	Steps 4-6 Development 1983
3. Laboratory scale—1 lb. organic waste/day yielding 5-10 ft. ³ methane/day.		Step 7 Commercial After 1983
4. Pilot plant—10 tons organic waste/day yielding 100,000-200,000 ft. ³ methane/day.		
5. Demonstration plant—100 tons organic waste/day yielding 1-2M ft. ³ methane/day.		
6. Commercial unit—1,000-10,000 tons organic waste/day yielding 10-100M ft. ³ methane/day.		

temperatures range from about 500°C to as high as 900°C or more.

STATUS

Extensive batch studies of pyrolysis of organic wastes have been carried out in the United States, Europe, and Japan [24,25, 26,27]. It has been established that pyrolysis is technically feasible as a method of processing solid municipal wastes. The efficiencies in the past have been low and the net fuel production was small. Significant increases in efficiency have apparently been made, and it is now reported that the combustible gases are sufficient to operate the plant and that about two barrels of oil are obtained per ton of dry organic material. A pilot plant handling four tons of urban waste per day has been operated. Figure 8 shows a schematic of the process. Laboratory tests show that at higher temperatures the process can also be used to make gas instead of oil. The heating value of the gas was about 770 BTU/ft.³, 80% of the dry organic matter being converted.

LIMITING FACTORS AND RECOMMENDED APPROACHES

There do not appear to be any factors limiting progress to the demonstration phase which

would be in the 50 ton per day size. Current designs are for processing urban wastes which are a non-uniform complicated mixture of materials. If a grown organic of relatively uniform properties were used, the efficiency might be improved and the operating costs reduced. The major uncertainty in the near term utilization of this process is the cost of the fuel:

GOALS AND PROJECTED IMPACTS

The immediate goal should be a 50 ton per day demonstration plant. The next step should be a 500 ton per day operation. The first use for such a plant would be for urban waste disposal. The 500 ton plant could handle the urban wastes for a city of about 300,000 people. The experience gained in operating the plant on waste organics would be directly applicable to one operating on grown organics.

If the total amount of solid wastes previously assumed ($4-6 \times 10^7$ ton/year) were converted to oil, 130,000 to 230,000 barrels per day would be produced which is about 1% of our daily requirement. When larger amounts of material are available economically the impact will increase.

A first estimate of the cost of producing fuel from organic wastes is presented below for a 2,000 ton/day pyrolysis plant.

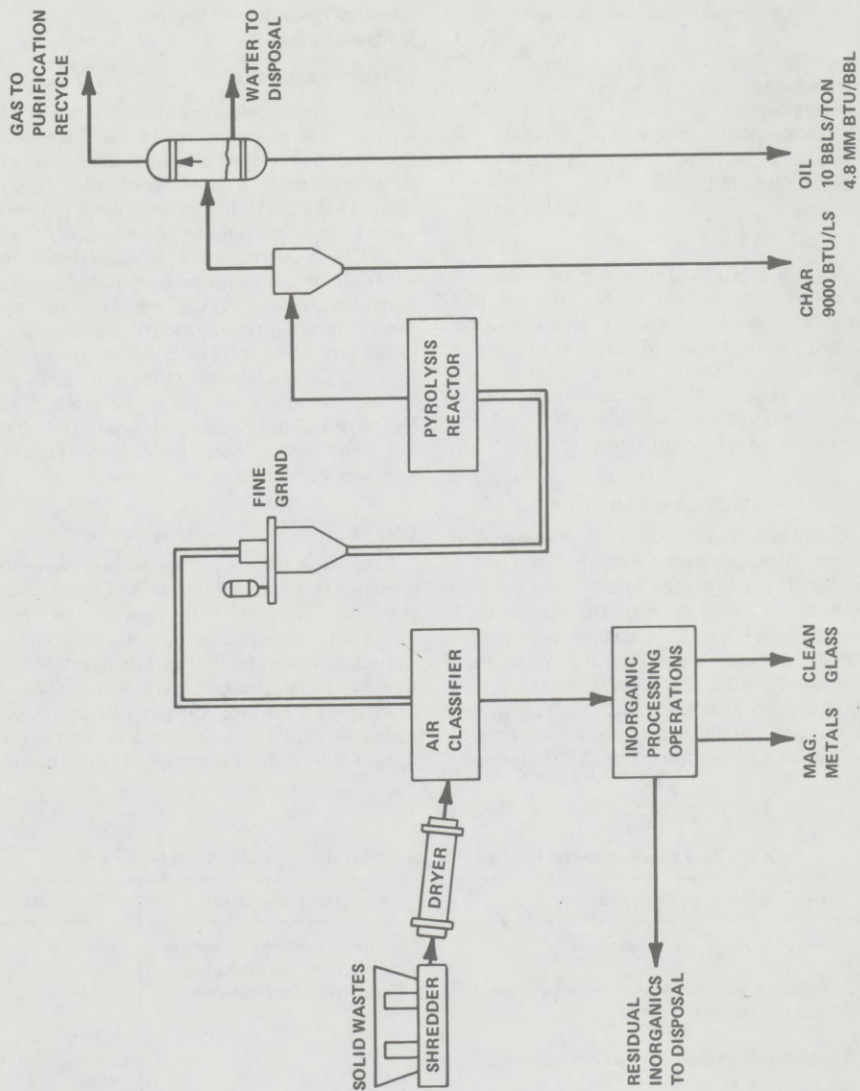


FIGURE 8. SCHEMATIC OF SOLID WASTE PYROLYSIS PROCESS

2,000 ton/day Solid Waste Pyrolysis Plant

Total Plant Capital (excludes land)	\$11.5 × 10 ⁶
Working Capital	\$0.4 × 10 ⁶
Annual Operating Costs (amortization, 25 years @ 6%)	\$3.313 × 10 ⁶
Annual Net Profit From Sales	\$3.647 × 10 ⁶

This indicates a total operating cost of about \$.450/ton of as-received wastes. The net projected revenue from sale of products, after allowing for the disposal of unrecovered inorganics, is about \$.500/ton (when based on 350 operating day/year). These economics suggest that a 2,000 ton/day processing plant could be operated at no net cost to a municipality.

RECOMMENDATIONS FOR R&D

Research is not required for the pyrolysis process. Although temperatures between 500°C and 900°C are used, the pressures are low and conventional structural materials can be used. The chemistry has been studied and demonstrated in both laboratory and pilot plant experiments. Work can begin immediately on a 50 ton per day production facility. Table 17 lists some major development projects. The expected funding for a 15 year program is \$50 million.

Chemical Reduction of Organic Materials to Oil

CONCEPT DEFINITION

Organic materials, when subjected to elevated temperatures and pressures in the presence of water, carbon monoxide and catalyst, are partially converted into oil having a heating value of about 15,000 BTU/lb. The continuous process is carried out at temperatures between 300°C and 350°C. Pressures between 2,000 psi and 4,000 psi are used with product yield increasing somewhat with increasing pressure. The residence time of organic material under reaction conditions is from 1 to 2 hours. During the reaction, oxygen is removed from the solids and appears as carbon dioxide in the product gas. Not all of the organic material is converted to oil and some residue is left for disposal. Figure 9 schematically illustrates the process.

STATUS

Laboratory batch experiments have converted organic refuse into oil by treatment with CO and water at elevated temperatures and pressures [28]. Simpler materials, such as sucrose and cellulose that typify the carbohydrate structure of organic wastes, were also studied. A small continuous unit, capable of handling one pound of feed per hour has been operated in tests of 5 to 20 hours duration. The product is a

Table 17. R&D Requirements for Pyrolysis of Organic Materials to Gas, Liquid, and Solid Fuels

Steps to economic feasibility	Major technical problems	Time scale
1. Full scale conceptual design studies.	1. Optimize operating parameters to maximize fuel production for different feed materials.	Steps 1-3 Research 1976
2. Economic, environmental and systems analysis pilot plant studies.		Step 4 Development 1980
3. Demonstration plant—50 b/bl. oil output/day.		Step 5 Commercial after 1985
4. Demonstration plant—500 b/bl. oil output/day.		
5. Commercial units—10,000 b/bl. oil output/day		

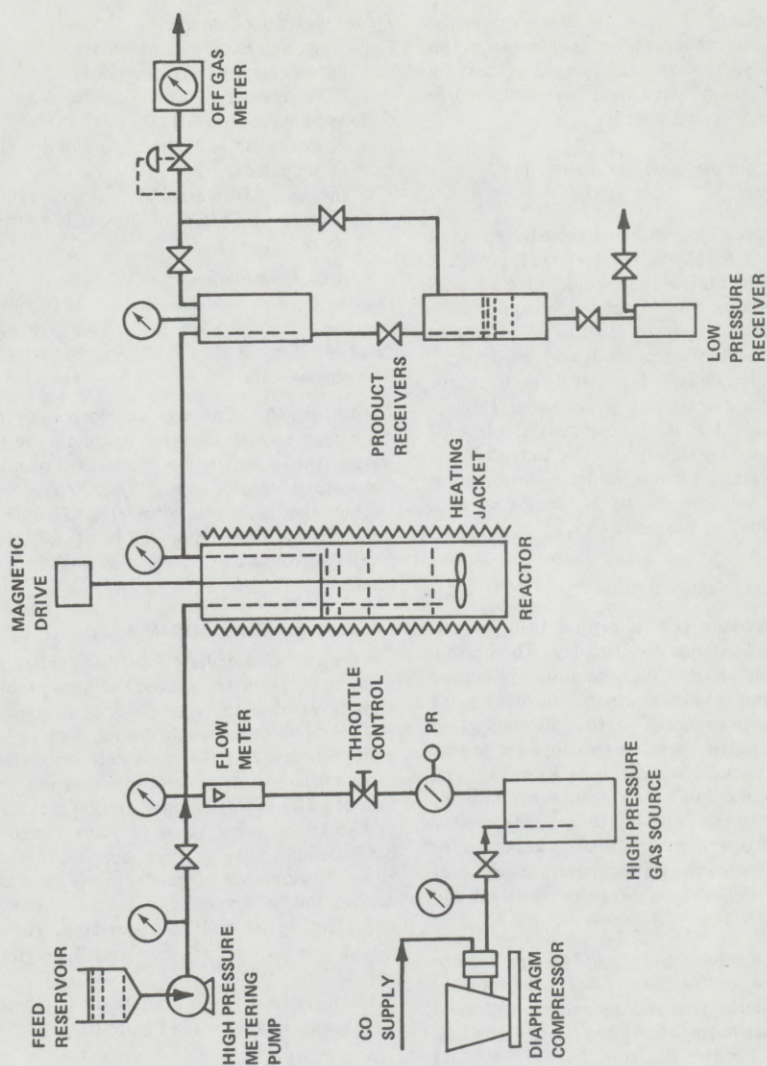


FIGURE 9. CONTINUOUS UNIT FOR THE CHEMICAL REDUCTION OF ORGANIC WASTES TO OIL WITH CO AND H_2O

liquid consisting of oil, water and unconverted refuse. The oil must then be separated from this liquid. Oil yields amounting to 40 percent by weight of the dry feed have been obtained in batch laboratory experiments.

LIMITING FACTORS AND RECOMMENDED APPROACHES

The process has been demonstrated in a laboratory size plant. No technical problems have been identified that would preclude full scale operations. The recommended approach is to proceed to a one to ten ton per day pilot plant to establish technical and preliminary economic feasibility. Successful performance would indicate economic information. This operation could lead to a commercial plant of 1,000 ton per day capacity. A one to ten ton per day plant would provide sufficient information to permit this process to be compared with other fuel making processes.

GOALS AND PROJECTED IMPACTS

The immediate goal is a pilot plant experiment of at least one ton per day. The organic feed systems and the oil separation system are sensitive to size. Consequently, the pilot plant size should be selected so that the important characteristics of these components are tested. The pilot plant would be used to qualify the process for the small scale demonstration plant phase (100 ton/day) leading to a 1,000 ton/day commercial operation. Information reported for this process suggests 100% recovery of the heat content of the feed in the form of an oil and carbon.

Using the solid waste quantity considered to be readily accessible, namely 4.6×10^7 tons dry organic material/year and assuming a 40% yield of a product having the stated heat of combustion of 30.4×10^6 BTU/ton, between 4.8 and 7.2×10^{14} BTU/year becomes available for use. This represents 67% of the heat value of the solid waste.

A first cost estimate for a 900 and a 10,000 ton/day oil production facility indicates:

Preliminary Cost Estimates:

Part A: Key Economic Factors

1. Process gas is CO, costing \$.01/lb.
2. CO consumption is 0.5 lb./lb. refuse.
3. System pressure is 4,000 psig.
4. Process yield is 2 b'bl. oil/ton of dry refuse (anticipated).
5. Income of \$4/b'bl. oil.
6. Income of \$5/ton of dry refuse, disposal charge.

Part B: Cost Figures

Plant size	900 ton/day	10,000 ton/day
Plant cost	20×10^6	200×10^6
Direct operating cost	2.1×10^6 /year	15×10^6 /year
Net operating profit	0	11×10^6 /year

The smaller plant was considered to have more than enough capacity to handle the solid wastes from a population of 300,000 people or from a cattle feedlot serving 200,000 head.

The larger plant was considered to handle the solid wastes from a population of 3.33×10^6 people or from a cattle feedlot serving 2.2×10^6 head.

RECOMMENDATIONS FOR R&D

Construct and operate a one ton per day pilot plant to pinpoint unforeseen technical problems and to establish the economics of the process. At least two years would be required to complete this task. At this time decision could be made relative to design, construction and operation of a 100 ton/day demonstration plant.

A total of seven years (2 years design and construction and 5 years operation) should allow development of good process cost information and, if economic, permit a commercial size plant to be built and operated. The estimated cost of this 15 year overall program is \$60 million.

Comparative costs of various fuels from different sources is shown in Figure 10.

Enzymatic Reduction of Organic Substances

CONCEPT DESCRIPTION

Closely related to the conversion of organic materials to gaseous fuel by means of a fermentation process is the conversion of suitable

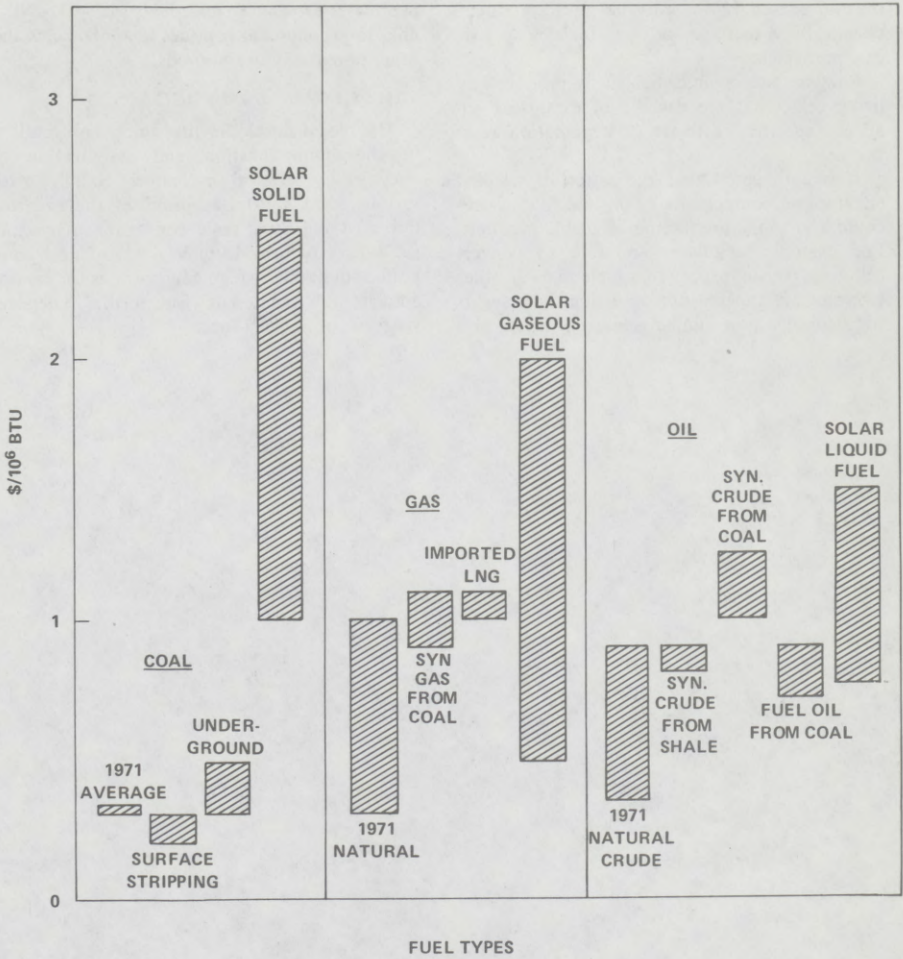


FIGURE 10. COSTS OF FOSSIL & SOLAR RENEWABLE FUELS

organic materials to valuable pure products, chemical raw materials or clean fuels by specific enzyme attack.

Enzymes are organic substances, produced by living cells, that are capable of catalyzing relatively specific synthesis or degradation reactions.

It is anticipated that the action of selected enzymes on components of organic solid wastes could lead to the production of salable products. For example, cellulases are able to convert cellulose (waste paper) to simple sugars; other enzymes are capable of converting these sugars to alcohol. In a similar sense proteases and

peptidases are able to hydrolyze the $-\text{CO}-\text{NH}-$ links in proteins and peptides to amino acids and other potentially useful foods.

STATUS, GOALS, AND IMPACTS

The recent developments which have resulted in the immobilization and stabilization of enzymes by physical or chemical coupling with various solid substrates promises the eventual low cost industrial scale conversion of organic substances to provide high yields of new compounds desirable as feed concentrates for man or animal, raw materials for further chemical synthesis or as clean fuels.

ELECTRIC POWER GENERATION

Solar generation of electricity for use on earth holds the promise of an abundant clean source of power. Solar energy systems can be designed so that they have a minimal effect on the local heat balance.

Even though most of the present power generation plants cause a very significant amount of pollution, it is technologically possible, but costly, to reduce air and water pollution to acceptable levels. The question of utilizing solar radiation for central power generation thus becomes primarily a question of establishing its economy in comparison with conventional power systems considering future trends in fuel cost, energy conversion and the cost of environmental protection.

A variety of approaches have been suggested for the use of solar radiation in central power generation. Each approach involves clearly identifiable steps in a chain leading from solar radiation to power delivered to the consumer as shown in Figure 11. Certain steps in different concepts correspond to the same generic function even though the specific implementations may be different.

At the start, a distinction is made between "natural" collection and "technological" collection of solar energy. Natural collection occurs in the atmosphere, giving rise to wind and rain, and on the earth's surface, resulting in the growing of plants, and the creation of temperature differences in the ocean.

In technological energy collection man-made structures collect the incoming solar radiation. The solar radiation may then be converted through the photovoltaic effect directly into electricity, or the heat generated by solar radiation, as one possibility, might be used directly to "fuel" a conventional power plant. In both cases there is power only while the sun shines.

In an alternate approach, an energy storage facility may be used from which heat is withdrawn at a constant rate, or on demand, for the operation of a power plant or from which electrical energy can be directly withdrawn. In a third possibility, the energy might be used to

generate a chemical fuel such as hydrogen and oxygen.

Electric power which is only available while the sun shines could be used to generate chemical fuel, for example, hydrogen, by the electrolysis of water. Chemical fuel could be shipped as such and could be converted to electrical power deliverable to a consumer either through a conventional power plant or through a fuel cell.

If one provides energy storage then electric power can be available on demand from a power source which delivers power only while the sun shines. After transmission, this power is deliverable to the consumer.

Solar power plants are capital intensive, while the "fuel" is free. This implies that all electricity that the power plant can generate should be used. Particularly if the power has to be transmitted over a considerable distance, the electrical output should be constant throughout a 24-hour cycle to minimize transmission cost. In order to equalize the diurnal variation in solar energy input, energy storage systems will be required in most cases.

In terms of today's cost, a large central solar powered plant with energy storage that is capable of delivering electricity at a constant rate, or on demand, must compete with other sources of electricity costing about 9 mills per kWh. Smaller plants, located close to an end user may compete with power worth up to three times the value indicated, due to savings in distribution cost and the higher fuel cost of conventional "intermediate load" plants.

In special cases, solar power generation without storage might be used for "peaking" applications. In general, however, such power if delivered directly into a network requires conventional standby capacity of equal magnitude. Energy provided in this manner would be worth the cost of fuel saved in the conventional plant.

Typically its value would be a factor of two or three lower than energy produced in a plant with energy storage. Other possible uses of such interruptible power include delivery to other

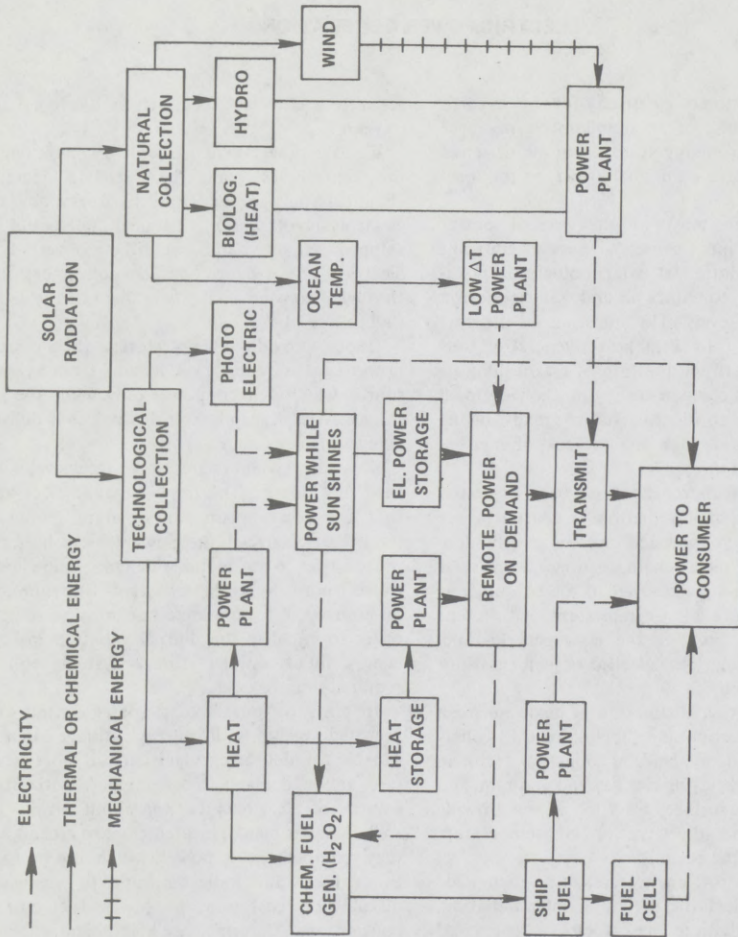


FIGURE 11. CONVERSION OF SOLAR ENERGY TO ELECTRICITY

energy storage facilities, the production of chemical fuel (another method of energy storage), or the use in certain manufacturing facilities such as aluminum plants. In all cases solar power without storage must compete with "dump" power such as excess energy from a plant which normally is not fully utilized around the clock.

Clearly if low cost methods of storing electricity become available, the power generated by all types of power systems can be made available on demand and will have the same nominal value. A potentially important energy storage and transmission system involves the use of hydrogen which can be generated by electrolysis and can be converted back to electricity at the demand point by use of fuel cell technology [29]. This system can not only provide storage but also permits very low energy transmission costs over long distances.

SOLAR THERMAL CONVERSION

Concept Description

Thermal conversion systems consist of solar collectors and thermal storage devices delivering thermal energy to a turbine power plant. Through the use of high temperature selective solar absorber coatings recently developed for the space program, temperature in the range of standard steam turbogenerators can be achieved with relatively low solar concentration—on the order of 10. This makes possible the use of relatively low precision optics for concentrating the solar radiation.

One of the current concepts [30] consists of five major elements, as shown in Figure 12: (1) a solar concentrator to concentrate the sun's energy; (2) a receiver to absorb the concentrated energy; (3) means to transfer the heat to the thermal storage facility or to the turbo-generator; (4) a thermal storage element to store thermal energy for use at night and on cloudy days; and (5) a turbo-generator to produce electrical energy.

Several variations of this basic approach have been proposed, and some are under active study. The most promising systems employ "linear"

heat absorbers, e.g., absorbers extending primarily in one dimension thus permitting heat transfer through a pipe and concentrators with cylindrical symmetry. Estimates of conversion efficiencies (direct solar insolation to electrical power) in the range of 20 to 30% have been made. In the southwestern part of the U.S. approximately 10 square miles are needed for a 1,000 megawatt power plant capable of operating on the average at 70% of capacity.

Status

There are no technical limitations that would prevent a solar thermal power station from being built today. The question is whether it would be economically competitive with other methods of power generation. It is this question which has to be answered to make the approach a practical reality.

Early systems, remarkably similar to the linear absorber system, were considered long ago. The most notable was a steam driven water pump built in Meadi, Egypt, in 1913-1914. With a parabolic trough reflector with cylindrical symmetry and a pipe receiver in its focal line sufficient steam was generated to operate a 50 hp steam engine.

Major new developments in civilian and military aerospace and in nuclear technologies, when applied to the basic thermal conversion approach, make the systems look far more attractive. For example, long life and low cost parabolic trough reflectors may result from recently developed durable reflective nickel coatings on plastic substrates. A variety of reflector coatings [31,32] were developed for the space program as well as high precision parabolic antennas made of fiberglass and reinforced plastic. Fresnel lenses represent today viable alternatives to reflectors.

The receiver located at the focus of the Fresnel lens or parabolic reflector is to be coated with selective solar absorber coatings which efficiently absorb solar energy and have low emissivity at longer wavelengths. Such coatings have been developed under government funding. With these coatings the design of efficient linear

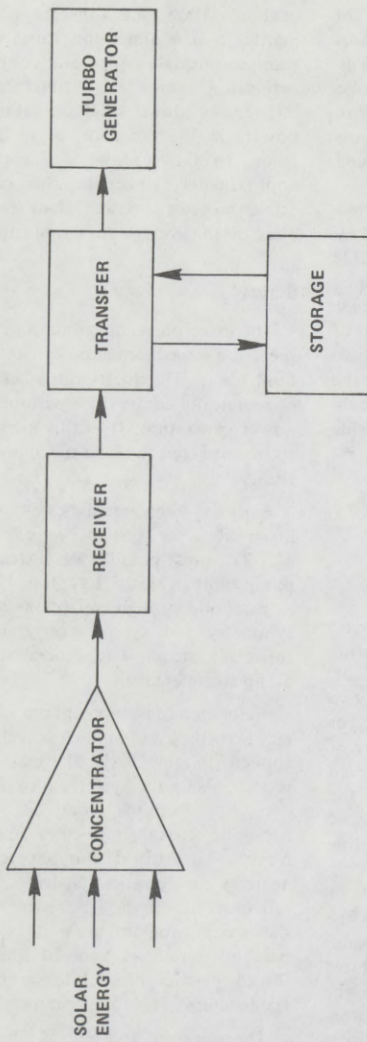


FIGURE 12. THERMAL CONVERSION CONCEPT

solar collectors with low precision optics operating at temperatures up to 1,000°F can be contemplated.

Considerable heat transfer technology has evolved as part of the reactor development and the space effort. Vast data exist on liquid metal heat transfer. Heat pipes* which can operate efficiently at steam turbo-generator temperatures have been developed and some of these heat pipes have been operated for over ten years.

Satisfactory schemes for storing thermal energy have been proposed, ranging from heat storage in large volumes of solids or liquids to heat of fusion of salts and salt mixtures. Liquid metal and molten salts containment techniques have been developed and heat storage using fused salts have been used in satellites. There is however a question of the applicability of the specific techniques from an economic point of view.

The present funding level of R&D directed specifically at solar thermal systems is approximately \$500,000 per year.

Limiting Factors and Recommended Approach

The key problem in central electric power generation via solar thermal conversion is to find an engineering solution that is economically viable and that assures long-life operation with a minimum of maintenance. Specifically, the optical components, e.g., concentrator and absorber surfaces, have to maintain their performance for many years while exposed to the elements.

It is recommended that all promising alternatives of component elements be studied under various environmental and simulated operating conditions. Subassemblies should be prepared and tested for feasibility demonstrations.

All available data on direct (nondiffuse) solar insolation for various parts of the country should be compiled. Measurements should be made to supplement any missing data needed for system trade offs. Continued systems analysis should be carried out in parallel with the component studies to evaluate the potential performance and cost competitiveness of the

subsystems under investigation. In addition, methods for best interfacing the solar-generated power with the existing electrical power grid should be studied.

When economic viability is indicated, a pilot plant of 10 to 25 megawatts should be constructed and operated. Based on the data from the pilot plant a size optimization study should be made and a full-scale demonstration plant should be considered. The size of the demonstration plant might be 100 to 1,000 MW as indicated by the optimization study.

A first attempt at estimating the cost of such a facility has been made, based on mass produced components. This pre-supposes a considerable amount of engineering and a successful solution to several unresolved problems. For the solar collection part including energy storage, a cost of \$600/kw has been obtained. The turbine generator unit and other power plant peripherals add about \$150/kw. Due to the summer-winter variation in average solar insolation such a plant can be expected to operate at a capacity factor of 70 percent. This gives an estimate of energy cost of about 20 mills/kWh assuming 15.5% cost of capital and 1 mill/kWh for operation and maintenance.

Although this number has a considerable amount of uncertainty it is sufficiently close to today's costs that a detailed evaluation leading to commercial readiness is warranted, since it is quite probable that this approach will be a viable alternative to electric power generation as fuel costs rise and environmental controls increase the capital cost of power plants.

Goals and Projected Impact

GOALS

The first major goal of the solar thermal conversion program is to establish technical feasibility for a low cost design. This should be achieved within about five years. If the cost or cost trends indicate that the system may be cost competitive in the future, a pilot plant followed by a full-scale demonstration plant should be built and operated. The program should be designed to permit commercial availability by 1990.

*A high efficiency, isothermal heat transfer device.

IMPACT

If at the date of commercial availability the approach proves economical, maximum impact on our nation's electrical needs is expected to be limited to about 1/4 of the new power plant starts after the year 2000 since the siting of such plants is restricted to areas with high direct (nondiffuse) solar radiation. Therefore, at best, about 15-20% of the total U.S. generating capacity in the year 2020 can be solar thermal. A more realistic estimate might be that 10% of the new starts after the year 2000 will be solar plants leading to 5% of the Nation's generating capacity in the year 2020.

No adverse environmental impact is expected except for the cooling problems similar to those of conventional power plants. Solar power

plants will be principally located in remote areas where the effects of appearance will be minimal.

Short-Range R&D

The recommended short-range research and development program (see Table 18) is geared to satisfying the first program goal of establishing cost competitiveness within about five years. The expected total effort planned over a 7-year period is estimated to cost \$25 million. A key feature of the program is to continue environmental life tests of the exposed optical elements and a system and heat storage analysis.

Long-Range R&D

The recommended long-range research and development program (see Table 19) consists of

Table 18. Solar Thermal Conversion Short-Range R&D Program
(Feasibility Study and Component Development).

Task	Year						
	1	2	3	4	5	6	7
System analysis (concept definition, component integration, cost trade offs, power plant interface and environmental impact)							
Establish environmental test procedures and preliminary tests of components							
Heat storage							
Analysis and selection of approach							
Verification tests						life test	
Concentrator development						life test	
Heat transfer							
Analysis and selection of approach							
Verification tests							
Collector subassembly verification test						life test	
Improved solar absorber coating development							

a pilot plant and demonstration plant design, construction and operation. The estimated program costs for these plants are \$100 million and as much as \$1,000 million, respectively. Industry may share the cost of the demonstration plant. The overall R&D program is laid out to meet the second program goal of making the solar thermal conversion power plant commercially available by 1990.

Phased Program Plan

The long and short ranged R&D plans are phased into three phases as shown in Table 20. Milestones are indicated where information will be available for making key decisions before the next larger and most costly tasks are initiated. The estimated funding for the total 15 year program is \$1130 million.

PHOTOVOLTAIC SOLAR ENERGY CONVERSION SYSTEMS

Concept Description

Photovoltaic conversion systems are based on the utilization of the photovoltaic effect in solid state devices. In these devices, absorption of light generates free electrical charges which can be collected on contacts applied to the surfaces of the semiconductor. The theoretical limit efficiency for the conversion process is about 25% for a single-semiconductor device operating at room temperature [33,34,35]. Device operation at lower temperatures results in increased efficiency [36], but operation below ambient temperature in the earth environment is energetically not advantageous.

The various proposals for photovoltaic systems to supply large amounts of electrical power for terrestrial consumption can be classified into three types:

1. Photovoltaic systems on buildings, with the converters attached to or incorporated into the building structures, and supplying energy to activities connected with the buildings;
2. Ground central systems [37], with large

contiguous or distributed, but connected photovoltaic collectors, serving either a distribution system or single large consumers; and

3. Central systems in space, with power transmission to central ground stations and subsequent distribution.

Status

Photovoltaic devices made from silicon have supplied essentially all of the power used by the spacecraft of all nations. Their performance and reliability in space is well established. In addition, small quantities of solar cells have been made and applied utilizing other semiconducting materials, predominantly cadmium sulfide, cadmium telluride, and gallium arsenide.

For terrestrial energy applications, solar cells are in use in the U.S., Great Britain, Japan, and other countries in form of small "packaged power" systems to energize transistor radios, various types of remote sensing devices, harbor and buoy lights, microwave repeater stations, highway emergency call systems, etc. [38]. Some of these systems have been in successful operation for over 9 years. However, large photovoltaic systems for terrestrial applications have not been built, although the basic technical capability exists.

Present annual U.S. production of silicon solar cells, manufactured nearly exclusively for the space program, amounts to 50-70 kw electric [39]. The average efficiency of present production cells is near 11 percent for space, 13 to 14 percent for terrestrial applications, with 13 to 13.5 percent for space and 15.5 to 16 percent terrestrial applications reported on recent laboratory cells [40]. To make extensive application of silicon solar arrays for terrestrial consumption economically feasible, their price will have to be reduced by a factor of at least 100 from present levels [41]. A significant part of this is expected to be gained through the required million-fold expansion of production rates and attendant automation. However, it is felt that new process approaches will have to be identified to provide for a continuous flow of

Table 19. Solar Thermal Conversion Long-Range R&D Program
(Pilot and Demonstration Plant)

Task	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pilot plant															
Design															
Component fabrication															
Plant construction															
Plant operation															
Demonstration plant															
Design															
Component production															
Plant construction															
Plant operation															

operations from the raw material to the completed array, possibly in part similar to integrated circuit fabrication. A number of ideas have been advanced for individual process steps which could be important to the establishment of such integrated processing. Foremost among these are methods for obtaining ribbons or sheets of single crystal or large crystal silicon by (1) edge-defined film growth [42], (2) dendritic growth [43], (3) rolling silicon [44], and (4) casting sheets with subsequent recrystallization through heated or molten zones [45]. Once such single or large crystal sheets are available, integrated solar arrays could be formed from them by possibly as few as 7 operations, e.g., vapor deposition, heating, and ion implantation in a continuous, flow through process. Optical filters with a comparable number of such operations are now quoted at \$0.40/ft.². Another approach consists of automated assembly of

small silicon spheres, produced by a modified shot tower method, into a large plastic encapsulated assembly. All of these approaches require experimental verification of technical feasibility. Several cost analyses have been provided which show possibility of reaching the economic goal of generating cost-competitive electric power [42,46]. Silicon itself is the second most abundant element in the earth's crust and is produced in the U.S. at the annual rate of 66,000 tons in metallurgical purity at \$600/ton [46], which is a sufficiently low basic material cost.

Thin film Cu₂S-CdS solar cells have been prepared in pilot line quantities (total 10 kw) for over 12 years, with efficiencies of 4 to 6 percent for terrestrial applications, and over 8 percent reported on development models [47]. The processes used for their fabrication appear readily amenable to low cost mass production

methods. In the past, the thin film Cu_2S -CdS solar cells have been plagued by degradation and low yields for long life [48].

Interest in the U.S. has been reawakened for terrestrial applications, and recently reported process changes are hoped to result in long life arrays [47,49]. A cost estimate for a system using Cu_2S -CdS solar cells and including power conditioning, system protection, installation, and a 15% annual cost of capital, taxes, and maintenance, has arrived at a cost of 2 to 4¢/kwh of generated electricity [50].

Other semiconductor materials have not been sufficiently developed to be of interest for extensive solar energy applications at this time but research into new methods of solar energy conversion should be initiated [51].

Current R&D is primarily directed towards increasing size and decreasing weight of spacecraft power systems, increasing resistance against radiation in space, and increasing the efficiency of silicon solar cells towards 20 percent in space. This work is supported by NASA and the U.S. Air Force at a combined annual level of approximately \$3 million.

NSF under the RANN program and NASA under its Applications program have an interest in terrestrial applications, and are beginning to support R&D towards low cost photovoltaic approaches. During the last year, one company has started to develop reduced cost photovoltaic systems in an effort to expand the market in "packaged power" as a step towards large scale terrestrial applications of photovoltaic systems. Also, a group of companies has pooled capabilities to develop the concept of obtaining power from space.

Photovoltaic Systems on Buildings

CONCEPT DESCRIPTION

The application of photovoltaic arrays on buildings locates the generator at the place of the load, reducing the need for energy transmission and distribution with the associated losses and costs. The system thus matches the distributed nature of solar energy to the distributed pattern of energy consumption.

In this approach, photovoltaic arrays are

mounted on buildings or form part of their structures, the latter presenting economic and possibly aesthetic advantages. The basic installation does not differ from that of solar thermal collectors. A particularly attractive approach is to combine the photovoltaic array with a flat plate thermal collector [52,53], since most buildings require both thermal energy (hot water supply, space heating, absorption refrigeration, air conditioning, low temperature process heat, etc.) and electrical energy (lighting, motive power, electronics, high temperature process heat, etc.). In this case which is illustrated in Figure 13 the absorber surface of the thermal collector is formed by the solar array which converts a portion of the incoming solar energy into electrical energy, and permits collection of about 50% of the remaining energy in the form of heat. Although some of the efficiency of the solar array is traded off for thermal energy collection, this combination system provides advantages:

- up to 60 percent of the available solar energy can be utilized;
- the thermal collector uses the same land area as occupied by the buildings; and
- the components fulfill several functions, yielding a more cost effective system.

As in all terrestrial solar energy utilization systems, energy storage is required. In general it is considered uneconomical to provide local storage capacity for more than an average day's requirement [6]. Thus, auxiliary energy will be needed at times. The overall system concept shown in Figure 14 includes several subsystems: solar array, electrical power conditioning, energy storage, auxiliary energy, and possibly power line interfaces. Storage can be provided by batteries, electrolysis cell-fuel cell systems, flywheels, etc. [54,55,56].

Benefits of the use of photovoltaic systems on buildings are:

- Minimal effect on the ecology through use of land areas already being used for other purposes.
- About three times the present average household consumption of electric power can be collected from average-size family residences, even in the northeastern U.S.

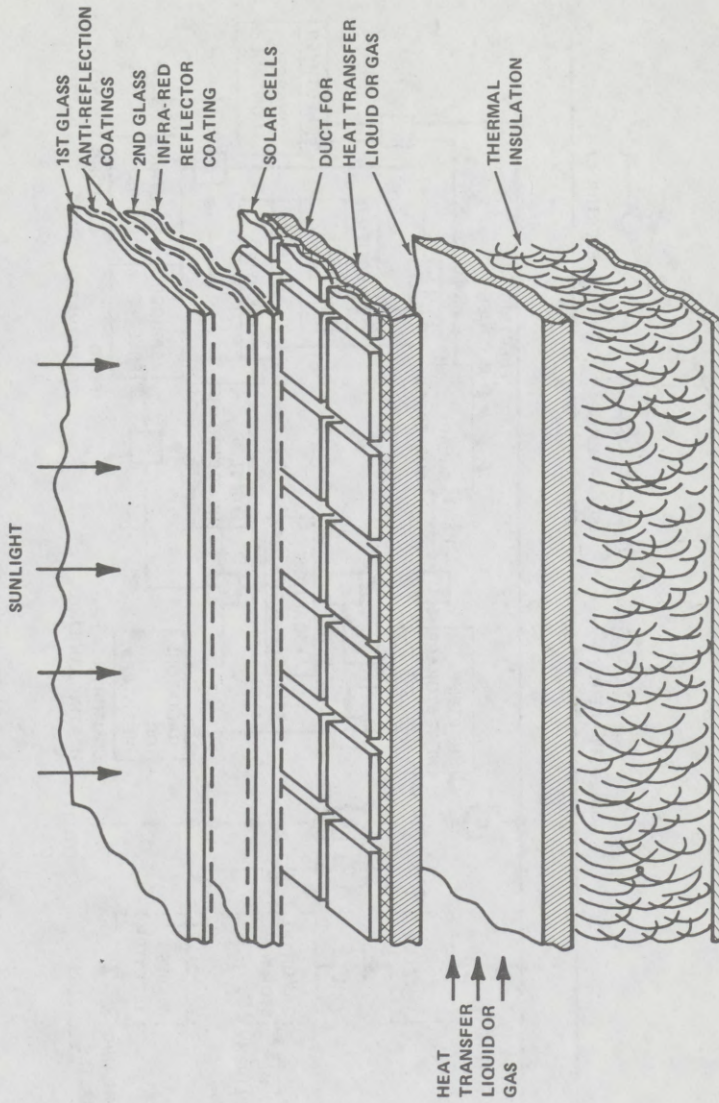


FIGURE 13. STRUCTURE OF COMBINATION THERMAL-PHOTOVOLTAIC SOLAR COLLECTOR

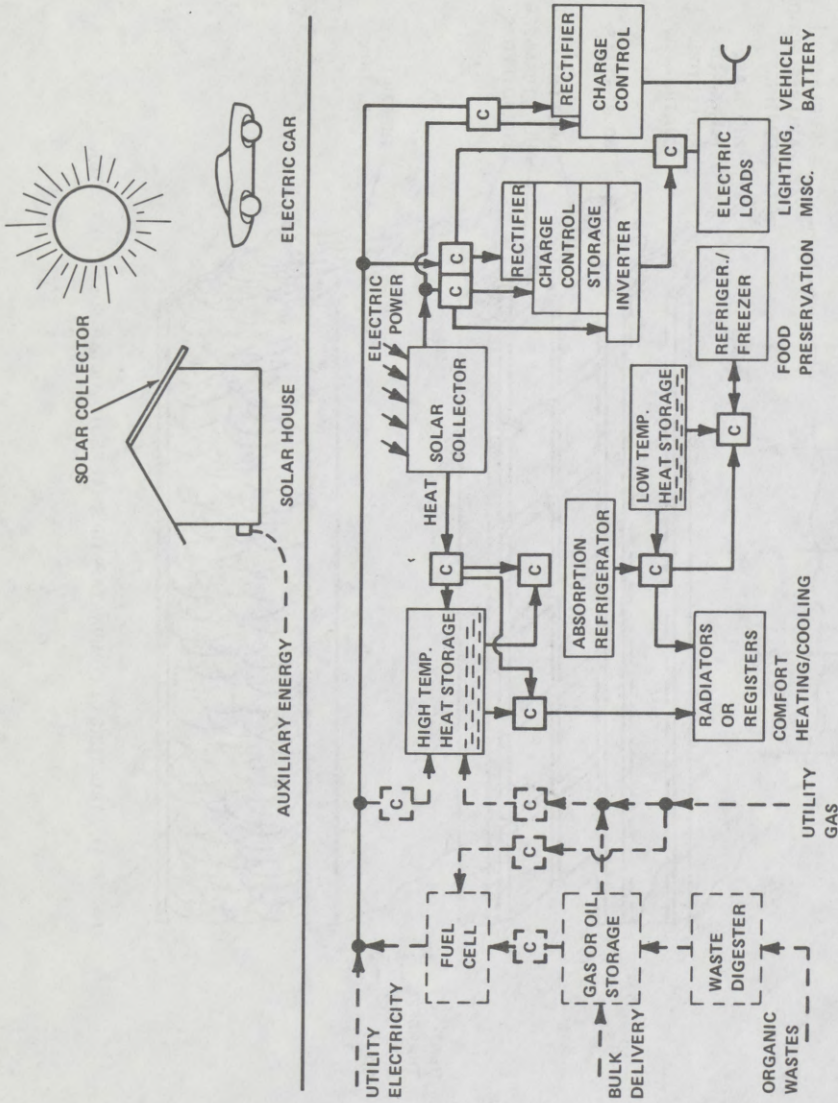


FIGURE 14. SCHEMATIC OF SOLAR ENERGY SYSTEM FOR RESIDENTIAL BUILDING

Assuming the energy storage problem solved, this energy surplus may make the electric automobile feasible.

- Invulnerability to breakdowns in energy distribution or centralized generation systems.
- The small size of the individual unit makes prototype testing and demonstration relatively inexpensive, and will help to attract consumer oriented industries.

STATUS

Systems larger than the "Packaged Power" systems have not been built, although the technology and the components are available. Only preliminary feasibility studies have been performed on combination thermal/photovoltaic systems.

LIMITATIONS AND KEY PROBLEMS

The maximum installable array area approximately equals the ground area covered by buildings. Attention will have to be paid to the orientation, location and shading of buildings in the same manner as for thermal collectors. This will make most existing buildings unsuitable for retrofitting. The introduction will therefore generally be limited to new construction. Further, only up to 90% of the new buildings will be suitable for solar energy collection. In addition, the highly fractionated nature of the construction industry will result in slow market growth, taking 20 years or more to reach saturation.

Low cost (\$0.50 to \$3.50 per ft.² for combination systems, less for others based on \$0.02/kWh credit for the energy supplied by the system) and long life of solar arrays (minimum: 10 to 20; goal: 20 to 40 years) in the earth environment are the key problems to be solved for reaching commercial readiness. For Si solar arrays, cost reduction is the primary task. For Cu₂S-CdS solar arrays, the major tasks appear to be increases in both life and efficiency. It is estimated that the development goals can be attained with adequate effort within 10 years.

Development of energy storage devices of sufficiently low cost and long life is the second key problem. Again, multiple approaches are under investigation. The remaining subsystem

and system problems such as inexpensive DC to AC conversion equipment, require engineering development.

GOALS AND PROJECTED IMPACTS

The key problem areas, status and goals for photovoltaic systems on buildings are outlined in Table 21. An estimated schedule to demonstration of commercial readiness is shown in Figure 15. Since confidence in reaching the key component goals is high, and subsystem and prototype systems are relatively small and inexpensive, it is recommended that subsystem development and system testing be undertaken in parallel with the component development. This approach will cut time to start of introduction approximately in half. The projected impacts are shown in Table 22.

Ground Central Stations

CONCEPT, STATUS, IMPACTS

Significant areas in regions of adequate insolation would be covered with photovoltaic arrays to feed power into a distribution grid in the manner of a utility power plant [37]. Many variations have been proposed, including arrangement of the arrays for partial shading to permit agricultural activities beneath, or distributed arrangement of the arrays interconnected to form a central station [50]. Since solar arrays without concentrators accept diffuse radiation, significant amounts of power can be generated even on overcast days.

The basic technology required for photovoltaic ground central stations does not differ significantly from that of the systems on buildings, except for scale and for site preparation and installation.

Because of the commonality in technology, and the smaller unit size of the systems on buildings, the emphasis should initially be placed on technology development for the latter system type, with simultaneous feasibility studies and subsequent systems definition for the ground central stations.

The projected impacts are shown in Table 22.

Table 21. Key Problem Areas and Required Action for Photovoltaic Systems on Buildings

Key Problem Area	Present Status	Development Goal	Basis for expectation of success	Required Action
I. Solar Array				
1. Cost (\$/ft ²)	70 for ground arrays Si 1,000-8,000 for space arrays Cu ₂ S-CdS —	3.5 or less 0.5 or less	Millionfold production increase, new approaches Estimates from lab. processes	Process develop't. automation, quantity production Automation, quantity production
2. Life (years)	Si >9 (no degradation) Cu ₂ S-CdS 2 (50% degradation)	20-40 10-20	Data, existing technology Prelim. data on few cells	Array design, life testing R&D, extensive life testing, array design
3. Cell efficiency (%)	Si 13 space; 15.5 GNO Cu ₂ S-CdS 5-8	20 10	Theory Laboratory experience	R&D R&D
II. Energy Storage				
1. Cost (\$/kW from each cycle at proper depth of discharge)	~100	≤50	Lead-acid batteries	R&D on batteries of abundant materials (li, Na, S, Cl), fuel cells and on flywheels etc.
2. Life (cycles) (years)	<3000 5-7	>4000 >10	Industrial Experience	"
III. Other Subsystems (Power Conditioning, Charge Control, etc.)				
1. Cost (\$/kW)	N/A	50	Existing Technology	Engineering Development
IV. System				
1. Data Acquisition				
a. Solar Input	N/A	Spectral Distribution-statistics	N/A	Development of sensor systems.
b. Use pattern	N/A	N/A	N/A	Instrumenting sample and prototype houses
2. Optimization	N/A	N/A	N/A	Engineering analysis

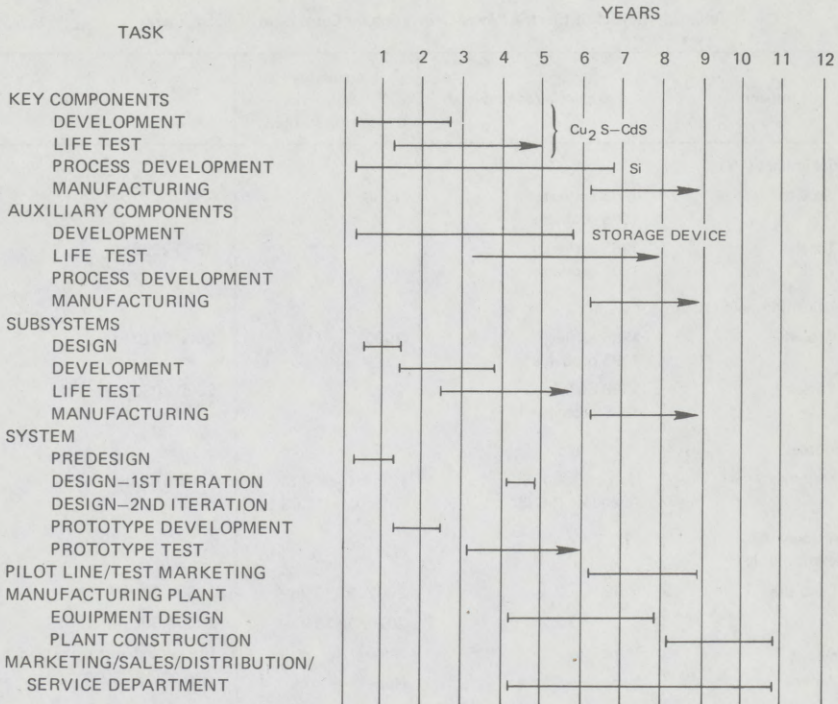


FIGURE 15. MILESTONES FOR PHOTOVOLTAIC SYSTEMS ON BUILDINGS.

Electric Power From Space

CONCEPT DESCRIPTION

A satellite in synchronous orbit around the earth's equator receives solar energy for 24 hours a day, except for brief periods around the equinoxes. In this orbit, a satellite receives six to ten times the amount of solar energy available in suitable terrestrial locations in the U.S. As illustrated in Figure 16 the dc power generated in space by such a satellite would be beamed via microwaves to the ground and there reconverted to high voltage dc or ac power to meet base or demand load needs. In addition such satellites could serve as communications or observation bases.

The use of microwaves at a frequency near 3GHz for power transmission from the satellite to earth provides minimum loss in the ionosphere and troposphere. This loss has been estimated to average 6 percent and to remain moderate even in severe rainstorms. To obtain adequate beam definition at this frequency, a transmitting antenna of approximately 1 km diameter is needed. The transmission efficiency is expected to be in the 55 to 75 percent range from dc in space to dc on earth [57].

The transmitting antenna diameter determines the economical system size, which ranges from 4,000 to 15,000 MW power output on earth. The system as initially conceived utilizes 2 mil thick silicon solar cells to form two solar

Table 22. Impact of Electric Power Generation by Conversion of Solar Energy

Impacts	Residential/commercial	Large industrial & ground central stations	Space station
Initial impact (1%)			
Growth	1980 earliest 1985 probable	1990	
Total	1985 earliest 1995 probable	2000	1990-2000
Significant impact (10%)			
Growth	1985 earliest 1995 probable	2000	2000-2010
Total	1990 earliest 1995 probable	2020	2020-2030
Resources			
Materials	Non-critical if Si Adequate if CdS	Non-critical if Si Adequate if CdS	Undetermined
Environmental (operation only)			
Land use	None	2002: $3 \times 10^2 \text{ mi}^2$ 2020: $3 \times 10^3 \text{ mi}^2$	2000: 30 mi^2 2020: 300 mi^2
Air	None	None	Rocket exhaust from launch
Water	None	None	Undetermined
Radioactivity	None	None	None
Noise	None	None	Restricted to launch
Visual	Minimal, may require larger roof angle	Dark surfaces observable	Undetermined
Safety	None	None	Low intensity microwave radiation
Waste	None	None	None
Thermal	None beyond conven- tional dark roofs	Possible development of heat islands	10-20% above consumable energy is added to terrestrial heating burden.

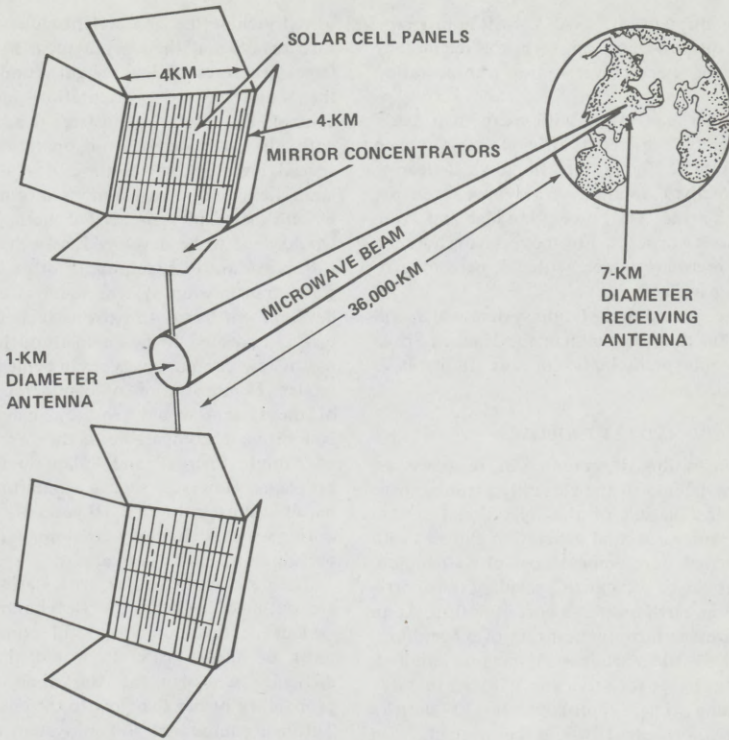


FIGURE 16. SPACE STATION CONCEPT TO PRODUCE 10,000 MW.

collectors capable of providing about 10,000 Megawatts on earth. For economy, lightweight mirrors would reflect solar energy onto the solar cells to achieve a concentration ratio of approximately 3. The 25,000 ton station would be transported in parts to low earth orbit by 300 to 1,100 flights of a second generation space shuttle, and from there to synchronous orbit by ion propulsion.

STATUS

Since 1963, over 50 satellites of the U.S. have been placed in synchronous orbit. They have been powered by silicon solar cells, with a combined capacity of approximately 7 kW, and

the power systems of some have functioned for more than 5 years. Through them, a considerable amount of information on photovoltaic power system performance and on attitude control in synchronous orbit is available. The Air Force has successfully flown a 1.5 kW rollout array of 22W/lb. [58], while designs of a 100 kW capacity system for the NASA Manned Space Station are being prepared. Present prices for space flight qualified solar arrays range from \$1,000 to \$8,000 per ft.².

A partially reusable space shuttle is under development, designed to provide transportation to low earth orbit for \$100 per pound. Solar powered ion propulsion has been demonstrated

in space through the NASA SERT program. Both of these systems can form the technology basis for the space power station transportation system.

Microwave generators with more than 5 kW output and 76 percent efficiency have been demonstrated. Highly directional, self-steering (retro-directive) antenna arrays have been developed by the Air Force for radar and communications purposes. For the receiving antenna system, rectifier diodes with 75 percent efficiency are available.

For the space power station system which will be 100,000 times larger than the Manned Space Station, only preliminary concept studies have been carried out.

LIMITATIONS AND KEY PROBLEMS

Demonstration of commercial readiness assumes availability of the presently planned space shuttle. Installation of the operational system would require a second generation shuttle, with an estimated development cost of \$10 billion, which would be capable of providing transportation to low earth orbit at a cost of \$50/lb. At an annual average introduction rate of 3.5 stations, up to 11 shuttle starts per day may be required, excluding flights for servicing. With a 2 to 3 day turn-around time, approximately 30 shuttles (\$100 million each) would be needed, with adequate service and launch facilities and noise buffer zone.

Chemical pollution could be minimized through use of hydrogen-oxygen fueled shuttles, but the influence of the additional water in the upper troposphere requires study. The microwave safety and radio frequency allocation/interference questions require answers, which are expected to be found in a planned Office of Telecommunications Policy Program.

At a projected cost for the commercial system of \$20 billion per station (\$2,000/kW), including transportation and ground station costs, the cost of the generated electric power would be near 38 mills/kWh. With 52 percent of the projected station cost attributable to the solar arrays, achievement of a solar array cost reduction to \$32/ft.² or less assumes special importance. Special engineering problems to be

solved include the large weight reduction for the solar arrays and their deployment in extremely large structures of low weight, combined with the requirement for orientation and attitude control. The interaction of large flexible systems with the attitude control operation requires special investigation. Methods for assembly of large, flexible systems, composed of many parts, by automated or man assisted methods in space would need to be developed, as well as low cost transportation to synchronous orbit. The microwave transmission system requires engineering development based on existing technology. This task is expected to be eased through repetitive use of few component types in benign operating modes. Demonstration of commercial readiness of the system would require a major national commitment, comparable to the "Peaceful Uses of Atomic Energy" and "Man on the Moon" programs. However, such a commitment is not required during the first 10 years of the project, during which technology development of general usefulness would be carried out.

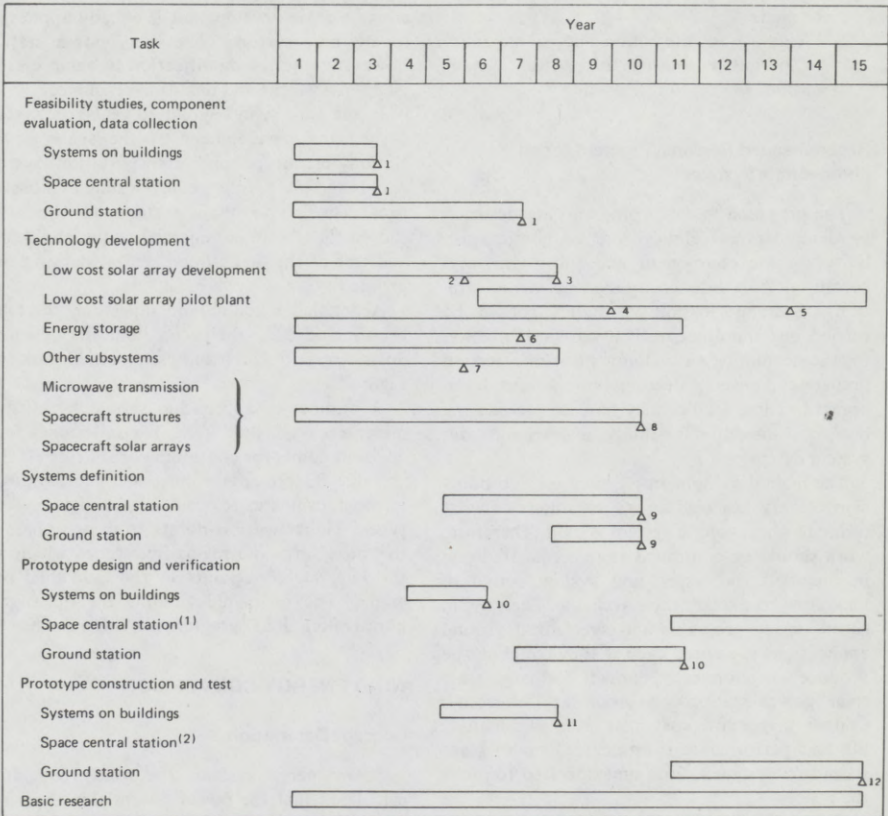
The development tasks, with status and goals, are outlined in Table 23. Development of the system depends on successful completion of most of these tasks. It would therefore be difficult to assign, at this time, a success probability higher than low to the entire system. Through component and subsystem technology development and systems studies in the first phase of the proposed program, this uncertainty would be stepwise decreased in the early years and should be essentially removed before a decision on commencing the second phase is made, which includes the major national commitment.

GOALS AND PROJECT IMPACTS

The impacts are listed in Table 22 and the phasing and milestone schedule is shown in Table 23. This schedule has been designed to allow for:

1. Sufficient systems/technology assessments to determine its true potential before proceeding to system development or demonstration.

Table 23. R&D Summary and Milestones for Photovoltaic Electric Generation.



Notes: (1) Includes flight experiments for verification.
 (2) Initiated after 15 years.

- Milestones:
- ① Technical and economic feasibility of system evaluated.
 - ② Technical feasibility and cost potential of process established.
 - ③ Processes further improved.
 - ④ Pilot plant constructed and operation initiated.
 - ⑤ Process sufficiently refined and evaluated to justify construction of large scale production plant.
 - ⑥ Feasibility of long-life, low-cost storage subsystems established.
 - ⑦ Basic engineering development of other subsystems complete.
 - ⑧ Technology adequately developed to permit systems development.
 - ⑨ Results of systems definition indicate feasibility for prototype design.
 - ⑩ Prototype design and component/subsystem verification tests justify prototype construction.
 - ⑪ Prototypes successfully demonstrated, justify test marketing.
 - ⑫ Prototype tests successful, justify test marketing of small systems, demonstration plant for large systems.

2. Sequential reviews where major programmatic go-no go decisions/commitments can be made.
3. Flexibility for the nation's decision makers to permit exercising this power system option, when and if needed.

Recommended Research Program for all Photovoltaic Systems

The proposed research programs are designed to demonstrate technical and economic feasibility on the component and subsystem level before entering into costly systems demonstrations. Systems feasibility studies should be carried out simultaneously to provide direction to the technology development work, and to prepare for ensuing decisions on systems development. These studies may have to provide the necessary input for feasibility analysis and later system design.

The main development required is the production of very low cost arrays, regardless of what ultimate photovoltaic system is used. Therefore, work should be continued at an accelerated rate in materials, processes, and system design to make low cost solar arrays available. Their use in future space programs and specialized ground applications is assured even if they could not be produced economically enough for large scale solar power stations. As soon as it becomes evident that a low cost solar array of adequate life and performance is attainable, a pilot plant should be designed, built and operated to prove the process.

During the first 3 program years, the emphasis should be almost completely on component and subsystem development and feasibility studies. As a possible exception, low cost prototype development could be started on photovoltaic systems for buildings to facilitate early introduction.

In the following 7 years, the photovoltaic systems for buildings should proceed to prototype evaluation, pilot line operation and test marketing, assuming the technology development having progressed satisfactorily. The space power station would continue in technology development and in systems definition, which

should also commence for the ground central stations. It may be noted that the low cost solar array process development is equally applicable to all three systems. The space power station however, requires modification to achieve especially low weight and radiation resistance.

In the time span beyond 10 years, the system design and development of the space power station prototype and transportation system could take place, followed by system demonstration. The photovoltaic systems for buildings should then be in commercial status, and design and test of the first ground central station could proceed.

A detailed schedule and milestone chart has been included for the pacing item, the Low Cost Solar Array Research and Development task (see Figure 17).

A number of approaches should be pursued under each schedule item. The milestones form decision points for continuing or shifting efforts.

Table 23 presents a milestone plan, arranged in program phases for each of the major system types. The transition points from one phase to the next form the major milestones which are the key decision points in the individual programs. The estimated funding for the overall photovoltaic R&D program is \$780 million.

WIND ENERGY CONVERSION

Concept Description

Solar energy sustains the winds [59]. It is calculated that the power potential in the winds over the continental U.S., the Aleutian arc and the Eastern seaboard is about 10^{11} kilowatts electric. Winds are remarkably repeatable and predictable. The momentum in moving air can be extracted by momentum-interchange machines located in suitable places such as plains, valleys and along the continental coastal shelves [60].

A desirable windpower system incorporates its own storage and its own peaking capability as shown in Figure 18. It is thus able to span between variable wind to patterned electricity consumer demand. This system could be nearly pollution-free. The electrical energy generated

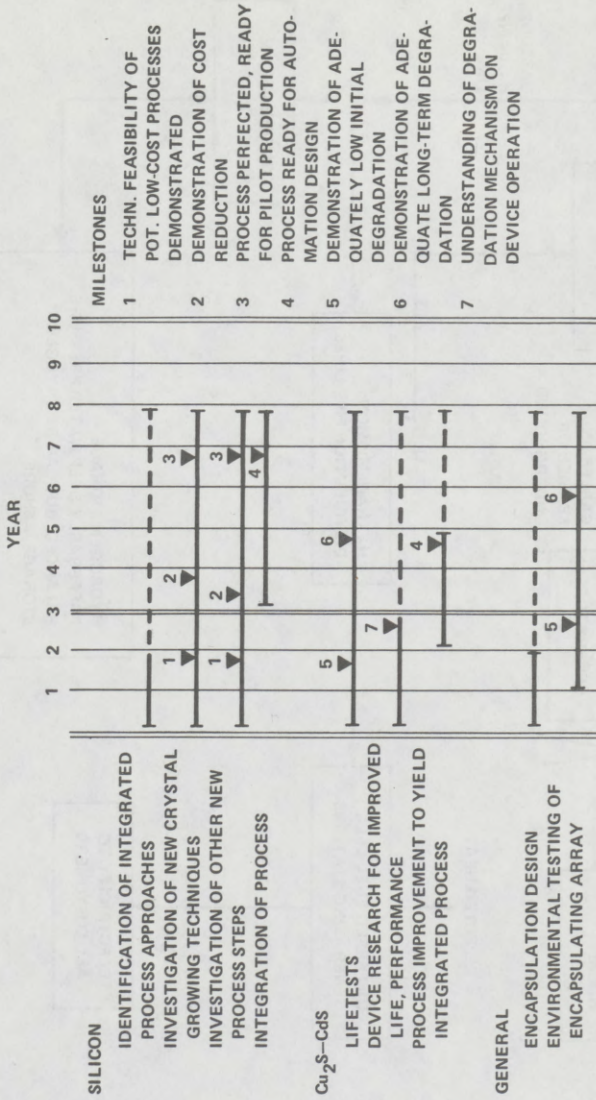


FIGURE 17. PLAN FOR LOW COST SOLAR ARRAY TECHNOLOGY DEVELOPMENT

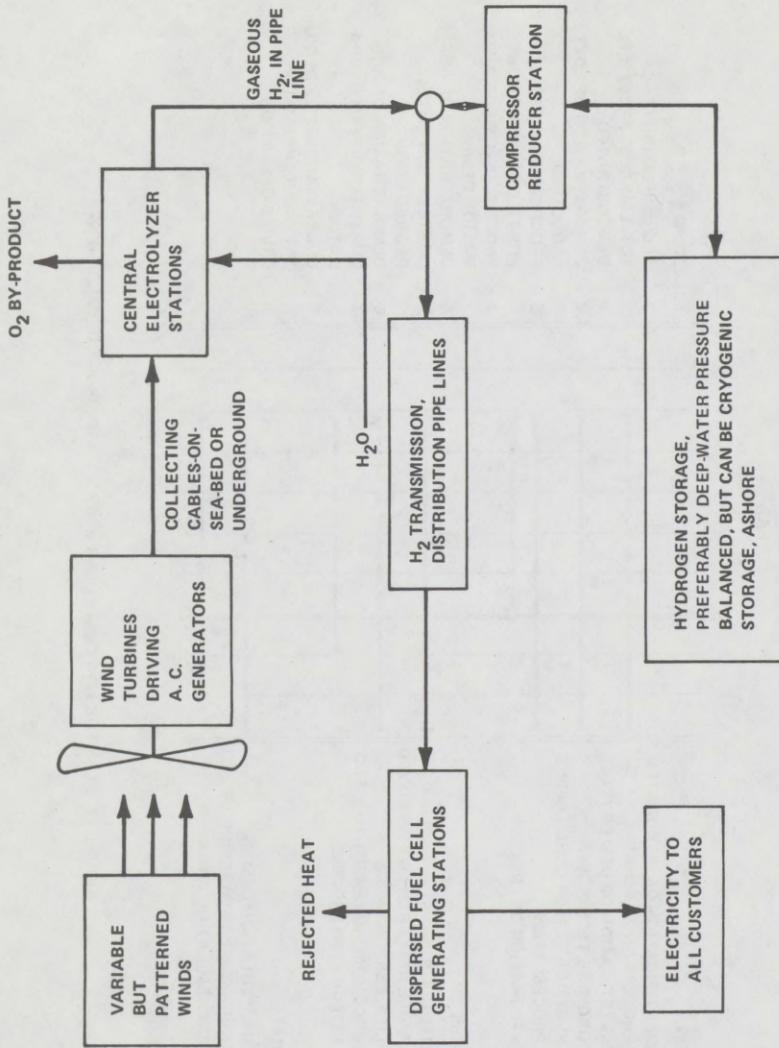


FIGURE 18. BLOCK DIAGRAM OF ONE PROPOSED WIND CONVERSION SYSTEM

by the aeroturbines located off-shore is used to electrolyze water. The hydrogen thus produced is transmitted by pipeline to shore or compressed and stored for use during calm periods. In such a manner hydrogen can be supplied on a continuous basis to fuel cell or thermal electric generating stations. It should be emphasized that the offshore-hydrogen storage approach is only one of several worthy of exploration.

Status

There was a mature technology for windpower sixty years ago. Steady improvement was made through the 1950's directed toward large-scale applications. In 1915, 100 Mw of electricity were being generated by windpower in Denmark. Today electricity brought in by cable from Sweden's hydroelectric plant is less expensive. In the 1940's a 1.25 Mw machine was built and operated at Grandpa's Knob, Vermont [61], but was shut down by a materials failure of the blade. A conceptual design using aeroturbines to produce 160 billion kilowatt hours of electricity per year has recently been completed for the offshore New England region [62]. This preliminary study shows that the electrical power when used to produce hydrogen which is then piped onshore for consumption in power plants is cost competitive with conventional methods of producing electrical power.

Limiting Factors and Recommended Approaches

The limiting factors in the large scale application of windpower are a combination of available wind energy and weather modification. The effect of large numbers of closely spaced windmills has not been assessed. There are no known technological limitations to the application of windpower.

The windpower program should start with a Federally financed research and development program which would include among its first tasks: (1) examination of global and local limitations on the extraction of kinetic energy from the winds with emphasis on possible weather modification, and (2) a study of legal constraints against the large-scale use of windpower.

Goals and Project Impact

It is proposed that windpower be developed in the regions described in Table 24. The maximum generating capacities are also shown in this table. The maximum total energy generated by conversion of wind power is about 19% of the year 2000 annual electricity production. The annual capacity in each site was calculated using available wind velocity-duration data, at specified heights, impinging that wind against either 200 ft. diameter (2 Mw) or 60 ft. diameter (100kW) wind turbines.

Short Range R&D Program

A 3-year program is set forth in Table 25. A large fuel cell development program is included because some of the most attractive concepts require efficient (>50%) and inexpensive (<\$115/kW) fuels cells. The same need for a fuel cell program can be found in many of the other Solar Energy and Ocean Energy Programs, however. Any energy scheme which produces hydrogen, methane or an alcohol fuel should be equally interested in this major task.

Long Range (4th through 10th year) R&D Program

A recommended program phasing is presented in Table 26. The estimated funding for this 10 year program is \$610 million.

POWER FROM OCEAN THERMAL DIFFERENCES

Concept Description

Between the Tropics of Cancer and Capricorn where the intensity of incoming solar energy reaches its peak, 90 percent of the earth's surface is water. That surface layer is in thermal equilibrium at a temperature that never drops below 82°F. To the far North and South the intensified summer insolation melts down the previous winter's accumulation of frozen precipitation. That meltdown slides to the depths of the oceans and slowly moves toward the equator, forming the cold water ways of the

Table 24. Maximum Electrical Energy Production From Wind Power

Site	Annual power production	Maximum possible by year
(1) Offshore, New England	159×10^9 kWh	1990
(2) Offshore, New England	318×10^9 kWh	2000
(3) Offshore, Eastern Seaboard, along the 100 meter contour, Ambrose shipping channel south to Charleston, S.C.	283×10^9 kWh	2000
(4) Along the E-W Axis, Lake Superior (320 m)	35×10^9 kWh	2000
(5) Along the N-S Axis, Lake Michigan (220 m)	29×10^9 kWh	2000
(6) Along the N-S Axis, Lake Huron (160 m)	23×10^9 kWh	2000
(7) Along the W-E Axis, Lake Erie (200 m)	23×10^9 kWh	2000
(8) Along the W-E Axis, Lake Ontario (160 m)	23×10^9 kWh	2000
(9) Through the Great Plains from Dallas, Texas, North in a path 300 miles wide W-E, and 1300 miles long, S to N. Wind Stations to be clustered in groups of 165, at least 60 miles between groups (sparse coverage)	210×10^9 kWh	2000
(10) Offshore the Texas Gulf Coast, along a length of 400 miles from the Mexican border, eastward, along the 100 meter contour	190×10^9 kWh	2000
(11) Along the Aleutian Chain, 1260 miles, on transects each 35 miles long, spaced at 60-mile intervals, between 100 meter contours. Hydrogen is to be liquefied and transported to California by tanker.	402×10^9 kWh	2000

Estimated Total Production Possible: 1.536×10^{12} kWh by year 2000

Table 25. Recommended Tasks, Short Range (3 Year) R&D Program for Windpower Development

1. Conduct technology review and economic feasibility studies.
2. Investigate global and local implications of large scale extraction of kinetic energy from the atmosphere.
3. Study institutional constraints against large scale windpower schemes.
4. Review and advance pertinent aerodynamic, structural, mechanical, and electrical theory and applicable design practice.
5. Assess environmental impact on marine, forest and plains ecology.
6. Study and advance marine architectural and pipeline theory.
7. Investigate and plan for least-cost large-scale production of components and subsystems.
8. With NOAA, establish and carry out a program for identification and quantification of "especially windy sites." Give emphasis to Great Plains and Rocky Mountains.
9. Design an appropriate set of demonstration units.
10. Start a large scale fuel-cell R&D program aimed at low-cost long-life hydrogen-oxygen and hydrogen-air mini-substation fuel cells.

oceans. It is thus possible under several hundred million square miles of ocean to find a nearly infinite heat sink at 35 to 38°F, at a level as little as 2,000 ft. directly beneath a nearly infinite surface heat reservoir at 82 to 85°F [63]. Both heat reservoir and heat sink are replenished annually by solar energy. A heat engine operating across a 50°F temperature difference in an 85°F heat source would be able, theoretically, to convert to useful work, 9 percent of the heat flowing across it.

The Gulfstream carries 1,000 and 1,500 million cubic feet per second of near-tropical sea water through the Gulf of Florida [64]. The stream can be said to flow in a path about 20 miles wide. Within a 500 mile length of that path, the thermal difference between the surface and the depths range from 27.5°F to 39°F [65]. That heat difference occurring at a surface temperature of 71.5°F, would permit a theoretical maximum conversion of heat into useful work of 5%. An overall practical efficiency of 2% can be expected. If one BTU from each pound of the warm Gulf Stream flowing through heat engines could be converted into useful work, an annual energy production of 700×10^{12} kWh would result. A collection system of units moored on one mile spacings along the length and across the breadth of that stream are thought capable of an annual energy production of 26×10^{12} kWh. In a suggested design, each unit would resemble a vertical axis spar buoy of about 100 feet diameter with an overall height of 220 feet. In one version, the hot-side heat exchanger would project outward to either side from a huge underwater kite. The total wing span (beam) for such a 400 MW unit is on the order of 400 feet.

A method for converting sea thermal difference into electrical power is shown in Figure 19, the Claude cycle [66]. One modification of the Claude cycle interposes an intermediate working fluid (e.g., propane) between the heat source and the heat sink. The expansion turbine operating on a hydrocarbon or fluoro-carbon fluid would be a fraction of the size of the turbine using vaporized sea water and the degassing ejectors could be eliminated in that cycle. However, the hot-side heat exchanger might be far more expensive than the flash evaporator which it replaces, so a trade-off will have to be made. For economy of energy transport, the electrical power can be conducted to electrolytic cells to make hydrogen fuel for use in fuel cells.

A preliminary estimate of the capital cost of each of these concepts is in the \$200 to \$400 range per kW of capacity; further information is needed for confident appraisal.

Table 26. Proposed Windpower R&D Program.

Task	Year											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Execute the tasks proposed to confirm windpower technical and economic feasibility (Table 25).												
2. Plan for large-scale component and system acquisition.												
3. Provide continuing R&D support for windpower development.												
4. Design, build, install, and operate windpower components and pilot plants.												
5. Development of fuel cells for use with aeroturbines.												
6. Construct, emplace, and operate several complete 100 Mw wind systems.												

△ 1 Decide if pilot plant should be started.

△ 2 Begin production of adequate prototype fuel cells and/or other storage devices for the 100 Mw wind system.

△ 3 Start detailed design purchasing and fabrication of several 100 megawatt wind units complete with energy storage and delivery systems.

① First demonstration units operable.

Status

In 1929 the Claude cycle was successfully demonstrated in Cuba; 22 kW of useful power were produced in an engine whose actual overall efficiency was less than 1 percent. Two experimental units of 3,500 kW net output, each working in the Claude cycle were installed off the Ivory Coast in 1956 by the French. Due to mechanical failure and other problems the plants were abandoned after a short time. There is a small continuing French R&D effort in this field at the time and the NSF has just funded a feasibility study in the U.S.

Limiting Factors: Recommended Approach

Large-scale use of the ocean thermal differences process could be limited by a combination of technical and economic problems.

The possible technical and economic problems require analysis. At least three competitive concepts, three heat engine cycles, and two energy transmission systems should be analyzed in enough detail, separately and in various combination, until credible cost estimates can be made.

1. The concepts to be investigated:

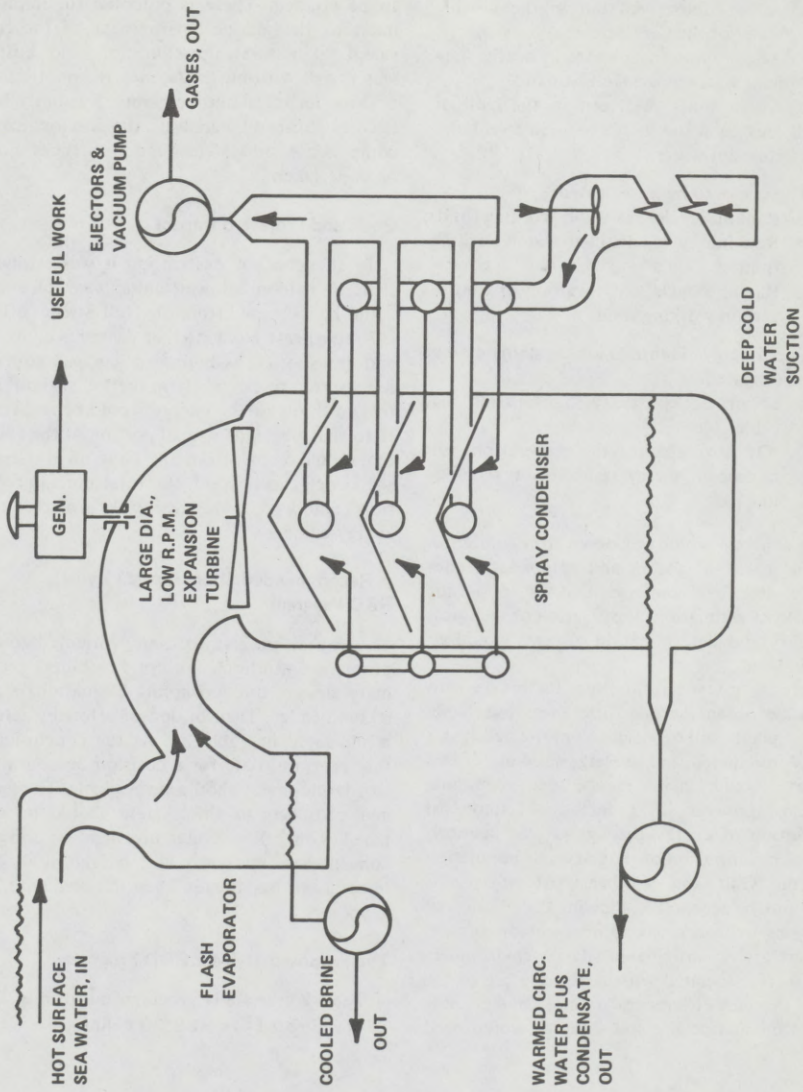


FIGURE 19. THE CLAUDE OCEAN THERMAL DIFFERENCES PROCESS

- a. Afloat units, well out in the moving water of the Gulf Stream.
 - b. Afloat units, near shore in nearly stagnant water in the Gulf Stream.
 - c. Afloat units, well out in the Gulf of Mexico at the shelf's edge, in essentially stagnant water.
2. The cycles to be investigated:
 - a. Rankine cycle, sea water working fluid.
 - b. Rankine cycle, distilled water working fluid.
 - c. Rankine cycle, hydrocarbon or fluoro-carbon working fluid.
 3. The Energy Transmission Systems to be investigated:
 - a. ac or dc electricity transmission via cable.
 - b. On-site electrolytic generation of hydrogen, energy transmission via pipeline gas.

The analyses would get down to a configuration for each subsystem and component, adequately described and specified as to permit careful cost estimation. Verification of technical feasibility and determination of costs would go hand-in-hand.

There is no social limiting factor seen to large-scale ocean thermal differences use. None of these plants will be visible from the beach.

It is anticipated that the large-scale use of this process would best meet socio-economic-political approval if it includes economical distribution of energy throughout the country. A new concentration of industry and population near the Gulf and southeast Atlantic Coast might not be acceptable. Pipeline distribution of energy as hydrogen gas seems to be an answer.

There are no anticipated adverse environmental effects associated with large-scale use of the ocean thermal differences process, but possible effects on marine life and shipping would need

to be studied. There is potential for improvement of the marine environment by the equivalent of natural upwelling of cold bottom water, rich with nutrients, into the photic zone.

Once technical and economic feasibility have been established by analysis, the development of components, subsystems, and prototypes should be undertaken.

Goals and Projected Impact

In the concept description it was estimated that 26 trillion kilowatt hours/year of energy could be recovered from the Gulf Stream off the U.S. southeast coast. If that energy is converted and transported as hydrogen gas, subsequently reconverted to electricity in fuel cells, about half to two-thirds of the energy would be recovered. If to that one adds a small portion of the energy that could come from the Gulf of Mexico, at shelf edge and beyond, the total annual production could exceed the year 2000 projected total energy demands.

A Recommended Short Range (3 year) R&D Program

A 3-year program of study oriented toward problem definition, concept feasibility, preliminary design, and economic evaluation is first recommended. Distribution of effort by activity is indicated in Table 27. At the conclusion of this program, data for a decision on continuing the development should be available. The merits and prospects of this system should be compared with others under investigation and with conventional methods. Part of the study outlined above has already been initiated with NSF support.

The Proposed 15 Year R&D Program

The 15 year R&D program, outlined in Table 27 is estimated to cost \$530 million.

Table 27. Electrical Power From Ocean Thermal Differences: 10 Year R&D Program.

Task	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Conduct technology and economic feasibility studies.															
2. Conduct oceanography review of selected sites; establish and monitor ecological base line.															
3. Design, fabricate, and test key subsystems and components.															
4. Prepare contract design, specifications, and bid package for large-scale plant acquisition.															
5. Design, build, install, and operate a 10 megawatt pilot plant.															
6. Demonstration plant (400 Mw).															

△ Determine if oceanography review and subsystem development should start.

△ Make selection of best-suited components for demonstration plant.

△ Determine if 10 Mw pilot plant should be built.

△ Determine if 400 Mw demonstration plant should be built.

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APPENDIX A

PROPOSED R&D FUNDING

Table 1. Proposed Funding for Thermal Energy for Buildings (\$M)

Development*	76
Demonstration	24
Total	100

*Collectors, storage, coolers, system engineering, product engineering, and architecture.

Table 2. Proposed R&D Funding for Photosynthetic Production of Organic Materials and Hydrogen (\$M)

Activity	Research	Development	Pilot plant	Total
Production of low cost fuels				
Improve crop yields				
Water plants (algae and floating plants)	1	1	2	4
Investigation of plant harvesting				
Land plants	1	1	4	6
Water plants (algae and floating plants)	3	2	6	11
Investigation of crop transport				
Land plants and solid waste	2	1	3	6
Water plants	1	1	3	5
Production of hydrogen	11	17	—	28
Total	19	23	18	60

Table 3. Proposed R&D Funding for Conversion of Organic Materials to Energy (\$M)

Activity	Feasibility study	Component development	Pilot plant	Demonstration plant	Total
Combustion of organics	1	10	30	28	69
Combustion of solid wastes	1	10	30	28	69
Total	2	20	60	56	138

Table 4. Proposed R&D Funding for Conversion of Organic Materials to Fuels (\$M)

Activity	System or laboratory studies	Pilot plant	Demonstration plant	Total
Bioconversion to methane	9	23	29	61
Pyrolysis	2	12	35	49
Chemical reduction	3	18	41	62
Total	14	53	105	172

Table 5. Proposed Funding for Solar Thermal Electric Generation (\$M)

Feasibility studies and component development *	30
Pilot plants	100
Demonstration plant **	1000
Total	1130

*Collectors, storage, energy transfer, and system engineering.

**Amounts represent total government and private funds on a cost-share basis.

Table 6. Proposed Funding for Photovoltaic Electric Generation (\$M)

	Feasibility study	Technology development	Systems definition	Phototype testing	Total
Low cost solar array development		40			40
Low cost solar array pilot plant		170			170
Ground/building subsystems		30			30
Spacecraft subsystems		70			70
Systems for buildings	1			5	6
Ground stations	2		4	70	76
Space central stations	3		45	340	388
Total	6	310	49	415	780

Table 7. Proposed R&D Funding for Wind Energy and Ocean Thermal Gradient Conversion (\$M)

Activity	Feasibility study	Component development	Pilot plant	Demonstration plant*	Total
Wind conversion	4	96	20	490	610
Ocean thermal gradient	2	43	55	430**	530
Total	6	137	75	920	1140

*Amounts represent total government and private funds on a cost-share basis.

**One 400 Mw ocean plant.

APPENDIX B

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Solar Energy in Developing Countries: Perspectives and Prospects

A REPORT OF AN AD HOC ADVISORY PANEL OF THE
BOARD ON SCIENCE AND TECHNOLOGY FOR INTERNATIONAL DEVELOPMENT
OFFICE OF THE FOREIGN SECRETARY

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. • March 1972

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Washington, D.C. • March 1972

This report has been prepared by an ad hoc advisory panel of the Board on Science and Technology for International Development, Office of the Foreign Secretary, National Academy of Sciences, for the Bureau for Technical Assistance, Agency for International Development, Washington, D.C., under Contract No. csd-2584.

NOTICE

The study reported herein was undertaken under the aegis of the National Academy of Sciences with the express approval of the Governing Board of the National Research Council. Such approval indicated that the Board considered that the problem is of national significance; that elucidation and/or solution of the problem required scientific or technical competence and that the resources of the National Academy of Sciences were particularly suitable to the conduct of the project. The institutional responsibilities of the Academy were then discharged in the following manner:

The members of the study committee were selected for their individual scholarly competence and judgment with due consideration for the balance and breadth of disciplines. Responsibility for all aspects of this report rests with the study committee, to whom we express our sincere appreciation.

Although the reports of our study committees are not submitted for approval to the Academy membership nor to the Council, each report is reviewed by a second group of scientists according to procedures established and monitored by the Academy's Report Review Committee. Such reviews are intended to determine, inter alia, whether the major questions and relevant points of view have been addressed and whether the reported findings, conclusions and recommendations arose from the available data and information. Distribution of the report is permitted only after satisfactory completion of this review process.

NATIONAL ACADEMY OF SCIENCES

OFFICE OF THE FOREIGN SECRETARY
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March 1972

Dr. Joel Bernstein
Assistant Administrator
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Washington, D.C. 20523

Dear Joel:

I am pleased to forward the report of the Ad Hoc Advisory Panel on the Utilization of Solar Energy in Developing Countries. The report represents the best judgment of the very able men who made up the panel, based on their wide-ranging practical and scientific experience and their deliberations at the Academy.

Energy questions are central to any attempt at improving the quality of life of people in any nation. The panel establishes that the solar energy developments of the past have not yet led to a device or system likely to have a broad impact on national, regional, or international development, though solar water heaters may prove an exception in the near future. The panel is confident that solar energy will play an important role in the future as a source of energy for man's application. It is an energy source that does not exploit unrenewable resources, does not add undesirable chemicals to the earth's atmosphere or water, and does not add to the thermal energy of the earth.

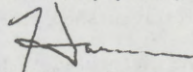
The rational development of uses of solar energy to benefit the developing countries must rest on a clear picture of the "energy niche" in which solar energy will best fit. At present we have no data base for determining even the existence of such a niche in any given area. The panel recommends, accordingly, that the first step be a thorough analysis of the energy needs in a given area. This analysis should include a complete market survey, a survey of the sociological characteristics, and a general identification of all the boundary conditions that any device or system would have to meet to be viable. This survey should include all forms of energy, and the results may show that in any given area solar energy may fill a major energy requirement or that it has no role to play. Once the niche for solar energy is identified, rational development of devices for its utilization will be possible. Short of this approach, any solar energy R and D will run extreme risks of economic failure and social unacceptability.

Dr. Joel Bernstein
March 1972
Page Two

The panel recommends consideration of the feasibility of establishing regional energy-research centers as one means of obtaining the necessary data on a systematic basis. The concept of these centers--particularly their relationship to national programs--is a matter deserving substantial study, and the panel recommends that this idea be further explored by a task group more broadly representative of the field of energy production than this panel, which was chosen specifically for its knowledge of solar energy.

The proposed North African Center, whose evaluation by the panel was requested by AID, could be one of these centers, and it could have a major impact if it is not restricted to solar energy alone.

Sincerely yours,

A handwritten signature in dark ink, appearing to be 'H. Brown', with a long horizontal flourish extending to the right.

Harrison Brown
Foreign Secretary

PREFACE

The Ad Hoc Advisory Panel on the Utilization of Solar Energy for Developing Countries was charged with the following responsibilities:

1. To assess the state of the art in utilizing solar energy for developing countries and review current practical applications;
2. To identify promising areas for research and development; and
3. To examine the desirability of establishing an international solar energy institute in North Africa, to carry out solar energy research and development.

A distinguished panel of specialists from the United States and abroad was assembled in Washington, D. C. May 6 - 7, 1971. In selecting the panelists, efforts were made to provide a balance between scientists and engineers from developed and developing countries. Written contributions were solicited before the meeting, and two that were submitted are included in the Appendix. The first day was devoted to expositions by the participants of their views. The second day was devoted to analyzing the information and formulating recommendations.

The panel wish to acknowledge the invaluable help of Manfred Altman and John A. Duffie in the work of the panel and the preparation of this report.

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I

SUMMARY AND RECOMMENDATIONS

In response to a request by the Agency for International Development (AID), an ad hoc panel convened by the Board on Science and Technology for International Development of the National Academy of Sciences has considered the present state of development of processes for utilization of solar energy, applications now being made of this energy resource, and possible future developments in solar processes, all in the context of energy needs in developing countries. The panel also considered the desirability of establishing an International Solar Energy Institute in North Africa.

Based on these considerations and on the experiences of its members, the panel drew several general conclusions: solar energy is an energy resource widely available in areas with energy needs in developing countries; useful applications of solar energy are now being made; other applications are in various stages of experimental development; knowledge of energy needs in developing countries is inadequate and must be improved; and research and development programs to meet these needs should include but not be limited to, consideration of solar energy. The panel concludes that solar energy is a resource that has the capability to meet energy needs substantially beyond the applications now being made, and that this potential can be realized only with further research and development.

The panel considered that the essential problems are energy problems, not solar problems, and that solutions to these energy problems require consideration of alternative sources of energy. From this the panel evolved,

and recommends to AID, consideration of the concept of regional energy research and development centers as institutions to study energy needs and the means (including solar) by which these needs might be met. The suggested international solar energy institute in North Africa, if expanded in scope to include other energy sources and with functions described below, could be one such regional center.

Applications of Solar Energy

The panel noted that some applications of solar energy are well established in developing countries, i.e., solar evaporation for salt production, and direct solar drying for processing crops.

Other applications are established, or becoming established, in more highly developed economies, with the corresponding technologies reasonably well developed. Solar water-heaters are widely used in some countries; and where the need exists, the technology of water heaters can be, and is being, adapted for use in developing countries. Solar distillation, for producing potable water for human or animal consumption, is in a "pilot plant" stage of development and is supplying a number of small communities with drinking water, on an experimental basis. Adapting solar-still technology to the situations of developing countries could solve some water-supply problems.

Other applications of solar energy, very much in experimental stages, are subjects for research and development:

- Solar drying, in enclosures to control the process and enhance product quality, may result in improved utilization of foods.
- Solar heating and cooling of buildings, and further consideration of scientific principles for control of thermal effects in simple housing, may be practical in some developing areas.

- Solar power systems based on heat engines are still a difficult challenge. Research on these processes is of a more difficult and speculative nature. The potential returns are larger, but so also are the problems in developing useful and economic systems.

- Solar refrigeration for food preservation, obtained by absorption cooling cycles, appears to be technologically feasible. The best systems and cycles have yet to be determined, as have the best scale of application and social and economic feasibility.

These processes are all thermal in nature. There are also biological and photovoltaic processes that might be used in developing nations:

- Photovoltaic conversion of solar to electrical energy is highly developed for space-vehicle use. It is now far too expensive for large-scale terrestrial use; but it is now useful for some highly specialized, very low-power applications, as in some applications to communications. Photovoltaic process research is best done in developed countries, and its potential contribution to energy economies of developing areas, other than for communication purposes, cannot be foreseen with present technological practice.

- Biological processes, for specially controlled agriculture or algae culture, are another class of solar processes that may become significant but were not considered in detail by the panel.

To summarize, the solar processes that are now useful or that could be brought to a stage of development in which they could produce useful results in the shortest time are evaporation, drying, distillation, and water heating. More extensive development of processes for refrigeration, new methods of solar drying, heating, cooling, and thermal design of buildings should make some of these uses practical within the decade.

Applications of solar power will require substantial development of new technology.

Determining Needs and Establishing Priorities

It was clear to the panel that it did not have enough information on needs for energy in developing countries to set firm priorities and to assign research and development resources to meet energy needs of particular countries, or to select those processes noted earlier that would be most useful. Further, the diversity of economic, geographic, social, and political factors in the developing countries make it impossible to assign a single set of priorities for R and D.

The panel recommends systematic approaches to energy resource- and-utilization programs for developing countries, or areas. The following approaches would be included:

1. Detailed studies of the needs for energy of the given region or country, as a basis for selecting the most useful energy processes to be developed;
2. Thorough understanding of the objectives to be achieved by the supply of energy;
3. An examination of the possible energy-supply alternatives, which would include solar energy but would not be confined to it;
4. A detailed set of criteria by which the desirability of actions can be measured;
5. Studies of the costs and worth of the available options of energy supply to meet known needs;
6. Surveys to determine the extent of investment and manufacturing capability required; and

7. The development of strategies to bring about desired action from suppliers and users, such as manufacturing in the appropriate location, suitable distribution, education of users, etc.

If this systematic approach is followed, then the question arises of how the needed information base can best be generated and the research and development proceed.

In the unanimous judgement of the panelists, the establishment of regional energy R and D centers is a valuable concept to consider for performing the above tasks. The panel feels strongly that the tasks can best be performed in situ, and that the regional centers should be staffed mainly with people from the region, if possible, and augmented by experts from developed nations. They should treat the practical energy problems of their regions, and at the same time exchange information and experiences with other regional centers, to avoid wasteful duplication and maximize the gains to the developing countries from their efforts. They must also be aware and ready to take advantage of advanced technology from developed countries that may be transferable to their regions.

The regional centers should have these specific responsibilities:

1. To help generate an information base on energy needs in the region;
2. To carry out the needed research and development to meet regional energy needs;
3. To field-test and provide feedback from users to the centers in order to improve energy processes and evolve useful solar (or other) processes;
4. To act as information, education, and training centers in cooperation with local universities; and

5. To maintain close contact with scientific and engineering developments and energy applications in other centers and in industrialized countries.

The needs of the developing nations can best be served if the centers do not confine themselves to solar energy. A rational decision, rather than a prejudgment, that solar energy will solve an energy problem should be made. The centers may, as a result of their studies, recommend the use of either solar energy or other energy sources. Participants from Niger and India gave very strong support to this position.

The panel recognized that the concept of regional energy R & D centers deserves further substantial, in-depth study. In particular, the relations between national energy programs and a regional center would have to be considered in detail.

The proposed International Solar Energy Research Institute in North Africa could constitute one of the regional centers envisioned by the panel. Its mission should be expanded to include consideration of solar and alternative energy resources. Support could include engineering and scientific laboratory equipment, library facilities, training of personnel, means of cooperation with similar institutions in other regions and developed countries.

There is an opportunity at hand for the United States. Energy and standard of living go hand in hand. Intelligent action on the part of this country could go far to help developing nations meet energy needs. A suitable method would be to assist in the development and operation of regional energy centers.

II

THE BASIS FOR CONSIDERING SOLAR ENERGY

There are several important reasons for considering solar energy as an energy resource to meet the needs of developing countries. First, most of the countries usually called "developing" are in, or adjacent to, the tropics and have available good solar radiation. Second, they do not have widely distributed, readily available supplies of conventional energy resources. Third, energy appears to be a critical requirement to meet the needs of developing countries, because it is related to the production of housing, clothing, food, and agricultural and industrial production. Most of the developing countries are also characterized by arid climates, dispersed and inaccessible populations, readily available labor, and a lack of investment capital.

Thus there are several compelling reasons for considering solar energy as a resource to meet the needs of these countries. They need energy, and have this resource available to them. It is tremendous in amount, and, in effect, is already distributed to the potential users. A substantial part of energy needs in developing countries is for thermal (heat) energy, and solar energy is most easily converted to thermal energy. Its use entails little or no undesirable side-effects on the environment. For some applications, the equipment needed is such that it might well be manufactured in the country of use, possibly saving foreign exchange. Use of solar energy could reduce dependence on, and financial outlay for, imported fuels, thereby contributing to the economic independence of developing countries. Solar processes have been devel-

oped, or are under development, that could meet specific needs of the countries (e.g., hot water, desalted water, etc.--to be discussed later). The probable costs of further developing these and other solar processes are not great, compared with the historical development costs of most conventional energy sources.

It must also be recognized that applications of solar energy entail some difficulties that result from the nature of the resource. The intermittent nature of solar energy results in problems of designing adequate levels of reliability into solar processes. The diffuse nature of solar energy dictates that large outputs of energy (or other products) can be obtained only with large areas of solar converters. Its applications are generally capital-intensive, with substantial investments (local currency and foreign exchange) needed to realize savings in operations. There may also be difficult social and educational problems in getting dispersed and technologically unsophisticated populations to take advantage of and use solar processes.

Recognizing these circumstances, the panel considered questions of the need for energy for various purposes in developing countries, the present status of solar-process development in relation to these needs, and what further activities would be appropriate (in terms of both research and development, and institutional arrangements) to assure that adequate assessment of the potential of solar processes is possible, the resource is appropriately utilized, and energy needs are met.

III

NEEDS AND USES FOR SOLAR ENERGY IN DEVELOPING COUNTRIES

It was clear, as the panel proceeded with its discussions, that its members were aware of a wide range of energy needs in developing countries that could potentially be met by solar energy. Many of the needs were general; others were specific. It was also clear that the panel itself was unable to assess adequately the total nature and extent of energy needs and uses in developing countries, a situation leading to a recommendation for study of these needs.

The statements brought to the panel by members from India and Niger are included in full in Appendices A and B; this information and other panelists' comments are briefly summarized here.

Fulfilling the material needs that center around food, housing, clothing, health, and education is a primary objective of the developing nations. Energy is a most significant requirement, and if solar energy is to have an impact on development, it must be able to contribute significantly to meeting one or more of these needs. Energy requirements include thermal, mechanical, and electrical energy, for use in such applications as heating, food cooling, cooking, lighting, water supply, cooling for human comfort, and the production of salt.

The particular needs of agriculture are for energy to pump water for irrigation and watering livestock, and for drying agricultural and other products--including timber, fruits, grain, forage, oil seeds, fish, meat, slaughterhouse waste, gypsum, and brick. Most of the energy needs of public services are in communications and transport; the latter

will probably continue to be met by fuels. In public health and education, the needs in hospitals, dispensaries, nurseries, etc., are for lighting, air conditioning, water heating, distillation, and sterilization. For household use, air conditioning, water heating, and heat for cooking are needed. In the industrial sector, both mechanical and electrical energy are generally in short supply. Telecommunications and educational institutions need electrical energy.

In the future, the needs and uses for energy we identify today will remain important and will grow at a fast rate, probably 10 - 15 percent annually in some areas.

Commercial sources of energy used now in developing countries are coal, oil, gas, and hydrogeneration, and, to a very limited extent, nuclear material. In some countries (e.g., India) noncommercial energy sources such as firewood, dung, etc., are very important. In these countries, the use of other sources of energy could save large amounts of firewood, which would help control soil erosion and the denudation of forests; and dung not used for fuel could be used as fertilizer.

Some more specific requirements of energy supply that might be met by solar energy were noted. These concerned possible applications to distillation, cooking, refrigeration, and other processes to meet needs of particular peoples.

Assembling these generalizations and specific situations, however, does not provide adequate knowledge of the real extent of energy needs, their geographical and temporal distribution, and the implications of meeting the needs. It is not known which energy needs are the most critical, which are most readily amenable to solution by various technologies, which might represent opportunities for development of new

industries to meet the needs, which involve difficult social and educational components in their solution, and which are the most likely, if met, to have the effects desired by the developing nation.

The limited information available to the panel led it to conclude that solar energy does indeed have the potential to contribute significantly to the solution of many energy problems in developing countries, and that much more thorough study of the nature and extent of energy needs is desirable and is a prerequisite to planning the activities that will most effectively help to meet these needs.

IV

APPLICATIONS OF SOLAR ENERGY: STATUS AND POTENTIAL

This chapter begins with a brief statement of the major characteristics of solar energy and solar processes. It next reviews the present status of solar processes and applications and then for each application, outlines further research and development projects which could be useful in the context of developing nations. For the convenience of the reader, a list of important references on solar energy and its applications is included as Appendix C.

Characteristics of Solar Energy and Solar Processes

Solar energy is electromagnetic radiation from a source (the sun) at an effective temperature of about 6000°K . Outside the earth's atmosphere, the average intensity of solar radiation is 1.36 kilowatts per square meter on a plane perpendicular to the direction of the radiation. The radiation is attenuated by the atmosphere and reduced by geometric factors, with the result that the supply at the earth's surface is variable and intermittent. Its maximum intensity is about 1.2 kilowatts per square meter; zero intensity occurs on the average for about one half of the time. Integrated daily energy on a horizontal surface on good days in low latitudes is 6 to 8 kilowatt hours per square meter. Variability of intensity is predictable with respect to time, latitude, and season; superimposed on this is less predictable variability due to weather.

The result is a radiation supply intermittent and variable in its availability, with typical clear-sky intensity of a little over 1 kilowatt

per square meter. The spectral distribution of the radiation is very roughly one-half visible, one-half near infrared, with a very small amount of ultraviolet. Solar radiation is further distributed between beam radiation which reaches the receiver in a direct line from the sun, and diffuse radiation which reaches the receiver after being scattered by clouds, dust, and molecules of the atmosphere. On very clear days, solar radiation might be 90 percent beam; on cloudy days it is 100 percent diffuse.

Solar processes are based on either of two basic concepts, i.e., flat-plate collectors or focusing collectors. Flat-plate collectors, as the name implies, consist of flat, blackened surfaces to absorb (beam and diffuse) solar radiation. Transparent covers and back-insulation may be provided to reduce or control losses from the plate. On the plate, absorbed solar energy is converted to a desired form of energy, usually heat, and means are provided to remove that energy, usually as heated water or air. Flat-plate collectors are generally operated in fixed position. Ponds or basins of water used in evaporation or distillation are, in effect, horizontal flat collectors. The present upper limit of the temperature of operation of these collectors is about 100°C.

The second concept is that of the focusing collector. The basic element is an optical device, e.g., a parabolic reflector, to focus the beam component of solar radiation on a receiver smaller than the reflector. The result is higher energy flux which allows collection of energy at higher temperatures. Energy-flux ratios (i.e., ratios of intensity of radiation on the receiver to intensity of the beam solar energy incident on the optical system) may range from 2 or 3 at the low end, to 10,000 -

20,000 at the high range. At any but the lowest of these ratios, some degree of "sun tracking" is required to orient the system to allow for the changing direction of the incoming beam radiation.

All practical solar energy systems now in use are based on flat-plate collectors. (The only exceptions are solar furnaces, which are in reality laboratory instruments.) Materials, costs, and operational problems have been major difficulties with focusing systems.

The intermittent nature of the energy supply dictates that storage of collected energy, or of other products of the solar process (such as product water from a solar still), must be provided if output from the process is to be available during periods of no radiation.

With this background, the present state of applications can be summarized. A review of the present status of solar energy applications indicates that those recently put into most widespread use have been based on carefully engineered equipment, usually factory produced, and in some cases for community-scale use. Small-scale application of "homemade" devices has not been widely made. An examination of the successful developments indicates they have the following characteristics: they are adequately engineered and will produce the desired result; "quality control" in the manufacture of the equipment is adequate; they meet a realistic need and fit with the economic and social situations of the users; and, except for solar evaporation, they are applied primarily in areas of relative affluence.

The applications (other than on spacecraft) enjoying most success today are (1) solar evaporation; (2) solar water-heating with factory-manufactured heaters; (3) solar distillation on a small-community scale, which is now in an advanced "pilot plant" state of development; and (4)

solar drying, particularly of crops. Beyond this there have been many experiments, some enjoying a high degree of technological success, but their economic and social feasibility is doubtful or has never been established. These experiments have concerned space (comfort) heating and cooling, refrigeration and ice making, desalting of water, cooking, pumping of water, production of salt, drying, hot-air engines, lighting, solar furnaces, horticultural systems, growth of bacteria to produce methane, and photochemical conversion.

Solar Process Applications Now Being Made

Solar evaporation, water heating, distillation, and drying are the four applications now being made on a scale which results in significant contributions to local energy economies.

Solar Evaporation. This has been a historical, traditional method of obtaining salt from sea water or brines; it remains important today on both a small and a large scale in many nations. The basic concept is simple: In areas where evaporation exceeds rainfall a shallow pond of brine is exposed, resulting in evaporation of water and ultimately in crystallization of salt. Solar evaporation is used in many developing countries--India, Pakistan, Mexico, Colombia, Chile, etc. It is also an important industrial process in the United States. Modern developments have been concerned with improved pond construction and harvesting techniques.

There appears to be little further research on traditional solar evaporation processes that cannot as well be done by the industries using the process. The suggestion has been made, however, that further studies of "solar ponds" might lead to improved salt production and by-products of power or distilled water. [Solar ponds are large-area brine

ponds of approximately 1 meter depth, in which vertical gradients of salt concentration are maintained so that the most concentrated and most dense solutions are at the bottom of the pond. The concentration gradients are such that the hottest solutions are at the bottom of the pond (rather than at the top, as is the case without concentration gradients). This arrangement permits collection of solar radiation in the bottom layers, which may reach 80 to 90°C, with the top at 25°C.]

Water Heating. This application has long been used in southern Florida, and has more recently been developed and applied in Israel, Japan, and Australia. There is now an established solar water-heater industry in Australia with a production of about \$1 million per annum. In Niger production of solar water-heaters is being undertaken, and small-scale manufacture may be undertaken in several other countries. (Application in Florida is less extensive than formerly because availability of natural gas has diminished the market for solar heaters. However, heaters are again being manufactured on a small scale.)

The main elements of a solar water-heater are a flat-plate collector and an insulated storage tank. Water circulates through the collector, is heated, and is held in the tank for use when needed. In Australian practice the absorbers (collectors) for household-scale use are typically 0.8 to 1.6 square meters, with a 300-liter water-storage tank, optionally fitted with a thermostatically controlled 1-kilowatt electric booster, producing about 180 liters of hot water on a good day. Domestic installations employ thermosiphon circulation, which allows the water to recycle through the absorber without pumps, but large commercial and industrial plants delivering some thousands of liters of hot water per

day use forced circulation with thermostatic control. One group of residential structures in Darwin has nine separate banks of solar water-heaters with a combined output of hot water of 13 cubic meters per day. Solar water-heaters are proving to be the most economical way of providing hot water in many parts of the Australian continent, particularly in the Northern Territory, where it is Australian government policy to install solar water-heaters in all government houses.

Hundreds of thousands of water heaters have been manufactured in Japan, many of a design that combines the collector and storage functions in horizontal plastic containers designed to produce hot water for use at the day's end.

Experiments with solar water-heaters have been undertaken in many areas, such as Chile, India, Egypt, etc. To the best of the panel's knowledge, however, use in countries other than the United States, Israel, Australia, and Japan has, to date, been quite limited. The technology of this process is well developed.

Water-heater technology is well established, and the needed development is largely to adapt the technology to use materials and manufacturing capabilities of the country in question. Hot water for hospitals, schools, and other institutions, and for families, could become much more widely available with these developments. The nature of equipment is such that it can be manufactured in developing countries, and adapting it to their conditions seems to be straightforward.

Solar Distillation. This is a process now in the "pilot plant" stage of development, the basic method being to admit solar radiation through a transparent cover to a shallow, covered brine basin; water evaporates from the brine; and the vapor condenses on the covers which

are so arranged that the condensate flows therefrom into collection troughs and thence into a product-water storage tank. The idea was first applied at Las Salinas, Chile, in 1872 in a plant supplying drinking water for animals used in nitrate mining and transport. The Las Salinas plant reportedly operated for 30 years. Modern developments in solar distillation have been directed at using new materials and designs for economical and durable construction, to reduce product water cost.

Solar distillation is used on a small commercial scale to supply small towns and motels in isolated areas in Australia and small communities in the Mediterranean basin and the Caribbean. The process must still be regarded as experimental, but small community-scale stills are near to extensive commercial application. Durable designs have been developed in the United States, France, Spain, and Australia which require little day-to-day attention and operate with minimal maintenance.

In addition, some experiments have been done on small family-scale distillation units, for possible use on Pacific islands and for emergency use.

Designs are now available for solar stills that are serviceable and that can be used with a reasonable degree of confidence. Further research in this application would involve further adaptation of existing technology to the specific needs of developing countries, through design modifications to allow use of locally available materials and locally manufactured components. Studies of this type could improve the economics of solar distillation, widen the areas in which it might be useful, and thus contribute to the solution of water-supply problems, particularly for small communities in good climates.

Solar Drying. A traditional and widespread use of solar energy is for drying, particularly of agricultural products. This is a process of substantial economic significance in many areas. The customary technique is to spread the materials to be dried in a thin layer on the ground to expose it to solar radiation and wind. In recent years innovations have been adopted, particularly for fruit drying, in which fruit is placed in carefully designed racks to provide controlled exposure to solar radiation and wind, and to improve material handling. Improved process control and product quality have resulted.

Other experiments have centered on crop drying, using either solar-heated air in more or less conventional air dryers, or a combination of direct and air drying by placing the materials to be dried in flat-plate collector-dryers. Development of solar drying can conceivably benefit from further development of collector-dryer combinations, and flat-plate air heaters and energy-storage systems to supply hot air to dryers. Design and control of these processes, for the particular crops or other materials to be dried, are areas of research that could lead to more practical application in developing countries which could result in improved utilization of food supplies.

Solar Process Applications in Experimental Stages

All other solar processes are in experimental stages of development and have not been used in developing countries (or elsewhere) on any basis other than as experiments. The present status of several processes and the observations of some of the major problems associated with them are noted.

Space Heating. This is not a primary problem in most developing

countries, but providing comfort-heating in some areas would improve living conditions. Much traditional architecture has evolved, in part, to control or minimize temperature fluctuations in the structure. This has been done by designing openings to control admission of solar radiation and designing the heat capacity of the structures to minimize undesirable low (or high) temperatures. However, traditional building methods have not always been followed in times of growing population; and there are modern scientific developments that can be applied to building design to control temperature somewhat under extremes of both high and low temperature. Thus space-heating in developing countries represents a limited problem, but one which may be improved by application of well-established principles.

Research and development efforts in solar heating have been aimed almost entirely at applications in the temperate climates of industrialized countries. About 15 experimental solar houses have been built and operated with the heating system comprised of the collector, a heat-storage unit, and appropriate heat distribution and control systems. Extensive economic studies have also been made, but are applicable to developed economies.

Solar heating in developing areas presents a set of problems which have received relatively little attention. Of several possible approaches, the first involves design of the structure to utilize fenestration, shading, insulation, selective paints, etc., to minimize heat needs. A second approach is to devise heating systems that can operate with no mechanical energy for fluid circulation. Systems have been proposed and studied (e.g., the Altenkirch solar house) using only natural circulation; there may be other possibilities worth considering for appli-

cation to small residences. A third approach is to adapt solar heating systems (with mechanical circulation) that have been developed for applications in developed economies, perhaps for use in larger buildings, particularly in urban areas, where there are significant annual heating loads to be met.

The panel knows little of the real extent of needs for space heating in developing countries, nor of the possible role of solar energy in meeting these needs.

Air Conditioning or Comfort Cooling. This process has received some attention for application in temperate climates by operating absorption coolers with solar heat; and other methods may be possible. These studies, aimed primarily at United States and Australian application, are still in early stages. Technological feasibility appears to be assured; economic feasibility is now under study. As with space heating, there are opportunities to use building design to increase comfort.

Designing air conditioning systems for use in developing nations again presents a different set of problems, of both potential utility and design. It has been suggested that air conditioning of factories and offices would significantly improve the productivity of people working in them; and there is also the prospect of applications to residences. There are also technological problems of system design for operation without mechanical power, and for solar operation of other types of cooling processes. Building designs to minimize needs for cooling may be productive. The best methods of obtaining cooling with solar energy in developing countries are far from clear at this time, and the immediacy and extent of needs for air conditioning are not known.

Solar Refrigeration. Closely related to air conditioning, solar refrigeration is intended generally for food preservation (or storage of biological and medical materials). There have been experiments in the United States, Ceylon, France, the Soviet Union, and elsewhere on solar-operated coolers, using absorption-cooling cycles, most of which are aimed at household-scale food coolers, or small-scale ice manufacture. A single experiment in Mexico with a solar-operated, household-scale cooler was unsuccessful; the machine was simple in its design but overly complicated in its operation, and was not usable by the people for whom it was intended.

There are many possible refrigeration cycles and systems that can be considered for solar refrigeration. It has yet to be established what may be the best scale on which to operate solar refrigeration for developing countries; community-scale systems may offer advantages of larger scale, reduced educational requirements for users, and (if appropriate) the possibility of distributing ice to smaller users (i.e., households). Thus there are a substantial number of open questions regarding solar refrigeration, and the application has the attractive possibility of better utilization of available foodstuffs if refrigeration could be successfully provided.

Conversion to Mechanical or Electrical Energy. This conversion remains an elusive, yet intriguing problem. Thermal conversion systems using heat engines and focusing collectors are one approach; perhaps the most difficult problems are the substantial difficulties of cost and long-term operation of focusing collectors which have received attention but are far from solved. Another approach is to use flat-plate collectors with heat engines operating at lower temperatures (and

thus lower efficiencies). There are experiments on solar power now underway which are based on flat-plate collectors.

A tremendous investment has been made in photovoltaic conversion processes for use in space. The costs of the converters, which convert solar to electrical energy, is now very high by ordinary terrestrial standards (from 100 to 500 times the cost of electrical energy from conventional sources). In developing countries there may, however, be applications in communications, which require power in very small quantities.

The possible applications of successful development of economic solar-energy conversion to needs for mechanical or electrical energy are wide; for example, pumping of irrigation or stock water and cooling by mechanical refrigeration. Therefore, several lines of study, of a more long-range nature, appear to be justified, although the difficulties inherent in the problem must be recognized. First, more development work on focusing-collector systems and their materials of construction might be productive and should be undertaken. Second, studies designed to raise the practical operating temperatures of flat-plate collectors would, if successful, help to solve solar power problems. There may be energy-storage and engine research which should be coupled to the collector studies. Third, further research and development in solar cells might, in the long run, reduce their cost and widen their areas of application, although the prospects of generating electrical energy at the same costs as energy from conventional sources are dim. (Research and development on photovoltaic processes is an activity best carried out by very well-equipped laboratories of industrialized countries.) Identification of the nature and extent of needs for electrical and mechanical

energy in particular areas, and the economic and social considerations that will affect the utility of solar power systems, are needed to plan development activities properly.

Solar Cooking. This application appears to be simple in its technology and significant in its advantages--if it can be successfully applied. Efforts to design and introduce successful solar cookers have been carried on for many years, with cookers of two types. One is based on concentrating the solar energy by a reflector onto a cooking vessel, and is the analog of a surface heating unit. The other is a solar oven which depends on some concentration of radiation, combined with the greenhouse effect, for trapping heat within a small space in which the food is placed. Both approaches have been developed to a degree of satisfactory technical performance for providing for at least partial cooking needs of families. However, extensive field trial efforts in India, Mexico, and Morocco have so far not resulted in social acceptance of these devices. After an initial period in which some degree of utility has been shown, the users revert to their traditional methods of cooking.

Solar cookers depend on focusing collectors, and their successful long-term utility will depend on solving the materials and operational problems of focusing collectors--as well as the social and economic problems that have deterred acceptance in experiments to date. It is possible that energy-storage or heat-transfer techniques to permit indoor or evening cooking might help solve some problems of social acceptance.

Biological Processes. Conversion of solar energy to useful materials, foods, or fuels in a sense represents an extension of agricultural

practice. Study of algae growth has been going on for some years with limited production in Japan. Water hyacinth has been proposed as another plant having relatively good ability to use solar radiation in photosynthesis to produce plant materials, and seaweeds may represent other possibilities. The resulting plants could provide fuel (directly or through fermentation to produce methane), useful protein, or plant fiber. (The panel devoted most of its attention to thermal processes, rather than biological. These observations simply draw attention to the existence of problems and possibilities of biological processes.)

IV

DISCUSSION

The panel membership included a wide spectrum of experience with solar energy research, developments, and applications. During the deliberations, a number of generalizations relating to solar processes, their development and application became clear. Of these, questions of the nature and extent of energy needs in developing countries were important enough to be treated separately in Chapter II and the Appendices. This chapter deals with several other general considerations that, in addition to the scientific and engineering aspects, lead to the recommendations and conclusions.

The developing countries, from an energy need/use/supply point of view, represent wide differences in living style and in the needs of village communities, cities, nomadic people, remote industrial towns, schools and hospitals, and industry. Physical situations, including climate, topography, and natural resources, are highly variable. Beyond these challenges, developing countries present problems of logistics; for example, in the rural areas where much of the need for energy exists people are scattered, facilities for transport are poor, and communications are difficult. People's skills and their levels of education vary. Clearly, no single description or set of criteria can be applied to these countries; corresponding variations in solutions to their energy problems may be expected.

Further, there are degrees of development, which can be expressed by such indices as per capita energy consumption or per capita production.

The degree of development affects the desires of people for energy or its products, their willingness and ability to invest in capital-intensive solar processes to obtain benefits therefrom, and the extent to which education is required to train users of solar processes. It was suggested that the best level at which to aim solar developments is the "middle" of the development scale, because some poorer countries may be unable to take advantage of an otherwise successful solar energy application because of lack of capital and social incentive.

Total energy resource needs for the next 20 - 30 years are now being projected for many countries, particularly the industrialized countries. Serious questions are being raised as to whether the developed countries can continue to use, at present and projected rates, the fossil fuel and nuclear energy sources now available to them. Pollution is a real problem; furthermore, other countries which today are major energy-resource suppliers may be less eager in the future to share their now-abundant energy sources. Developed countries may have an "energy ceiling" (particularly on fossil fuels) imposed on them as other populous nations, such as India or China, compete for shrinking supplies of natural resources. In addition, the developing countries' quest for higher living standards may result in an intolerable level of the side-effects of today's methods of producing and using energy. It can be foreseen that in the long run present and future demands for energy will pose tremendous problems to all societies unless environmental degradation and exhaustion of natural resources are controlled. Aspirations, energy needs, and resource utilization are highly time-dependent, and the needs of the large part of the world's population in the developing countries cannot, in the long run, be considered independently from energy planning in the industrialized nations.

Process reliability of solar processes is of primary importance.

There are two sets of considerations, the first of which deals with more or less predictable reliability problems arising out of weather variability and energy (or other product) storage requirements. Desirable degrees of reliability can be designed into solar processes, depending on solar energy availability (i.e., climate) and on costs and availability of alternate supplementary energy sources.

The second set of reliability criteria may be self-evident, but again needs emphasis: A prime requisite for success of any solar application is that the process perform as intended over extended periods of time, e.g., the anticipated lifetime used in calculating the annual capital costs of the process. Developing countries should not be expected to expend their very limited capital resources on a solar device unless they have adequate assurance that it will perform for those extended periods. Process engineering must be adequate; poorly engineered systems are a disservice to those who are led to invest in them.

The capital-intensive nature of solar processes, in comparison with energy systems using conventional fuels, has been noted in the preceding sections. Because of their intrinsic shortage of capital, the developing countries rely on outside support. Solar, or other, energy resources must compete for capital investment, wherever the capital comes from--for roads, schools, water supplies, agricultural implements and improved animal husbandry, basic public health facilities, to say nothing of the non-constructive uses of capital for military purposes or prestige projects.

This situation emphasizes the importance of careful selection of research and development programs, to direct development toward appli-

cations with realistic prospects for returns in a particular country or area, and to assure that the developed processes will be reliable.

The scale of applications and manufacture was discussed. Two approaches to solar-energy applications have developed, interrelated but with different philosophies. One approach has been to develop simple, inexpensive, household-scale devices, designed to be made with local labor and materials on an individual or very small scale. The other approach has been to design more carefully engineered systems with controlled manufacture, often factory produced, and sometimes for larger-scale applications.

At present most useful solar-energy applications fall into the second category. Extensive efforts to develop applications for individuals have not enjoyed much success, except for solar water-heaters which have been factory produced. Experience suggests that carefully engineered and manufactured systems are more likely to affect developing countries in the next decade; this is the more fruitful approach. The best route to solar applications may be through systems designed for the middle and upper classes, or for community or industrial users, with the expectation that success there might lead to ultimate applications by the less affluent or smaller-scale users. It is further likely that some solar applications will result from technology developed for use in industrialized areas, by transferring and modifying the technology for the developing country.

Small-scale applications on a household scale should not be ruled out, but it will probably take longer to realize the benefits. Any

applications that involve educating potential users to accept, utilize, and maintain equipment naturally take a longer time than those for which the technology is in the hands of a few and the product is distributed to individuals. The effective, widespread application of small-scale solar processes in developing countries may well be coupled to educational extension programs. (It took a generation of extension activity in Mexico before the economy felt the full effects of the Rockefeller Foundation - Mexican Department of Agriculture wheat and maize crop research.)

The advantages to developing countries of domestic production of solar-process equipment are evident. However, low cost is essential to economically viable solar processes, and some sophisticated items of equipment, such as refrigeration equipment, should be produced in a limited number of large-scale manufacturing facilities, if the economic advantages of large-scale production are to be realized. Equipment less demanding to manufacture could probably be economically produced in more widely dispersed facilities.

Finally, the objectives of energy development should be clearly understood. In a developing nation, with its particular needs for energy, what should be the goals? To meet rudimentary needs of rural populations to improve an undesirable state of existence? Or other kinds of results, such as sharply increased industrialization and redistribution of population (an end which might be served better by providing large central power stations)?

The panel felt strongly that the objectives of research and development on energy needs should be to meet those energy needs by whatever sources may be available. Thus, energy R and D for developing

countries should not be restricted to consideration of solar energy, even though solar energy will be a primary consideration in such R and D.

In view of these discussions, why have more applications not been made of solar energy in developing countries? The answers are not entirely clear, but these essential points can be made:

- The research and development efforts that have gone into solar processes for terrestrial applications have been very limited, in relation to the problems involved and in contrast to funds invested in other energy resources.

- R and D activities have been carried out with insufficient knowledge of energy needs or human problems in technological innovation-- a case of hindsight. The result was, in part, an emphasis on developments that appeared easy but that in fact were very difficult, such as solar cookers.

- Work to date has not resulted in cost reduction sufficient to make solar processes attractive in the economies of many developing countries.

- Incentives for industrial development and manufacture of solar-process equipment have not evolved.

The summary conclusions and recommendations, presented at the beginning of this report, reflect these situations, the present status of solar applications, and the panel's assessment of appropriate steps to be taken to help solve the energy problems of developing countries.

APPENDIX A

ON SOLAR ENERGY UTILIZATION FOR DEVELOPING COUNTRIES

Abdou Moumouni

The countries or states falling within the scope of this paper are those partly or totally located in the sahelian zone of West and Central Africa: Mauritania, Senegal, Mali, Upper Volta, Ivory Coast (northern part), Niger, Nigeria (northern region), Chad, Cameroon (northern part), Dahomey (northern part), Sudan; possibly Ethiopia, Uganda, Kenya, and Tanzania. The author is aware of the interest in, and potential importance of, solar energy utilization for such countries as Morocco, Algeria, Tunisia, Libya, and the United Arab Republic, but because of a lack of personal familiarity, this paper does not concern them.

Needs and Uses for Energy Today in the Developing Countries of West and Central Africa

It is somewhat difficult, if not impossible, to assert precisely the needs and uses for energy in the countries concerned. Tentatively, a qualitative analysis will be done here.

It is a widely accepted opinion derived from the observations of various development attempts that the process of development in non-industrialized countries should be based on

- The development of agricultural production (food, export products) and efficient exploitation of cattle-breeding products (milk, butter, meat, skin, etc.);

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- The growth of local industries that process agricultural and cattle-breeding products to meet local needs as well as those of export;

- The exploitation of other available natural resources (minerals, petroleum, natural gas, etc.) for export and for the local needs;

- The growth of education and health levels to provide the skilled manpower required, to raise the cultural level of the population, to improve their living conditions, and to increase the efficiency of labor.

On the basis of "in the field" qualitative surveys of needs and uses for energy today in the developing countries of West and Central Africa, the following appear to be the fundamental needs and uses for energy:

1. Energy needs and uses, of and by local industries of the modern type

- Mining, fuel, and coal industries
- Minerals-processing industries
- Industries that process agricultural and cattle-breeding products--textile plants, tinned and canned products, leather industries
- Other industries--plastics and glass, brewery and food industries, various workshops

The fraction of the total energy consumption represented by the industries amounts to from 50 to 70 - 80 percent.

2. Energy needs and uses for the development of agriculture and cattle-breeding

- Pumping of water for irrigation
- Pumping of water for cattle
- Workshops of rural craftsmen

The importance for the economy of these needs and uses for energy is evident. However, these needs and uses are very far from being met today at a satisfactory level: the sahelian-zone peasant has 3 months of agricultural labor (corresponding to the only rainy season), and his average annual income of 15 - 20,000 F CFA or \$54 - \$72 U.S. is in fact gained during this period.

3. Energy needs and uses for public services, communications, and transport

- Of basic importance because of the widespread population, distance to the sea, and other factors; conventional fuel consumption (gasoline, fuel oil, etc.) in the various countries mainly directed to meet these needs

4. Energy needs and uses for public health, education, domestic economy

- For hospitals, dispensaries, nurseries--light, refrigeration, air conditioning, water-heating, distillation, sterilization, etc.

- For cooking (today mainly met by consumption of wood and charcoal), other domestic uses (lighting by kerosene lamps, eventually refrigeration and air conditioning)

- For various educational institutions, radio broadcasting, and educational television

Probable Needs and Uses for Energy in 10 Years and Beyond

About the needs and uses for energy in the developing countries of West and Central Africa for the next 10 years and beyond, the following points seem to be clear:

- The needs and uses identified today will continue and will probably be growing at a rather fast rate.

- It is difficult to make a definite or precise projection, if only because basic surveys are not available. However, on the basis of growth of electrical energy production and consumption, and fuel-products consumption, in the past 10 - 15 years, a 10 - 15 percent annual growth rate in consumption of energy appears to be highly probable. These figures, in the opinion of the author, are only indicative; in fact, the needs for energy in agriculture and cattle-breeding, if they were to be met, could give rise to far more than a 15 percent annual rate of increase. The financial means required have been the main reason why these needs have been met at a very low level.

Priorities for Utilizing Solar Energy in West and Central Africa

These priorities are based on the personal thoughts of the author, based on his experience of the problems in the developing countries concerned.

1. Small engines (0.5 to 10 HP) for pumping water and the functioning of various rural workshops and little industries
2. Hot water for schools, hospitals, nurseries, rural dispensaries
3. Distillation and sterilization of water for hospitals, dispensaries, nurseries; desalination of brackish water
4. Solar thermo and/or photo batteries
 - for pumping water
 - other uses of electricity (telecommunication educational needs, information, etc.)
5. Solar cookers

Here the question of low prices of the cookers, as well as the necessary complementary equipment, is of critical significance in view

of the above-mentioned low income of the majority of the population. It must be kept in mind that solar cooking cannot be developed on an eliminatory basis, as sociocultural and sociological problems have to be solved before a population will adapt to it. Here the economics is of paramount importance if broad classes of the population are to use solar cookers. Linked with that problem is the fact that any significant impact on the economy of the country, or on the climatic and agricultural consequences (stopping the present wide-scale destruction of vegetation in already destitute regions), can only be attained by mass consumption of this type of solar energy utilization.

As to the important question of why solar energy utilization in developing countries has not reached a reasonably high level, the following seem to be the basic reasons:

1. Perhaps considerable funds have been invested in research and development, but they were, and are, far below the level required (i.e., compared with space programs of the more developed countries of Europe and America).

2. Efforts have been directed mainly to research and development in developed countries (chiefly Europe, the United States, the Soviet Union); whereas "in the field" developments are, in the opinion of the author, the best and only means of genuinely integrating solar energy utilization (where it is of significance) to economic, social, and cultural development.

3. The process of development is a rather complex one. Developed countries seem to be, or are mainly, interested in broadening their exports at lower costs of investment and lower industrialization of developing countries (c.f., New Delhi Conference). Solar energy utilization cannot,

at the present stage, move without preliminary significant financial means invested in developing countries, for the following purposes:

- To promote research "in the field" for various aspects of solar energy utilization;
- To favor local industries that produce solar energy utilization devices and that produce the basic materials required by this utilization;
- To improve the present situation in which important needs and uses of energy that can be met by solar energy utilization are waiting to be satisfied because of the "vicious circle" aspect of the economy of developing countries (that is, production cannot be undertaken until markets are available, and markets cannot be developed until production is possible); and

4. With the increasingly higher-level training of qualified manpower from developing countries, it becomes more and more difficult for the developed countries to maintain the economic policy of investing in the developing countries only for their own profit or to develop market conquests only on the basis of their own interests.

The effects of the experimental results already attained in the field of solar energy utilization cannot be demonstrated unless regional and subregional institutions are set up, permitting efficient work "in the field" with the participation of interested states, scientists, engineers, and technicians. It is hoped that developed countries will more and more realize that, in view of their own economic interests and with regard to the interests of developing countries, the only feasible and practical way of going ahead is really and efficiently to help the development of research, experimentation, and local manufacturing of solar energy utilization devices.

The above statements refer only to one side of the problem. It must be pointed out that more and more states in West and Central Africa (as in North Africa) are displaying more and more interest in solar energy utilization. Thus in Senegal, Mali, and Niger, national research and development centers have developed a low-temperature solar engine (by Professors Masson and Girardier); in Senegal, produced solar water-heaters; in Niger (started by the author and now at the stage of attracting local and foreign investors in industrial-scale processing) undertaken long-term testing of the Masson-Girardier solar engine. States like Chad, Cameroon, and Upper Volta also show a great interest in solar energy utilization (a small solar engine is operating in Ouagadougou).

This interest is best demonstrated by a Regional Solar Energy Center in West Africa, a project submitted to the U.N. Development Programme, through the Niger River Basin Commission (and backed by all the member states, in particular by Cameroon, Mali, Niger, and Chad). It may be important to recall that, as early as 1964, the Sixth Session of the Economic Commission of Africa backed a resolution in favor of a Regional Solar Energy Center in Niamey, in Niger.

Such a Regional Center could be the first step in implementing a more general Energy Research and Development Center for the sahelian zone; at present, their interest in such a center is not evident to the states concerned.

Anyway, the will and the means of the African states alone cannot solve the financial and other problems related to the implementation of such centers. It is to be hoped that the developed countries' governments, their philanthropic and scientific institutions, and the institutions of the United Nations family will give full support and genuine help, instead

of the now well-known procedure of backing a project with only self-interest in mind. The National Academy of Sciences Panel could play an important role in this direction, if only through their conclusions and recommendations.

APPENDIX B

SOLAR ENERGY UTILISATION IN DEVELOPING COUNTRIES

R. L. Datta

The developing countries are characterised by quite a few salient features, and their major material needs and problems centre around food, housing, clothing, medical aid, and education. Fulfillment of these needs to at least a minimum level for maintaining a reasonable standard of living is the aim of the developing countries. In attaining these objectives, the most significant requirement is energy. Economic backwardness stands in the way of producing sophisticated power sources, and the peoples there will have to depend on other sources, or forms, of energy. Quite a few of the developing countries are characterised by (a) arid or semi-arid regions, (b) a high percentage of people living in rural areas, (c) high dispersion of people in these rural areas, (d) absence of suitable transport facilities, (e) aversion of rural people to sophisticated technological developments, (f) surplus labour, and (g) availability of other forms of energy.

Considering this background, it is pertinent to mention the structure of energy requirements for India, which is typical of the developing countries and has a wide range of environmental conditions. India accounts for 15 percent of world population and only 1.5 percent of the energy consumption of the world. One third of this energy is in animate form, in-

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cluding human labour; the same amount is accounted for by noncommercial energy in the form of firewood, dung, etc.; the remaining amount is shared by commercial energy sources like coal, oil, hydroelectricity, nuclear energy, etc. (See Tables 1 and 2.)

A few significant facts emerge from Tables 1 and 2:

1. Noncommercial forms of energy constitute more than half the total inanimate energy supply.
2. The average growth rate per annum for coal is 5 percent; oil, 10; hydropower, 14. The total for commercial energy is 7.5 percent.
3. The average growth rate per annum for dung is 0.4 percent; firewood, 3.4; vegetable waste, 1.75. The total for noncommercial energy is 2.75 percent.
4. Commercial forms of energy are gaining at a faster rate, although the consumption of noncommercial fuels is increasing at more or less the same speed as population growth.

In order to increase the standard of living of the country, the favourable ratio of commercial to noncommercial sources of energy has to be increased. Apart from this, to bring about a rapid growth in the agricultural sector, control soil erosion, and stop denudation of forests, the noncommercial sources of energy should be replaced as speedily as possible by either commercial sources (comparatively more difficult for a developing country) or other sources of energy. Here solar energy can play a great role.

Another pertinent fact in the case of India is that within the commercial energy sector there is a trend toward more and more dependence on oil as a source of energy. Such a trend may lead either to attempts

Table 1. Energy Consumption, India, 1953 - 1969

	Commercial Energy				Noncommercial Energy		
	Coal (ton x 10 ⁻⁶)	Lignite	Oil (KWH x 10 ⁻¹⁰)	Hydro power (KWH x 10 ⁻¹⁰)	Dung	Firewood	Vegetable Waste
1953-54	34.1	-	3.5	2.9	46.4	86.3	26.4
1955-56	35.1	-	4.4	3.7	48.8	88.8	27.7
1960-61	49.9	-	6.7	7.8	54.0	100.0	30.7
1962-63	59.6	-	8.5	11.8	54.9	101.6	31.1
1965-66	67.7	2.5	10.7	15.2	44.06	126.4	32.5
1968-69	69.5	3.4	14.8	20.8	49.40	142.0	34.2

Table 2. Forms of Energy in Total Commercial and Noncommercial Consumption, India (Percent)

	Commercial					Noncommercial			
	Coal	Lignite	Oil	Hydro Power	Total	Dung	Firewood	Vegetable Waste	Total
1953-54	18.5	-	11.9	1.4	31.8	-	-	-	68.2
1955-56	18.1	-	13.2	1.7	33.0	-	-	-	67.0
1960-61	20.6	-	16.2	2.6	39.6	-	-	-	60.4
1962-63	22.2	-	18.9	3.9	45.0	-	-	-	53.0
1965-66	21.6	0.5	20.0	4.1	46.2	5.6	38.3	9.9	53.9
1968-69	19.4	0.6	23.5	4.2	47.7	5.5	37.7	9.1	52.3 ^{a/}

^{a/}The coal-equivalent for the last of above indicated years is 358.65 million tons of coal.

to discover more indigenous sources or to more imports. The transport and domestic sectors will be the maximum consumers.

Kerosene is the universal illuminant, particularly in rural areas, and a source of domestic heat in towns. The demand for kerosene has been maintained at a high level and is steadily increasing. There is not enough indigenous production of kerosene to meet this demand; about 0.7 million tons had to be imported in 1969 - 1970. This is another field for solar energy.

This typical picture of a developing country leads one to examine further the conditions in the rural areas where the people are very much scattered, with few transport facilities; and requirements for energy are localised. In arid and semi-arid zones, the intensity of solar energy is fairly high (higher than $650/\text{cal}/\text{cm}^2/\text{day}$) for a long period of the year. Brackish water sources have been known in many of the areas, and the ground-water is known to exist at high depth. High temperatures prevent people from working outside their dwellings for long periods. Firewood, dung, vegetable waste, and oil are the main sources of energy for cooking and lighting. Salt is an essential article of food as much as water. Commercial sources of energy in the rural areas of many developing countries will continue to be only a very long-term expectation.

The future community development centres in these areas will also require that small-scale industrial centres be developed. The transportation sector is to be cared for in these centres, which will also have to take care of the health and training of the people. Problems encountered, therefore, centre around (a) water shortage, (b) fuel shortage, (c) lighting, (d) power shortage, (e) water lifting and irrigation, (f) comfort of people, and (g) food and salt. The overall picture in re-

spect to energy consumption is that the requirements for energy of a small rural community of 40 to 50 families may be about 3,000 KWH per family per year.

In view of the conditions existing in these regions and the requirements of the people, the known technologies in the harnessing of solar energy have immense possibilities.

Some possible applications of the scientific principle and technologies to meet the needs of rural, developing areas are listed:

<u>Needs</u>	<u>Scientific Principle and Technology</u>
Solar salt	Design of salt farm based on relationship between solar evaporation rate of brine and vapour pressure of brine, wind velocity, and other ambient conditions. Enhancement is effected by addition of green dyes.
Fresh water	Water desalination by solar distillation and humidification-dehumidification techniques. Technology has been developed, and needs extension.
Water heating	Water heating by use of solar energy collectors, which can be introduced in any developing country now.
Water Lifting	(1) Pump driven by semiconductor solar generator. (2) Pumping by the use of solar engine using methyl chloride or synthetic fluids of freon group as working fluid.

Comfort of people, food storage	Solar-operated refrigeration and air-conditioning plant. By the use of ammonia absorption system, or other system.
Drying of agricultural products, and dehydration	Solar air-heaters corrugated or meshed type, temperature more than 30°C above ambient, controllable.
Cooking	Solar cooker of paraboloidal mirror or other design, and incorporating heat storage for kitchen cooking.
Lighting	Silicon solar cell with battery.
Small power	(1) Solar heat engines. (2) Thermoelectric and thermoionic conversion. (3) Photovoltaic conversion. (4) Photochemical conversion.
Food (green vegetables)	Controlled-environment agriculture using desalinized water to provide arid zones with fresh fruit and vegetables.

This list is not intended to be comprehensive but only to indicate that the solar scientists have the scientific principles/technologies, a few of which are already being applied and others which require further development.

A close examination of research and development activities over the world indicates that the greatest advances have been, are being, and are likely to be made in utilising solar energy in relatively small units, mainly because the diffuse nature of solar radiation means that larger devices will necessitate much higher capital investment. This factor is

is particularly important to the needs of rural people, and it fits into the pattern of rural economics.

The total solar energy reaching the earth is estimated to be much greater than that required by world's population, and, technically, can replace the conventional sources like fuel and electricity. But, because of the limitations set by the higher cost of collecting solar energy and the higher investment cost for solar devices, due to the diffuse nature of this energy, it is used at present only for some special cases. The changing direction and the intermittent nature of solar energy have brought problems of storing solar energy devices, along with increased cost. Searches for cheaper materials in solar devices have not always brought results on account of the varying radiative properties of materials. Even a complete picture of solar insolation is not available in most parts of India.

In order, therefore, to ultimately evolve technologically sound and economically acceptable solar devices, a systematically planned approach by scientists and engineers is necessary. It is, therefore, essential that such planned investigations should cover fields relating to

1. The preparation of a world solar-energy map, for which the cheaper, portable type of bimetallic pyranograph may be used;
2. Radiative properties of the comparatively cheaper solar materials, specially those available in different regions of the world, particularly rural areas; and
3. Trapping devices that work by using either selective materials or indigenous design or both; and also a storage system for solar energy-- which amounts to a substantial investment cost for solar devices.

APPENDIX C

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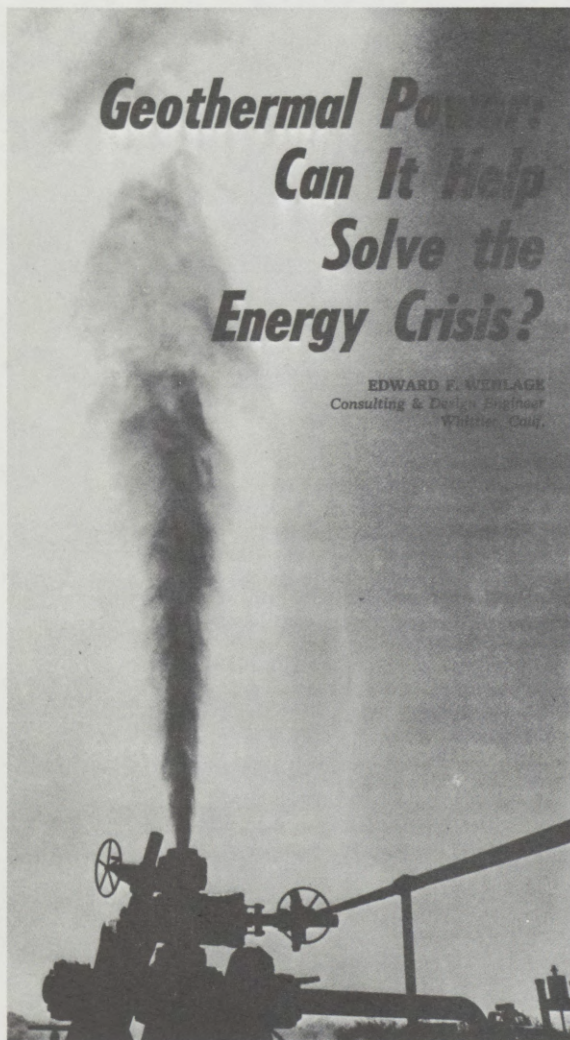
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APPENDIX F



Geothermal well in the Imperial Valley, California, "blows in." Hot brine from the 8,030-ft deep test well may be used as a source of power for a desalination plant. The U. S. Bureau of Reclamation hopes the project will ultimately produce pure water for the Colorado River.

30

Geothermal Power: Can It Help Solve the Energy Crisis?

EDWARD F. WEHLAGE
Consulting & Design Engineer
Winters, Calif.

MANY METHODS of producing power, formerly filed under "interesting but impractical" are being revived as a solution to the energy crisis. Geothermal power is one of them. The concept brings with it the image of a limitless furnace in the bosom of mother earth that can provide man's power needs for centuries to come.

To the technically naive, geothermal power means simply drilling a deep hole, tapping the earth's interior heat, and conducting it to a power plant. Theoretically, this is possible. But geothermal power, like solar cells, tidal, and other unconventional power-producing schemes, encompasses an awesome number of known and unknown technical problems.

Indications are that present geothermal sources can produce an important, but a limited, amount of power economically in a number of regions. If the present geothermal power generation sources in the U. S. A., now in operation and under development, progress as planned, they will provide 608 Mw of power by 1980. With a breakthrough on a few known problems, that figure could be 1,138 Mw. The projected total energy need for the U. S. summer peak demand in 1980 is predicted at 655,700 Mw.

Broader predictions for the use of geothermal reserves as a national, or worldwide, power source will have to await further research.

Two schools of thought exist on how geothermal heat is created. One is a theory that the earth agglomerated from molten material at some primordial time and is cooling down like a baked potato. The second theory holds that there is a constant furnace in the inner earth, fired by radioactive decay or friction.

Heat, What Kind?

The ideal geothermal source produces clean dry steam that is close to the quality of steam used in conventional power

MACHINE DESIGN

plants. These sources are rare. In few cases, can steam be piped directly from the ground to a steam turbine with minor cleaning to remove solids. More often the source produces wet steam or hot water, requiring the water to be flashed. The resulting steam goes to a turbine. The remaining hot water may be pumped back into the ground. At present, only water hotter than 360° is considered usable.

Disposing of geothermal waste water is a problem because of the mineral content, which can run as high as 30%. These materials can cause problems initially, by corroding, or solidifying, and blocking the pipes and turbines. Once through the turbine, the condensed water may be too full of contaminants to dump into natural streams or lakes. Because the saline and siliceous solids precipitate out as water temperature and pressure drop, reinjection into the ground also may be difficult. The solids may block the porosity of the underground rock. An entire new water-treatment technology may have to be developed to handle large quantities of high-temperature water.

Another problem that must be considered with present geothermal sources is that many are in isolated regions and are capable of producing only small amounts of power. Practical utilization of these sources will require the building of industry or towns closer to the power generator or developing the ability to transmit small blocks of power without prohibitive line losses.

Many of the more optimistic predictions concerning geothermal power are based on the "hot rock" idea. With this plan, two deep wells are drilled to contact a subterranean hot-rock strata. The rock at the base of one well is fractured with high-pressure water or a similar agent. Surface water is then pumped down, heated as it passes through the fracture area and returned to the surface through the other well. This water can be used for heating

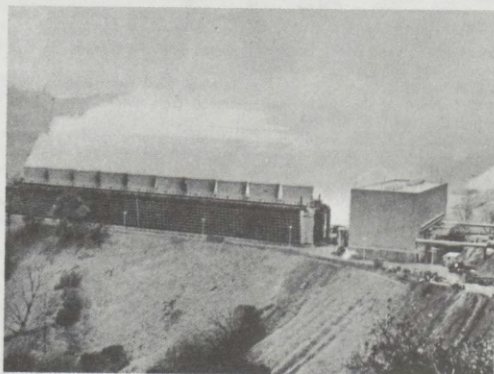
or to generate power. This basic system was proposed to heat the U.N. building at a recent geothermal energy symposium.

Although the heat is known to be available, a number of problems still must be solved. For example, relatively little is known about geothermal "prospecting." Unlike petroleum geology which is well developed, geothermal sources occur in a different type of rock. At the depths considered, rock mechan-

ics are not well known. In addition, drilling technology, now limited to around 30,000 ft, would have to be improved to reach 50,000 ft. This is the depth, according to some experts, where such wells could contact hot rock. Friction losses in such a long borehole offer another very serious threat to efficient pumping of the required quantity of fluid.

Sustained length of life in practical operation for a hot-rock

World's largest geothermal turbine generators are now in operation at Pacific Gas and Electric's Geysers Geothermal Power Plant in Sonoma County, California. Pipes with expansion loops gather steam from the geothermal wells and carry it to the power plants, top photo. PG&E will reach a capacity of 396,000 kw this year in the six Geyser units. The Geysers is a nearly ideal geothermal power operation since high quality steam is available and the site is close enough to a large city to eliminate prohibitive transmission-line losses.

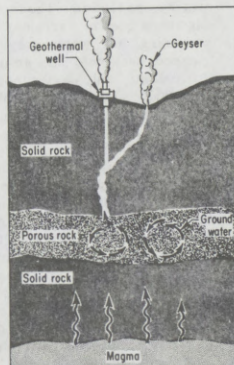


May 3, 1973



GEOTHERMAL POWER

Workmen line a reservoir with plastic film at a Mesa Project test well. The U. S. Department of Interior program is investigating potential geothermal power sources in California's Imperial Valley. Conventional oil rigs are used to drill the wells.



Geothermal power sources are found in rock formations such as this. Ground water seeps into porous rock "boilers." The layer is sealed above and below by solid rock. Heat, conducted from the magma, or molten rock, heats the ground water. Fissures in the solid rock channel the hot water or steam to the surface. There the heated fluid creates a geyser or forms a hot spring, or is tapped as a geothermal well.

well would also be an unknown initially. A 25 to 30 year power-plant life is the estimated break-even point. Only continued operating experience will answer these unknowns.

Where in the World?

The U.N. has listed 18 countries where geothermal energy sources are being developed or are in actual use.

The efforts of the geothermal experts at the U.N. are consistently directed toward improving the living standard in the underdeveloped areas where more electric power is not the only need. Geothermal wells might provide a heating source, a saleable chemical, or even better, a supply of much needed pure water.

The first commercial geother-

mal power development was begun at Laderello, Italy in 1904. With a present capacity of close to 400,000 kva, it is currently the largest geothermal power installation in the world. Laderello produces from a "dry-steam" field, a distinction shared with only two other producing areas—the Matusukawa operation in Japan and the Geysers in California.

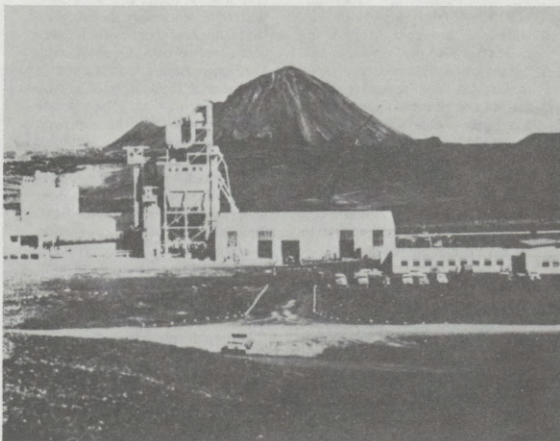
New Zealand steam is produced from typical "wet field" operations, where water and steam mixtures are released at the well heads. The Wairakei power stations generate around 200,000 kva of electric power. The thermal area also provides direct commercial heat for buildings and a paper-making operation.

Iceland is probably the most effective user of geothermal

heat in the world today. As a result, it not only saves a large amount of fossil fuel and foreign exchange, but its capital city, Reykjavik, is one of the cleanest cities in the world. Two water-supply systems, domestic cold water and 80-C hot water, are metered from street mains to homes and buildings on a utility basis. Some geothermal electricity is generated in northern Iceland, but the abundance of hydroelectric power makes that form of power more economical. In the far north of Iceland, the National Energy Authority, an agency of the Icelandic government, has joined Johns-Manville de France, S.A., in using geothermal steam for the production of dried diatomaceous earth.

In Baja, California, just south of the U. S.-Mexican border, the

GEOTHERMAL POWER



Iceland, which has an abundance of geothermal power sources, uses little of it for power generation. Plant, above, utilizes geothermal steam to process diatomaceous earth. In other countries, geothermal water and steam have been suggested as possible sources of saleable minerals, fresh water, and home heating and cooling.

Reykjavik, capital of Iceland, is heated by hot water which originates at these geothermal fields. Water is metered to homes at 80 C on a utility basis. The heat is also supplied to green houses and municipal swimming pools.



Cerro Prieto water-steam field is characterized by hot water at high temperature and pressure. In this operation, high-temperature water is flashed to release steam under pressure for turbine-power generation. Excess water will be wasted to natural drainage. The plant will eventually produce 75,000 kw.

Power in the U. S.

There are many areas designated KGRA (known geothermal resource areas) in the U. S., but few have justified substantial investment. Despite this fact, the U. S. will assume the place of world leader in producing electric power through geothermal energy within two years.

The Geysers field in California has become the world's largest field and the only geothermal plant operating in the U. S. It is a private utility venture, in contrast with geothermal enterprises in other countries which are government sponsored. During 1973 the generating capacity installed by the Pacific Gas and Electric Company will reach 396,000 kw. An additional 106,000 kw will be added in 1974 and in 1975. More than 1,000,000 kw of generation equipment is being considered by the utility subject to developments in steam, contract, and other factors. According to estimates, the field can support 2.5 million kw of generating capacity. Complete development is not likely until well after 1980.

The Geysers' dry-steam field delivers 99% pure water vapor and has some superheat as it enters the turbines. The steam is gathered from numerous well heads, leased by a joint venture company. The pioneer developers, Magma Energy and Thermal Energy Co., are associated with the field operator, Union Oil Co. These, in turn, deliver and sell the steam to the generating plants.

Another great potential heat reservoir may lay beneath the Imperial Valley of Southern California. North of the Cerro

Prieto field, the Department of Interior's Bureau of Reclamation completed a test drilling to 8,030 ft last year. Although it tapped a hot-water strata, the source may not be practical for power generation. It may be useful for desalting water, however, and a pilot desalination plant on the well site is the next step. Fresh geothermal water would ultimately be used to dilute the high salt content of the Colorado River and serve some of the Imperial Valley's water requirements.

New test wells drilled at the south end of the Salton Sea in California have uncovered another potential geothermal field. The San Diego Gas & Electric Co. and Magma Energy Inc. have entered a joint arrangement for the design and testing of a new research and development facility in the area. They will explore the ultimate capacity of the geothermal reservoir and study the effect of geothermal fluids on materials and equipment. The test facility will be based on potential power generation of 10,000 kw per hr. No power will be generated now, but the capability will exist for inserting vapor-cycle turbines in modular blocks of 10,000 kw.

Such a vapor cycle, or binary-fluid, heat-transfer system would be a major breakthrough not only for geothermal power, but nuclear and conventional power generation. By transferring the energy of the hot water to a second working fluid, low-temperature water (below 360°) can be utilized, and part of the problem with equipment contamination eliminated. Needed are reliable second fluids, pumps, and an efficient heat exchanger. Their development would mean that waste heat from all forms of power plants might be converted to useful power production.

The binary-fluid system called Magmamax uses a secondary loop with isobutane. The isobutane boiler operates at 500 psi with vapor superheated to about 300 F. The vapor is ex-

panded to drive a turbine and then condensed at about 85 F. The high-pressure, superheat, and the high density of the isobutane are said to give efficient turbine performance. Isobutane is noncorrosive, non-toxic, and low cost. Its flammability is not considered to be a serious problem.

Detailed proposals have been developed for several applications of the Magmamax system. This is the vapor cycle which will be the basis for the research plant described earlier to be set up at the Salton Sea.

Another geothermal development is a newly patented device called a "Rotary Screw Expander." This device is a modification of the helical-screw com-

pressor that works well with dirty gases. Its two helical rotors are balanced and separated within a stationary housing so that mineral deposition may actually improve the rotor seal. Foreign particles that abound in geothermal fluids should not be as damaging to the screw mechanism as they have proved to be to more delicate turbines. One small expander has been field tested, and a larger unit is now being installed on a remote well in the Cerro Prieto field. Successful expander operation may upgrade the power recovery from the steam-flashing cycle by utilizing the pressurized hot water remaining after steam has been flashed off.

Although the size of present



Cerro Prieto field, Baja, Mexico, could eventually produce 75,000 kw for the Mexican power grid. Hot water from the field's wells is flashed. Steam is removed in separators, such as this, then carried to the turbines. Remaining hot water is, at present, wasted.

GEOTHERMAL POWER

rotary screw geothermal power equipment appears small, a unit rated at 1,000 kw, operating automatically at a well head, could become a substantial power contributor for remote areas. Small well-head units could be quickly placed in service as new wells are drilled to serve isolated communities where geothermal energy is found.

Other Uses

Power production is not the only potential use for geothermal water and steam. As mentioned earlier, one of the Imperial Valley experiments involves desalination. Home heating appears to be a practical application and is already in limited use in the western U. S. A. One U. S. company has used geothermal water in the manufacture of explosives because it is flameless. Its use in agriculture is another possible service.

Geothermal power may be applied to the heat pump. Early residential heat-pump installations in colder climates were based on coils imbedded in the earth for the heat source. In a sense, this was geothermal utilization. The problems that arose however, were often more annoying than justifiable for a residential heating system. For small space heating loads, any source with a relatively higher heat level can be used with radiation and convectors for comfort heating. The most successful large heat-pump applications have used well water both as a heat source and heat sink, but research for geothermal heat pump is nonexistent today.

Lithium bromide absorption systems for air conditioning homes and buildings in geothermal areas, also may be practical. They could come into use when factories and communities are located to take advantage of geothermal heat. A modular refrigeration plant, based upon modification of standard lithium bromide absorption water chillers, was designed by the

author. In this system, the primary geothermal brine (or steam) passes energy through a special heat exchanger to the refrigeration plant. Each module delivers about 100 tons of refrigerating effect through chilled water circulation.

Research efforts have been unpromising on the possible use of appliance type—3 to 5 ton—absorption units which are normally fired by gas. If a geothermal 3-ton absorption machine appears, it will probably be the result of efforts in Japan and Italy, not in the U. S.

Partial Progress

Enthusiasm for geothermal resources is sparked in some cases by an intellectual appeal that overshadows practical limitations. Both a "dry hole" and a first class steam-producing well require the expenditure of \$200,000 to \$500,000. Even with success, there may be a product for which there is no immediate market while investment charges accumulate. There are tax advantages, however, for private and corporate enter-

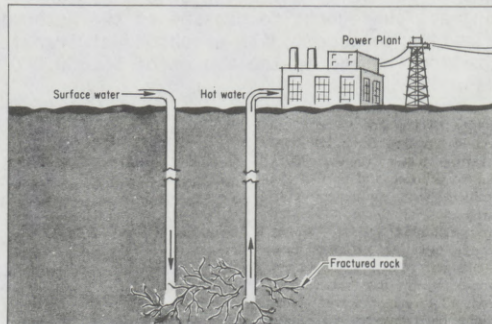
prise. This could be one reason major oil companies are including geothermal exploration in their search for fuels and energy systems.

Development of geothermal resources in the U. S. is presently centered in three areas:

Land Acquisition: Financial interests are locating and exploring prospective areas. Many areas of Federal lands are going to be available for bids.

Increased Surveying: The desire for property with geothermal potential has increased the demand for explorational services. As a result both private industry and institutions are expanding their facilities and improving their techniques. Well drilling methods are being improved at the same time.

Research: Methods for handling fluids, separating steam and water, disposal of geothermal waste liquids, and testing of materials are receiving the most attention. Low-level energy utilization has a correspondingly lower priority. Much of the research work for utilization is being carried on with private funds.



Hot-rock method of utilizing the earth's heat would require wells an estimated 30,000 to 50,000-ft deep. A hot-rock strata would first be fractured by high pressure water or an explosion. Surface water would be injected into the fissured rock, heated, and returned to the surface where the energy would be utilized for power generation or heating. A number of technical problems remain to be solved before the feasibility of the idea can be tested.

APPENDIX G

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550



January 17, 1973

Honorable Harrison A. Williams, Jr.
Chairman, Committee on Labor
and Public Welfare
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Reference is made to my letter of November 22 and my letter of November 3 to Senator Kennedy, Chairman, Special Subcommittee on the NSF, Committee on Labor and Public Welfare (copies attached) which proposed reprogramming actions within the NSF 1973 Authorization Act line items to accommodate three aircraft approved by the Congress and also to provide an up-to-date report on program funding actions taken and planned by the National Science Foundation.

It has been brought to my attention by a staff member of the Committee on Science and Astronautics, that the adjustment of \$7,240,000 transferred from the line item for Computing Activities to the National and Special Research Programs to partially cover the authorization of three aircraft approved by the Congress subsequent to passage of the Authorization Act left insufficient authorization to accommodate a subsequent transfer of the Computer Innovation in Education Program in the amount of \$6,800,000 to the line item for Science Education Improvement.

The reprogramming actions indicated in my letter of November 22 included a proposal by the Foundation to use \$7,240,000 authorized for the Foundation's Computing Activities Program to cover part of the authorization required to purchase three aircraft for the U.S. Antarctic Research Program. Funds for the purchase of the aircraft were appropriated as a part of the FY 1973 Supplemental Appropriation Act (P.L. 92-607). This adjustment in the Computing Activities item was considered possible at that time because the amount to be allocated by NSF for this program was substantially below the amount authorized due to a transfer of the Computer Innovation in Education portion of the Computing Activities Program to the Science Education Improvement Program. The objectives of the Computer Innovation in Education Program fit more logically under the Science Education Improvement Program. The basic thrust is to increase the effectiveness of science education through the use of new technology. This action resulted in the transfer of \$6,800,000 from the Computing Activities line item to the Science Education Improvement Activity. There was no change in the content or the objective of the Computer Innovation in Education Program. The transfer was made to facilitate better program management.

- 2 -

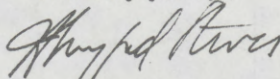
Since there was sufficient authorization in the Science Education Improvement Activity to cover the increase of \$6,800,000 without exceeding the 10 percent flexibility provision in the Authorization Act, the Foundation did not include a transaction that would reduce the Computing Activities authorization amount by \$6,800,000 and increase the Science Education Improvement Activity by a like amount to cover the transfer of program responsibility.

We have now been informed by a member of the staff of the House Committee on Science and Astronautics that to make the record clear it will be necessary to make this adjustment in the amounts authorized for Computing Activities and Science Education Improvement.

Attached is a revised Table II which reflects necessary actions in the various line items of the authorization and provides for a transfer in the authorization amount of \$6,800,000 from Computing Activities into the Science Education Improvement activity and a concurrent transfer of \$7,240,000 from the Science Education Improvement activity into the National and Special Research Programs to cover the authorization formerly transferred from Computing Activities to partially cover the authorization total needed for the aircraft.

Although, the net result is essentially the same as originally requested, I feel that the proposed action more clearly reflects the Foundation's intent. I will advise you of any future adjustments to the plan that may become necessary during the course of the year in concurrence with the provisions of the FY 1973 Authorization Act.

Sincerely yours,



H. Gayford Stever
Director

Attachments

Copy to Honorable Edward M. Kennedy

NATIONAL SCIENCE FOUNDATION

Comparison of FY 1973 Operating Plan
With Funds Authorized and Appropriated
(in thousands of dollars)

	Authorization, Act P.L. 92-372 (1)	Adjustment for Aircraft (2)	Adjustment for Computer Innovation in Education Program (3)	Proposed Authorization by Activity (4)	Appropriation Act P.L. 92-383 (5)	Operating Plan Based on Appor- tionment Request and Including Three Aircraft (6)
Scientific Research Project Support	\$275,300			\$275,300		\$261,210
National & Special Research Programs	108,600	\$+14,710 <u>2/</u>		123,340		123,340
Oceanographic Ship Construction/Conversion	(4,500)(M)					
National Research Centers	42,300			42,300		41,300 <u>2/</u>
Computing Activities	19,500		-6,800	12,700		11,700
Science Information Activities	9,500			9,500		10,450
International Cooperative Research Applied to National Needs	4,700			4,700		4,700
Scientific Activities	87,500	-7,500		80,000		70,000
Energy Research and Technology	(19,500)(M)					
Earthquake Engineering	(8,000)(M)					
Intergovernmental Science Program	1,700			1,700		1,000
Institutional Improvement for Science	18,500					
Minimum limitation of above	(13,000)(M)			18,500	(\$18,000)(M)	18,000
Maximum for Research Management Improvement Grants of \$13M above	(4,000)(L)					
Graduate Student Support	21,200			21,200	(20,000)(M)	20,000
Minimum limitation	(16,500)(M)					
Graduate Fellowships	(13,000)(M)					
Postdoctoral Fellowships	(3,500)(M)					
Science Education Improvement	76,000	-7,240	+6,800	75,560	(71,000)(M)	77,800
Supplementary Training for Secondary School Teachers						
Minimum limitation of \$76M above	(74,000)(M)				(23,300)(M)	(23,300)
Experimental projects to encourage new initiatives (of \$74M above)	(1,500)(L)					

NATIONAL SCIENCE FOUNDATION

Comparison of FY 1973 Operating Plan
With Funds Authorized and Appropriated
(in thousands of dollars)

	Authorization Act P.L. 92-372 ¹ (1)	Adjustment for Aircraft (2)	Adjustment for Computer Innovation in Education Program (3)	Proposed Authorization by Activity (4)	Appropriation Act P.L. 92-383 (5)	Operating Plan Based on Appor- tionment Request and including Three Aircraft (6)
Planning and Policy Studies	\$ 2,800			\$ 2,800		\$ 2,000
Program Development and Management	29,300			29,300	(\$28,900)(L)	28,900
Subtotal S&E Appropriation	696,900			696,900	619,000	670,400
Special Foreign Currency Appropriation	7,000			7,000	7,000	7,000
TOTAL	<u>703,900</u>	<u>-0-</u>	<u>-0-</u>	<u>703,900</u>	<u>626,000</u>	<u>677,400 ^{3/4/}</u>

L = Limitation (Maximum) M = Minimum

^{1/} This \$14,740 plus \$5.0M already available in this line item provides up to \$19,740 for Antarctic Aircraft.^{2/} Reflects transfer of Computer Innovation in Education Program (\$6.8), from Computing Activities in Education and Research to Science Education Improvement.^{3/} Includes release of all OMB Reserves for general purposes of appropriation.

^{4/} Source of Total

SAE Appropriation	\$619,000
Special Foreign Currency Approp.	7,000
1972 Unobligated Funds	460
Release of OMB Reserve	31,200
Three Antarctic Aircraft	<u>19,740</u>
	<u>677,400</u>

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

nsf

November 22, 1972

OFFICE OF THE
DIRECTOR

Honorable Harrison A. Williams, Jr.
Chairman, Committee on Labor and
Public Welfare
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

The purpose of this letter is to provide you with an up-to-date report on the status of program funding actions taken and planned by the National Science Foundation. These actions reflect the results of FY 1973 Authorization and Appropriation Acts passed by the Congress and apportionment action taken by the Office of Management and Budget.

The allocation of funds to the major activities of the Foundation has been influenced significantly by the fact that the Foundation's appropriations for 1973 were \$77.9 million below the amount authorized. Another significant factor is the treatment of funds carried forward from prior years, that totaled \$31,660,000. Of these funds, \$30,500,000 had been previously earmarked for science education and institutional science programs. The FY 1973 Appropriation Act made these funds available for the general purposes of the NSF appropriation. This action by the Congress has permitted the NSF to offset, to some degree, the differences between the amount appropriated and the amount authorized. The minimums established for Science Education, Institutional, and Graduate Student Support programs were more than \$13 million above the amounts requested for these programs. This fact coupled with the net reduction of \$18.5 million in our program request meant that more than \$31 million in reductions had to be made in NSF science support activities to accommodate the minimums and appropriation reductions imposed by the Congress.

In order to accommodate the appropriation cut and the minimums established by the Congress, certain adjustments in other programs had to be made. As Table I shows, Scientific Research Project Support has been cut by about \$14.0 million, National and Special Research Programs by \$5.7 million, and Research Applied to National Needs by \$8.8 million below the program levels that were included in NSF budget request to Congress in order to accommodate the reductions in the

appropriation and to meet increased minimum limitations above the amounts requested by NSF. In making these adjustments, the Foundation has taken the interests of the Congressional committees into account insofar as possible within the funding available.

As you know, since the Foundation's Authorization and Appropriation Acts were passed, the Congress has deleted from the budget of the Department of Defense funds requested for the purchase of aircraft needed for logistic support of the NSF-managed U. S. Antarctic Research Program. In recommending this action, the Appropriations Committees of both the House and the Senate recognized the need to replace obsolete aircraft that are now being used in support of the Antarctic program but felt that NSF should finance them since the Foundation has been given full responsibility for funding and managing the U. S. research program in the Antarctic. Therefore, it was necessary for NSF to request a supplemental appropriation for FY 1973 to fund the purchase of these aircraft. The supplemental appropriation which included \$19,740,000 for the purchase by NSF of three C-130 type aircraft for the Antarctic program was signed by the President on October 31, 1972. Reprogramming actions necessary to accomplish the purchase of the aircraft under the Foundation's line item Authorization Act for FY 1973 are shown separately in Table II. (Attachment 2).

Funding allocations to the major activities of the Foundation were developed within the following constraints:

I. Congressional Action -

Appropriation Action

The FY 1973 Appropriation Act established minimums as follows:

Institutional Improvement for Science.....\$18.0M
(Including \$4 million for a program of institutional grants for research management improvement)

Graduate Student Support.....\$20.0M

Science Education Improvement.....\$71.0M
(Including not less than \$23.3M for program of supplementary training for secondary school science and mathematics teachers)

These minimums exceeded the amounts requested in the President's budget for these activities by a total of \$13.0 million.

\$28.9 million for program development and management which covers management and administration costs of operating the Foundation.

Authorization Action

The FY 1973 Authorization Act established minimums for use of authorization authority as follows:

National and Special Research Programs - Within a total of \$108.6 million, not less than \$4.5 million is for the oceanographic ship construction/conversion program.

Research Applied to National Needs - Within a total of \$87.5 million, not less than \$19.5 million is for energy research and technology and \$8.0 million for earthquake engineering.

Institutional Improvement for Science - Within a total of \$18.5 million, not less than \$13.0M is for this purpose. In addition, within the minimum of \$13.0 million, not more than \$4.0 million may be used for Institutional Grants for Research Management Improvement.

Graduate Student Support - Of the total of \$21.0 million, not less than \$16.5 million is for this purpose. Of the \$16.5 million, \$13.0 million is specified for Graduate Fellowships and \$3.5 million for Post-Doctoral Fellowships.

Science Education Improvement - Of the total of \$76.0 million, not less than \$74.0 million is for this purpose, and of this amount, not more than \$1.5 million for experimental projects to encourage initiatives in Science Education.

II. OMB Action -

In late August, 1972, NSF requested apportionment of all funds appropriated by the Congress. OMB apportioned all but \$93,450,000 which was reserved pending receipt of additional information from NSF. The attached tables show the NSF program plan for FY 1973 based on our apportionment requests.

To the extent possible, within the funds appropriated, NSF plans increased emphasis in the areas specified by the

Authorization Act. In some cases full compliance is not possible because of the appropriation reductions below the Authorization Act already noted.

The following specific actions have been taken in an attempt to comply within the funds made available by the Congress:

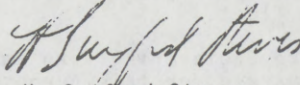
- Ship Construction - An amount of \$2.8 million has been allocated for this function to permit the Foundation to proceed with its program to modernize the academic research fleet.
- Earthquake Engineering - An amount of \$6.1 million has been earmarked for this purpose or more than \$1.0 million above the FY 1972 program.
- Energy Research & Technology - The Foundation is increasing its Energy Research & Technology program under RANN by \$3.8 million for a total of \$12.7 million in FY 1973.
- Graduate Student Support - The minimum of \$20.0M established by Congress for this program is \$6.0M more than the amount requested by NSF. The increased funds are expected to be used to provide productive research training for graduate students on environmental, technological, economic and other problems of national concern.
- Science Education Improvement - The minimum of \$71.0 million established for this program by the Congress is \$1.0 million above the NSF request. The additional funds will be used for education programs focused on selected science education problems. In addition, the Foundation has transferred its Computer Innovation in Education function to the Science Education Program in order to consolidate the Foundation's education efforts. This resulted in a transfer of \$6.8 million in funding and program responsibilities to the Education Directorate, bringing the total for Science Education Improvement to \$77.8 million. It does not reflect any change in the program as proposed to the Congress.

In addition to the program transfer of Computer Innovation in Education mentioned above, the Foundation has reprogrammed \$950,000 into Science Information Activities. The Foundation's FY 1973 budget included a very constrained program for Science Information activities. There is an urgent need to identify science information user needs. The results of these efforts should provide the basis for designing or modifying computerized science information systems to meet specific user

requirements rather than attempting to process all of the available science data in a given field.

Column 5 of Table II is the baseline operating plan for FY 1973. We will advise you of any further adjustments to that plan that may become necessary during the course of the year, in accordance with the provisions of the FY 1973 Authorization Act.

Sincerely,



H. Gustaf Stever
Director

Attachments

TABLE I

HATCHMAN, SCIENCE FOUNDATION

FY 1973 PROGRAM PLAN
(In thousands of dollars)

	Authorization (P.L. 92-372) (1)	Appropriation (P.L. 92-383) (2)	Available Carryover Distributed (3)	NSF Adjusted FY 1973 (4)	NSF Prog. as Submitted to Congress (5)
<u>Salaries and Expenses Appropriation</u>					
<u>Scientific Research Project</u>					
Support	\$275,300			\$261,210	275,300
National & Special Research					
Programs	108,600			103,600	109,300
National Research Centers	42,300			41,300	42,300
Computing Activities	18,500			11,700	20,500
Science Information Activities	9,500	\$481,100		10,450	9,500
International Coop. Scientific					
Activities	4,700		\$51,660	4,700	4,700
Research Applied to National Needs	87,500			70,000	78,775
Intergovernmental Science Program	1,700			1,000	1,000
Planning & Policy Studies	2,800			2,000	2,500
Institutional Improvement for					
Science	18,500	18,000(M)		18,000	12,000
Graduate Student Support	21,200	20,000(M)		20,000	14,000
Science Education Improvement	76,000	71,000(M)		77,800	70,000
Program Development & Management	29,300	28,900(L)		28,900	29,243
Subtotal, Salaries & Expenses					
Appropriation	696,900	619,000	31,660	650,660	669,118
Special Foreign Currency Approp.	7,000	7,000	-0-	7,000	7,000
TOTAL	703,900	626,000	31,660	657,660	676,118

M = Minimum funding prescribed by P.L. 92-383

L = Limitation (maximum) prescribed by P.L. 92-383

1/ Reflects transfer of Computer Innovations in Education program (\$6,900,000) from Computing Activities to Science Education Improvement.

2/ Prior to inclusion of funds for three aircraft.

NATIONAL SCIENCE FOUNDATION

Comparison of FY 1973 Operating Plan
With Funds Authorized and Appropriated
(in thousands of dollars)

	Authorization Act P.L. 92-372 (1)	Adjustment for Aircraft (2)	Proposed Authorization by Activity (3)	Appropriation Act P.L. 92-383 (4)	Operating Plan Based on Appropria- tion Request and including 3 Air (5)
Scientific Research Project Support.....	\$275,300		\$275,300		\$261,210
National & Special Research Programs.....	108,600	\$14,740	123,340		123,340
Oceanographic Ship Construction/Conversion	(4,500)(M)				
National Research Centers.....	42,300		42,300		41,300
Computing Activities.....	19,500	- 7,240	12,260		11,000
Science Information Activities.....	9,500		9,500		10,450
International Cooperative Scientific Activities.....	4,700		4,700		4,700
Research Applied to National Needs.....	87,500	- 7,500	80,000		70,000
Energy Research and Technology.....	(19,500)(M)				
Earthquake Engineering.....	(8,000)(M)				
Intergovernmental Science Program.....	1,700		1,700		1,000
Institutional Improvement for Science.....	18,500		18,500		18,000
Minimum limitation of above...	(13,000)(M)			(\$18,000)(M)	
Maximum for Research Management Improvement Grants of \$13M above.....	(4,000)(L)				
Graduate Student Support.....	21,200		21,200		20,000
Minimum limitation.....	(16,500)(M)				
Graduate Fellowships.....	((13,000)(M)				
Postdoctoral Fellowships...	((3,500)(M)				
Science Education Improvement...	76,000		76,000	(71,000)(M)	77,800

TABLE II

NATIONAL SCIENCE FOUNDATION

Comparison of FY 1973 Operating Plan
With Funds Authorized and Appropriated
(in thousands of dollars)

	Authorization Act P.L. 92-372 (1)	Adjustment for Aircraft (2)	Proposed Authorization by Activity (3)	Appropriation Act P.L. 92-383 (4)	Operating Plan Based on Appropria- tion Request and including 3 Aircraft (5)
Supplementary Training for					
Secondary School Teachers...					
Minimum limitation of	(74,000)(M)				(23,300)
\$76M above.....					
Experimental projects to					
encourage new initiatives	(1,500)(L)		2,800		2,000
(of \$76M above).....	2,800				
Planning and Policy Studies....	29,300		29,300	(28,900)(L)	28,900
Program Development and	696,900		696,900	619,000	670,400
Management.....					
Subtotal NSF Appropriation....	7,000		7,000	7,000	7,000
Special Foreign Currency	703,900	-0-	703,900	626,000	677,400
Appropriation.....					
TOTAL					

M = Limitation (Maximum) M = Minimum

/ This \$14,740 plus \$5.0M already available in this line item provides up to \$19,740 for Antarctic Aircraft..

/ Reflects transfer of Computer Innovation in Education Program (\$6.8), from Computing Activities in Education and Research to Science Education Improvement.

/ Includes release of all OMB Reserves for general purposes of appropriation.

/ Source of Total
 NSF Appropriation.....\$419,000
 Special Foreign Currency Approp..... 7,000
 1972 Unobligated Funds..... 460
 Release of OMB Reserve..... 31,200
 3 Antarctic Aircraft..... 19,740
 677,400

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

nsf

OFFICE OF THE
DIRECTOR

NOV 3 1972

Honorable Edward M. Kennedy
Chairman, Special Subcommittee on
the NSF
Committee on Labor and Public Welfare
U. S. Senate
Washington, D.C. 20510

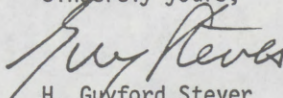
Dear Mr. Chairman:

On behalf of the Foundation's Antarctic program, I wish to express my thanks for your support of the Foundation's request for the C-130 aircraft in the Supplemental Appropriation bill for 1973.

Although we did not receive all five of the planes requested, the three to which the Congress did agree will enable us to keep the program functioning without taking immediate steps to shut down any of our inland bases.

By my letter of October 12, 1972, to the Chairman, Committee on Labor and Public Welfare (of which you received copies) I transmitted a table indicating reprogramming requirements necessary to provide four aircraft for Antarctic Logistic Support. As a result of Conference Committee action on the Supplemental Appropriation bill, the number of aircraft approved for the Foundation was reduced to three at a total cost of \$19,740,000. Attached is a revised table indicating reprogramming actions needed to provide for three aircraft rather than four.

Sincerely yours,


H. Guyford Stever
Director

Attachment

NATIONAL SCIENCE FOUNDATION
Comparison of FY 1973 Budget Request
With Funds Authorized
(in thousands of dollars)

	NSF Budget Request	Authorization Act P.L. 92-372	Adjustment for Aircraft	Proposed Authorization by Activity (R)
Scientific Research Project Support	\$274,600	\$275,300	-	\$275,300
National & Special Research Programs ..	109,300	108,600	\$ +14,740 *	123,340
Oceanographic Ship Construction, Conversion		(4,500) (M)	-	42,300
National Research Centers	42,300	42,300	-	42,300
Computing Activities in Education and Research	20,500	19,500	- 7,240	12,260
Science Information Activities	9,500	9,500	-	9,500
International Cooperative Scientific Activities	4,700	4,700	-	4,700
Research Applied to National Needs	78,775	87,500	- 7,500	80,000
Energy Research and Technology		(19,500) (M)		
Earthquake Engineering		(8,000) (M)		
Intergovernmental Science Program	1,000	1,700	-	1,700
Institutional Improvement for Science ..	7,000	18,500	-	18,500
Minimum limitation of above		(13,000) (M)		
Grants for Research Management Improvement of \$13.0 above		(4,000) (L)		
Graduate Student Support	9,200	21,200	-	21,200
Minimum limitation		(16,500) (M)		
Graduate Fellowships		((13,000)) (M)		
Postdoctoral Fellowships		((3,500)) (M)		
Science Education Improvement	58,800	76,000	-	76,000
Supplementary Training for Secondary School Teachers	(23,300)	(74,000) (M)		
Minimum limitation of \$76M		(1,500) (L)		
Experimental projects to encourage new initiatives (of 74.0M above)	2,500	2,800	-	2,800
Planning and Policy Studies	29,243	29,300	-	29,300
Program Development and Management	647,418	696,900	-	696,900
Subtotal S&E Appropriation	7,000	7,000	-	7,000
Special Foreign Currency Appropriation ..			-0-	
Total	654,418	703,900		703,900
Proposed Release of OMB 1972 Reserve ..	21,700			
TOTAL proposed 1973 NSF Program	676,118			

L=Limitation (Maximum) M=Minimum R=Recommendation

* This \$14,740 plus \$5.0M already available in this line item provides up to \$19,740 for Antarctic Aircraft.

APPENDIX H

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550



OFFICE OF THE
DIRECTOR

February 15, 1973

Honorable Edward M. Kennedy
Chairman, Special Subcommittee on
the NSF
Committee on Labor and Public Welfare
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

This letter is submitted in accordance with Section 6 of the National Science Foundation Authorization Act, P.L. 92-372. The purpose of this letter is to complete re-programming of a number of line items within the National Science Foundation's Authorization Act of 1973. Adjustments to the original Act were necessary primarily to provide authorization for acquisition of aircraft (provided in the first Supplemental Appropriation Act of 1973, October 31, 1972, and not contained in the NSF Authorization Act of 1973, August 14, 1972).

By the following letters I provided proposed line item adjustments within the authorization total to provide authorization for C-130 Antarctic research support aircraft.

- October 10, 1972 -- adjustments for five aircraft requested in the first Supplemental Appropriation Bill for 1973 (\$32,900,000)
- October 11, 1972 -- revised adjustments for four aircraft as approved by the House (\$26,320,000)
- November 2, 1972 -- revised adjustments for three aircraft as appropriated (\$19,740,000)

On November 21, I sent you a letter which provided an up-to-date report on the status of the authorization amounts and also of the appropriated funds planned against those amounts for Fiscal Year 1973 by the National Science Foundation. In subsequent

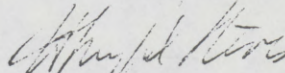
conversations with the House Science and Astronautics Committee staff and staff of the Special Subcommittee on the NSF of the Senate Committee on Labor and Public Welfare it was indicated to my staff that the administrative transfer of the sub-category Computer Innovation in Education Program from the Computing Activities line item into Science Education Improvement must be accompanied by an authorization amount transfer of \$6.8 million. In order to satisfy this requirement I sent a letter to the Chairman of that Committee dated January 17, 1973, in which I made adjustments within the authorization line items which seemed to be indicated or necessary.

Following receipt of my January 17 letter, however, staff of the House Science and Astronautics Committee, in telephone conversations with members of my staff, said that, by letter from Chairman Miller dated October 13, 1972, approval had already been given to transfer \$7.2 million for partial authorization coverage of the aircraft from the Computing Activities line item. This amount plus the "automatic" transfer of \$6.8 million in the administrative transfer to the Science Education Improvement line item leaves only an authorization amount of \$5.46 million in Computing Activities, an amount insufficient for the planned program in that activity.

This letter provides the necessary adjustments to correct the deficiency based on the new understanding expressed by the staff of the House Science and Astronautics Committee. Our current understanding of the transactions to date is shown in the attached table. Column two of the attached table shows the adjustments to the original Authorization Act (Column one) as recorded and approved by the House Science and Astronautics Committee to a revised authorization shown in Column three. Column four indicates the further adjustments needed to provide authorization for the aircraft and Computing Activities and to maintain the intent of the Act. Column five reflects the proposed adjusted authorization by line item.

I will be happy to provide any additional information which you may desire.

Sincerely yours,



H. Guyford Stever
Director

Attachment

NSF AUTHORIZATION ACT OF 1973
(As adjusted)

(In Millions of Dollars)
FY 1973 AUTHORIZATION

	Auth. Per P.L. 92-372 (1)	House Authorization Committee Acknowledged Adjustments to Col. 1 (2)	Revised Amount (3)	Further Adjustments Needed (4)	Adjusted Authorization (5)
Scientific Research Pro- ject Support	275.30		275.30	-6.29	269.01
Natl. & Special Research Programs	108.60	+ 14.74	123.34	+1.70	125.04
Ship Construction/ Conversion	(4.50)		(2.80)	(1.70)	(4.50)
Aircraft Procurement ...	NA		NA		NA
National Research Centers.	42.30		42.30	- .60	41.70
Computing Activities	19.50	- 14.04	5.46	+6.24	11.70
Computing Innovation in Education	-	* - 6.80	-	-	-
Other		* - 7.24			
Science Information Activities	9.50		9.50	+1.00	10.50
International Coop Scientific Activities ...	4.70		4.70		4.70
RAVN	87.50	- 7.50	80.00		80.00
Energy Research and Technology	(19.50)		(19.50)		(19.50)
Earthquake Engineering.	(8.00)		(8.00)		(8.00)
Intergovernmental Science	1.70		1.70		1.70
Instnl. Improvement for Science	18.50		18.50		18.50
Instnl Improvement for Science	(13.00)		(13.00)		(13.00)
Instnl. Grants for Res. Mgt. Improv.	Max([4.00])		Max ([4.00])		Max ([4.00])
Graduate Student Support.	21.20		21.20		21.20
Graduate Student Support	(16.50)		(16.50)		(16.50)
Graduate Fellowships .	((13.00))		((13.00))		((13.00))
Postdoctoral Fellow- ships	((3.50))		((3.50))		((3.50))
Traineeships	-		-		-
Science Education Improve- ment	76.00	+ 6.80	82.80	-2.00	80.80
Science Education Improvement	(74.00)		(74.00)		(74.00)
Exp. Proj. to Encourage Init. in Sci. Ed.	Max([1.50])		Max ([1.50])		Max ([1.50])
Computer Innovation in Education	NA	* + 6.80	* (6.80)		* 6.80
Planning and Policy Studies	2.80		2.80	-0.05	2.75
Program Development & Management	29.30		29.30		29.30
Subtotal, S&E Approp.	696.90	-0-	696.90	-0-	696.90
Special Foreign Currency Appropriation	7.00	-0-	7.00	-0-	7.00
TOTAL, NSF	703.90	-0-	703.90	-0-	703.90

Explanation of Symbols:

{ } = Minimum specified in Authorization Act.
 { } = Minimum specified within a minimum.
 [] = Maximum specified within a minimum.
 * = Non-Add amount.

APPENDIX I

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550



OFFICE OF THE
DIRECTOR

March 20, 1973

Honorable Edward M. Kennedy
Chairman, Special Subcommittee
on the National Science Foundation
Committee on Labor and Public Welfare
United States Senate
Washington, D.C. 20510

Dear Senator Kennedy:

This is in reference to Congressman Davis' letter of January 26 concerning program item authorization minima contained in the FY 1973 authorization legislation for the National Science Foundation (P.L. 92-372). As you know, NSF's FY 1973 appropriation legislation (P.L. 92-383) also contained program line item minima with respect to the dollars appropriated. The minima in both bills are in addition to the major budget activity maxima with some program flexibility contained in the authorization bill and other minima and maxima amounts contained in both the authorization and appropriations bills. This has been a very difficult and complicated matter to handle especially since the total appropriated dollars were significantly less than the total amount provided in the authorization legislation.

In the absence of our ability to find clear and unambiguous ground rules governing this type of programming situation, we at the National Science Foundation in programming FY 1973 appropriated monies followed the interpretation that the last piece of legislation passed by the Congress, in this case the appropriations bill, should prevail. In observing this protocol, and since the minima in the appropriation legislation are different from those in the authorization legislation, we did, as Congressman Davis observed in his letter, not program actual dollars to cover all of the minima indicated in the Authorization Act. However, as shown in the attached table, we are providing for all of the appropriation minima, and, all of the authorization minima except one--ship construction of \$4.5 million.

The latter would require an adjustment to the President's FY 1974 budget request now before you. Parenthetically, as you probably know, several federally-owned oceanographic research vessels are being inactivated at the present time; and therefore, the Foundation believes that a study of the oceanographic research vessel situation should be undertaken prior to a decision to construct any new oceanographic vessels. Attached is an analysis of the impact of FY 1973/1974 budget reductions on the Federal Fleet.

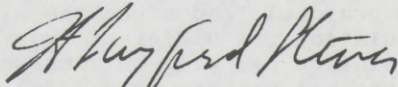
However, despite the status of oceanographic ships, it is our desire that the wishes of you and your Committee be carried out to the fullest extent possible consistent with the President's program. Therefore, after receiving Congressman Davis' letter, my staff met with Mr. Mottur of your staff and the staff of the House Committee and obtained their views on possible actions. Based on these discussions, I submitted a request to the Office of Management and Budget to reprogram our FY 1973 apportionment request. The purpose of this reprogramming request was to provide for actual funding in appropriated monies for all the items (minima) which Congressman Davis expressed in his January 26 letter should be funded.

I feel that you and the Committee members should know that I made this request to the Office of Management and Budget, discussed it with officials of OMB personally and that there were subsequent staff discussions. However, OMB subsequently advised the Foundation that no change would be made in the President's budget request. The attached table is based on that decision.

Information contained in the attached table has been discussed in formal hearings beginning on February 27, 1973, before the Subcommittee on Science, Research and Development of the House Committee on Science and Astronautics. It was also discussed in formal hearings on March 14, 1973, before the HUD-Space-Science-Veterans Subcommittee of the House Committee on Appropriations.

Let me thank you for your assistance to the Foundation and the assistance provided to us by your staff in this matter.

Sincerely yours,



H. Guyford Stever
Director

Attachments

Impact of FY 73/74 Budget Reductions on Federal Fleet

A. Operations Support

The attached table gives the detailed information on probable ship lay-ups.

In brief:

- Academic fleet - likely to lose 7 ships in FY 74
- NOAA (Ocean Survey) - loses 2 ships in FY 74
- NOAA (Marine Fisheries) - loses 4 ships in FY 73/74
- NSF - loses 1 ship in FY 73/74
- USCG - dropping 7 ocean station ships
- USN - no outright lay-ups

B. Construction Support

The following ships funded prior to FY 1973 are under construction:

Navy:	AGOR - 21	<u>Due for completion</u>
	AGOR - 22	August '73
		October '73
NSF:	OCEANUS (WHOI)	Fall '74
Coast Guard:	Two icebreakers	July '75 & '76

No construction being funded in FY '73 or planned for FY '74

Attachment

Impact of FY 73/FY 74 Budget Reductions on Federal FleetAcademic Fleet

Anticipate lay-up or phasing out of 7 ships ranging in size from 65 ft. to 213 ft. owing to shortfall of \$2.5 - 3.0 million in support funds from all sources.

NOAA-Ocean Survey

Ship	Age	Length	Status
DISCOVERER	7	303	Going out of service late in FY 73; out of service FY 74
SURVEYOR	13	292	Going out of service late in FY 73; out of service FY 74

NOAA-National Marine Fisheries Service

CROMWELL	10	158	Going out of service late in FY 73; out of service FY 74
DELAWARE II	5	156	Going out of service late in FY 73; out of service FY 74
GILBERT	21	123	Being permanently disposed of in FY 74
KELEZ	29	177	Decommissioned in FY 73. Permanently out owing to shortage of funds FY 73 and FY 74.

NSF

ELTANIN	16	266	Out of service mid FY 73; no funds for FY 74
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USCG

Loss of 7 ocean station ships through permanent lay-up late in FY 73, during or at end of FY 74. (Reduction from 26 to 19 ocean station ships.)

USN

No out-right lay-ups

USNS HAYES to be out of service most of FY 74 (extended yard period to save operating money)
 USNS SANDS } funding uncertain in FY 74 as in FY 73
 USNS LEE }

Federal Fleet Size in FY 1972

No. of ships reported	90
Minus	
No. of Ships "temporarily" out of service	- 4
Minus	
No. of ships replaced during year	<u>- 3</u>
Net operational fleet size	83

Federal Fleet Changes - FY 72-74

<u>Agency</u>	<u>No. of Operational Ships - FY 72 (Net)</u>	<u>No. of Operational Ships - FY 73 (Net)</u>	<u>No. of Operational Ships - FY 74 (Net)</u>	<u>Difference</u>	
				<u>73/74</u>	<u>72/74</u>
ACADEMIC	33	32	25	- 7	- 8
NOAA					
NOS	14	13	11	- 2	- 3
NMFS	9	10	6	- 4	- 3
NSF	2	2	1	- 1	- 1
USCG	9 (30)	9 (26)	9 (19)	0 (- 7)	0 (- 11)
USN	16	16	16	0	0
	83 (30)	82 (26)	68 (19)	-14 (- 7)	-15 (- 11)

() indicates USCG ocean station ships

FY 74 Status of Non-operating Ships
(Projected)

AGENCY	TEMPORARILY OUT OF SERVICE	PERMANENTLY DISPOSED OF
ACADEMIC FLEET		*GERDA (22) PROTEUS (26)
NOAA	1-2 ships (being negotiated)	5-6 ships
NOS	DISCOVERER (7) SURVEYOR (13)	PATHFINDER (31)
NMFS	CROMWELL (10) DELAWARE II (5) ** FREEMAN (6)	**DOLPHIN (18) **GILBERT (21) KELEZ (29)
NSF	ELTANIN (16)	**ROCKAWAY (31)
USCG		*KELLAR (3) *KEATHLY (27)
USN		

Total - 7-8 Ships

14-15 Ships

() indicates age

** Temporarily out of service in FY 72

* Replaced

NATIONAL SCIENCE FOUNDATION

Budgetary Financing Providing Maximum
Available Funding of FY 1973 Authorization Minima

	1	2	3	4	5
	FY 1973	C/O	'74	C/O	
	Orig. Col.	to '74	NOA	Total	to '75
	Total				
Sci. Res. Proj. Supp.	261.00	-0-	275.00	275.00	-0-
National & Special	114.74	-0-	99.60	99.60	-0-
Ship/Conv.	-0-	(-0-)	(-0-)	(-0-)	-0-
Nat. Res. Cen.	39.54	2.00	46.00	48.00	-0-
Computing Act.	10.00	.90	9.10	10.00	-0-
Science Info.	8.30	-0-	8.30	8.30	-0-
International Coop	4.70	-0-	6.20	6.20	-0-
RANN	70.00	8.70	70.50	79.20	-0-
Energy	(12.70)	(6.80)	(13.90)	(20.70)	-0-
Earthquake	(6.10)	(1.90)	(5.10)	(7.00)	-0-
Intergvt. Science	1.00	-0-	1.00	1.00	-0-
Institutional	9.00	9.00	-0-	9.00	-0-
Graduate Students	14.00	-2.50	6.70	9.20	3.5
Science Education Imp.					
Computer Inno.	(5.95)	(.85)	(6.15)	(7.00)	-0-
Science Education	(41.05)	(32.95)	(20.05)	(53.00)	-0-
Subtotal Sci. Ed.	47.00	33.80	26.20	60.00	-0-
Planning & Policy	2.00	-0-	2.00	2.00	-0-
PD&M	28.72	-0-	29.00	29.00	-0-
Total	610.00	56.90	579.60	636.50	3.5
F/C	5.00	2.00	3.00	5.00	-0-
TOTAL	615.00	58.90	582.60	641.50	3.5

