S. HRG. 116–340

INTERNATIONAL EFFORTS TO INCREASE ENERGY EFFICIENCY AND OPPORTUNITIES TO ADVANCE ENERGY EFFICIENCY IN THE UNITED STATES

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED SIXTEENTH CONGRESS

FIRST SESSION

OCTOBER 22, 2019

Printed for the use of the
Committee on Energy and Natural Resources

Available via the World Wide Web: http://www.govinfo.gov

U.S. GOVERNMENT PUBLISHING OFFICE
39–883 WASHINGTON : 2021

COMMITTEE ON ENERGY AND NATURAL RESOURCES

LISA MURKOWSKI, Alaska, *Chairman*

JOHN BARRASSO, Wyoming
JAMES E. RISCH, Idaho
MIKE LEE, Utah
STEVE DAINES, Montana
BILL CASSIDY, Louisiana
CORY GARDNER, Colorado
CINDY HYDE-SMITH, Mississippi
MARTHA MCSALLY, Arizona
LAMAR ALEXANDER, Tennessee
JOHN HOEVEN, North Dakota

JOE MANCHIN III, West Virginia
RON WYDEN, Oregon
MARIA CANTWELL, Washington
BERNARD SANDERS, Vermont
DEBBIE STABENOW, Michigan
MARTIN HEINRICH, New Mexico
MAZIE K. HIRONO, Hawaii
ANGUS S. KING, JR., Maine
CATHERINE CORTEZ MASTO, Nevada

BRIAN HUGHES, *Staff Director*
KELLIE DONNELLY, *Chief Counsel*
CHESTER CARSON, *Senior Professional Staff Member*
SPENCER NELSON, *Professional Staff Member*
SARAH VENUTO, *Democratic Staff Director*
SAM E. FOWLER, *Democratic Chief Counsel*
BRIE VAN CLEVE, *Democratic Senior Professional Staff Member*

CONTENTS

OPENING STATEMENTS

WITNESSES

ALPHABETICAL LISTING AND APPENDIX MATERIAL SUBMITTED

INTERNATIONAL EFFORTS TO INCREASE ENERGY EFFICIENCY AND OPPORTUNITIES TO ADVANCE ENERGY EFFICIENCY IN THE UNITED STATES

TUESDAY, OCTOBER 22, 2019

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The Committee met, pursuant to notice, at 10:08 a.m. in Room SD–366, Dirksen Senate Office Building, Hon. Lisa Murkowski, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

The CHAIRMAN. Good morning, everyone. The Committee will come to order.

Today is all about efficiency.

Back in May, we met to examine opportunities to advance renewable energy and energy efficiency here in the United States, and today we are going to take that just a step further to look at the efforts to increase efficiency internationally and what best practices we can potentially utilize here at home.

Efficiency is a key ingredient to good energy policy. As we work to make energy more affordable, I think the first place we should look is to ensure that we are using energy in the best and the most efficient way. By reducing energy use, we reduce energy costs which matters to every family and business. We can improve reliability through technologies that reduce load when demand is high, lessening the likelihood of brownouts or blackouts. Efficiency, of course, can also play a major role in reducing greenhouse gas emissions by reducing energy consumption. So whether we are talking about impacting the lives of low-income and rural communities, or ways to address the impacts of climate change, energy efficiency is a big piece of that puzzle.

I am pleased that we have Dr. Brian Motherway, the Head of Energy Efficiency at the International Energy Agency (IEA), joining us this morning. IEA has placed an increased focus on efficiency. I was pleased to be asked to be an honorary member of their new Global Commission for Urgent Action on Energy Efficiency, and that is something that I thank you for this opportunity but again to focus on not only what we are doing but best practices globally.

We all know that efficiency presents an amazing opportunity, but really, we know that it is an opportunity but how do you turn it into a reality? There are many international efforts that are underway to share policies and best practices for advancing clean energy, and expanding research and development into innovative technologies. Hopefully we will hear a little bit more this morning about the "Three Percent Club." This is a coalition of countries and businesses that are committed to increasing global energy efficiency by three percent annually.

Here at home, energy efficiency remains one of the easiest steps that we can take, and its benefits can be significant.

The Alliance to Save Energy reports that 25 million American households have reduced or foregone medical or food purchases to pay energy bills, and households earning less than 200 percent of the federal poverty level spend on average 16.3 percent of their income on energy costs.

As we were looking at our background memo for Committee members, in the very first sentence in our briefing memo, it states here in the United States energy efficiency measures have helped reduce energy use by 50 percent relative to what it would have been had the 1980's energy use pattern continued, saving each American an average of $2,500 per year on their energy bills. That is significant.

Even small changes in using energy more efficiently can make a big difference. I like to cite some of the things that we see in my state. A little community called Yakutat, which is in the northern end of the Southeast panhandle, with a population between 500 and 800 people depending on the fishing season, but the elementary school there made a change out to more efficient lighting. It doesn't sound like that big of a deal, but they are able to save about $70,000 a year which for them in that community translates to a teacher's salary. When you look at what the benefit is and then the payback to that community has already been completed. So lots of good examples out there.

We have a lot to discuss this morning, so I just want to briefly introduce our panel of expert witnesses as I wrap up.

I mentioned Dr. Motherway. So again, thank you for traveling across the Atlantic to join us here this morning. We are also joined by Dr. Daniel Bresette, the Executive Director of the Environmental and Energy Study Initiative (EESI); Ms. Jennifer Layke is the Global Director for Energy at the World Resources Institute (WRI); and Mr. Scott Tew is the Executive Director of the Center for Energy Efficiency and Sustainability at Ingersoll Rand.

We will have good conversation this morning as we talk about how we advance energy efficiency here in this country and globally.

With that, I turn to my friend and my colleague, Senator Manchin.

STATEMENT OF HON. JOE MANCHIN III,
U.S. SENATOR FROM WEST VIRGINIA

Senator MANCHIN. Thank you, Senator Murkowski, for holding the hearing today on energy efficiency. I would also like to welcome and thank all of you for being here and enlightening us on what is going on and what we need to do.

We have been focusing on climate solutions in this Committee and we need a variety of solutions to make the differences that we need, but energy efficiency really is the low-hanging fruit and I think we have all acknowledged that.

Multiple studies have shown that energy efficiency is cheaper than investing in any other type of new generation. It is truly the cheapest kilowatt out there.

It is also readily available. There are lots of opportunities to improve efficiency in buildings, industry and transportation, and it is a jobs creator. In energy efficiency, jobs grew in my home State of West Virginia by nearly five percent last year to 1,600 jobs. That is important for a state like mine where we are losing some of our more traditional energy jobs. Nationwide, 2.35 million people work in energy efficiency, over twice the number employed in fuel, gas and coal jobs. I am hoping the discussion today will focus on the role of energy efficiency and economic competitiveness in our global fight to address climate change. Energy efficiency improvements starting in the 1970s have helped us produce more economic output with less energy.

That increase in energy productivity is a shot in the arm for U.S. competitiveness. Today, energy use, per dollar of gross domestic product, has fallen by more than half compared to 1980. That means we produce twice the GDP for the same energy, saving each American an average of $2,500 per year on their energy bills and also making the overall economy stronger.

This is a clear example of why energy efficiency is a win-win. It increases productivity, creates jobs and helps us expand overall economic activity. In fact, the International Energy Agency found that if cost-effective and technically available energy efficiency measures were fully deployed, the global economy could double in size by 2040. That is a big number, double in size by 2040, while seeing only a marginal increase in energy consumption.

I am glad that we have Dr. Motherway here to discuss these findings. The U.S. should be leading the pack in energy productivity including helping emerging economies in the world enjoy the same benefits, like reduced energy costs, access to modern conveniences like dishwashers and air conditioning, things we have taken for granted for many years now.

As I have mentioned, energy efficiency is also a tool to help us reduce emissions, a very significant tool, and I know our witnesses are going to discuss that today.

Senator Murkowski and I took a trip to several Arctic nations earlier this year and what struck me is that for those nations, climate change is not political, it is a fact. We are the only Arctic nation that uses climate change as a political divide, the only one, and they have much more diverse political challenges than we do.

Our Committee has been forward leaning this year in having experts here testify on the facts around the changing climate because we may not all agree on the approach to take, but we should be starting from the same place with a baseline of facts. That is the only way we can really start working together on solutions.

I think that commonsense climate solutions, like energy efficiency, should be our common ground. We should be counting energy efficiency as among the nation's most abundant natural re-

sources that we can leverage to increase the prosperity of all Americans. I hope the panel can help us identify barriers and opportunities to accelerate investment in efficiency.

I think this Committee has demonstrated a commitment to energy efficiency. So far, we have reported 12 bills that would increase energy efficiency in buildings, manufacturing, industrial and transportation sectors. Two of those bills are focused on the Federal Government, because we are the largest energy user in the country. That is great material for a robust energy efficiency title in an energy innovation bill, and I hope to work with my colleagues and my Chairwoman on that.

In the meantime, I look forward to hearing from all of you to increase energy efficiency.

Thank you, Madam Chairman.

The CHAIRMAN. Thank you, Senator Manchin.

Let's go ahead and begin the testimony here this morning. I have introduced each of you.

We would ask that you try to keep your comments to about five minutes. Your full statements will be incorporated as part of the record, but we would like to have plenty of opportunity for the questions afterward.

Dr. Motherway, if you would like to begin. Again, thank you for joining us from across the seas. Welcome to the Committee.

STATEMENT OF DR. BRIAN MOTHERWAY, HEAD OF ENERGY EFFICIENCY, INTERNATIONAL ENERGY AGENCY

Dr. MOTHERWAY. Thank you very much, Chairman Murkowski, Ranking Member Manchin, Senators and fellow panelists. It's a privilege and an honor to be with you today to talk about the topic that we see as very important for reasons that the opening remarks of the Chairman and the Ranking Member have already said very eloquently are why energy efficiency is so important to money, energy, environment and wider social and economic goals.

As you may be aware, the International Energy Agency is working with governments amidst a growing recognition around the world of the need for stronger progress in energy efficiency. And, of course, this is the context for the recent establishment of the Global Commission for Urgent Action on Energy Efficiency, which was mentioned, which we see as a very important, high-level examination of opportunities to accelerate progress on energy efficiency.

And Chairman Murkowski, we're very pleased and honored that you have generously agreed to be an honorary member of that committee. We believe its work will be very significant for energy efficiency's future around the world.

As has been mentioned, energy efficiency is already making major contributions in a number of domains, including energy security, cost reduction, environmental protection, as well as enhancing competitiveness and resilience around the world. But our analysis shows that globally, progress in energy efficiency is slowing down which is of great concern to us. Energy efficiency policy action is not keeping up with wider pressures and social trends that are pushing energy demand up. And for us, this represents a significant lost opportunity, especially when we know that more can be achieved.

As the Ranking Member mentioned, we have undertaken analysis that shows that we could more than double our rates of annual energy efficiency improvement, if the only thing we did was use technologies that are already existing and fully cost-effective today. And if we did double that rate of improvement and got back on track to around three percent annual improvement a year, in the next few decades we could see the global economy double in size while using, effectively, the same amount of energy that we use today which, in turn, would make lives better all over the world, giving people lower energy bills, reduced greenhouse gas emissions and greater energy security.

We're very pleased that our analysis, looking at how to get back on track at three percent, is inspiring discussions around energy efficiency around the world. And for our part, we look at how policy can make a difference, and we look around the world at some of the best policies. And let me, please, just mention a couple that I think are of interest.

Many countries use regulatory approaches to policy. It's a very common approach such as building codes, standards for vehicles or appliances. They are effective in reducing consumer costs. They drive innovation, and they can enhance industry competitiveness.

One example I would mention is in Japan, the so-called Top Runner Program, which covers a range of products from passenger cars to refrigerators and everything in between. Performance standards are dynamic so that every few years the best in class, the most efficient technology, becomes the standard for everybody to meet, therefore driving innovation and efficiency over time which it leads to greater international competitiveness for Japanese companies as well as giving consumers access to efficient and highly cost-effective equipment.

Higher standards are also driven through voluntary approaches, not least here in the U.S. where public and private organizations have come together to agree to new efficiency levels, for example, for television set top boxes and internet routers. Elsewhere, in many countries, voluntary engagement is used in industry as well where sectors agree to set themselves cost-effective energy efficiency improvement targets.

We also see the widespread use of market-based approaches and market instruments to drive innovation and mobilize action. Many European states, for example, have utility obligation programs where energy providers are given energy efficiency targets to meet. They are given freedom to choose where to focus and that drives innovation and lowers costs. Many U.S. states have used similar approaches very effectively as well. Many governments focus on homes and how to make them more efficient.

One interesting example here in the U.S. is Alabama Power's Smart Neighborhood Program supported by the Department of Energy which is a public-private collaboration linking very efficient, high technology homes via a community-scale microgrid. The result is desirable, modern, sustainable and resilient homes and neighborhoods.

In my view, we are entering now a new epoch for energy efficiency, driven by the fast pace of innovation in digital technologies. Such technologies allow us to think about efficiency in new, more

dynamic system-wide ways. For example, here in the U.S. many states have very successful programs that reduce stress on electricity grids by incentivizing consumers to reduce their consumption at peak times. What is new now, driven by technology, is that this can be done easier, cheaper and more effectively and the demand side can be more flexible and can help not only reduce cost but also make the best use of clean energy resources.

In our view then, this means that efficiency is no longer just about the end use of energy in devices but also about how to optimize the whole energy system, and this new modernized way of thinking about energy efficiency will open up many new opportunities.

So in closing, I just want to stress that the IEA looks at all fuels and all technologies. We are the world's policy advisor across the entire energy system, and we see energy efficiency as a top priority. We support governments by analyzing trends, sharing best practices and encouraging exchange and collaboration. When we look at best policy practices around the world, we see that there is—with good design and good implementation, policies can succeed in bringing many benefits to economies and citizens through engaging the market, driving innovation and lowering costs for all.

And a key lesson we find around the world is there is always more potential. There's always a greater opportunity for more efficiency. And, of course, this is why we think the Global Commission for Urgent Action will play such an important role.

So Chairman, Ranking Member, Senators, colleagues, thank you very much for the opportunity to present my testimony today, and I hope it has been of some value to you.

Thank you.

[The prepared statement of Dr. Motherway follows:]

Dr Brian Motherway, Head of Energy Efficiency, International Energy Agency

Written testimony
Hearing of the U.S. Senate Committee on Energy and Natural Resources
Dr Brian Motherway
Head of Energy Efficiency
International Energy Agency

October 22, 2019

Introduction

I wish to thank the Senate Committee on Energy and Natural Resources for the kind invitation to present my testimony and to exchange views on the important topic of energy efficiency.

This discussion on energy efficiency is very timely as many governments consider the issue in the context of wider energy policy goals, and a growing recognition of the need for stronger progress on energy efficiency. This is also the context for the recently established Global Commission for Urgent Action on Energy Efficiency. This Global Commission represents a very important global process of high-level engagement to examine opportunities to accelerate progress on energy efficiency through policy. It comprises heads of state, energy ministers, CEOs and thought leaders, and we are very pleased and honoured that Committee Chairman Lisa Murkowski is an honorary member. We believe that the work of the Global Commission will be very significant for energy efficiency's future progress globally.

This statement provides background information on energy efficiency and demand trends, and highlights some successful policies from around the world. The information contained in this statement is based primarily on analysis and research conducted by the International Energy Agency.

In this statement, I will first set out an overview of the global dynamics of energy efficiency – how and where energy is used, and how efficiently is it being used. Last year, global energy demand saw its largest increase since 2010, driven primarily by increased levels of economic activity. Energy efficiency can play a key role in making sure this kind of growth is sustainable, not only from an environmental point of view, but also in terms of ensuring the resilience of electricity grids, reducing import dependency, and lowering energy costs for all.

Efficiency has already made major contributions to a range of energy goals, including energy security, cost reduction and environmental protection. However, we are observing a noticeable slowdown in the rate of improvement, as measured by global energy intensity (the energy required to produce one unit of GDP). This is driven by wider trends putting pressure on energy use that efficiency policies are not keeping up with.

The second part of this statement considers how this trend could be reversed through readily available and cost-effective technology options. According to IEA analysis, maximising the available energy efficiency opportunities could allow the global economy to double by 2040, with essentially the same energy demand as today. These efficiency measures would also allow the global industrial sector to save about USD 600 billion on energy spending, and households about USD 550 billion.

Much more policy ambition and investment are needed, however, to achieve these kind of outcomes. The final part of this statement looks at what such policy ambition might involve, by setting out examples of global best practice in energy efficiency policy making. Numerous compelling examples from across the world show how efficiency policies can be deployed by governments to achieve a range of both energy and non-energy benefits. It also explores how rapid and far-reaching innovations in digitalisation have the potential to take efficiency policies to the next level, by transforming the way that energy is used across the entire energy system.

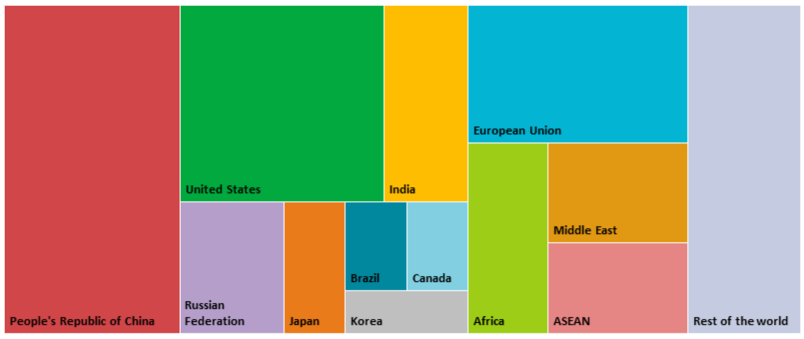
Since its foundation in 1974, the IEA has worked closely with the United States and all its member governments on energy issues of global importance. The IEA looks at all fuels and all technologies, and is now the world's leading policy advisor across the entire energy mix. Energy efficiency is seen by the IEA as a high priority, and we have greatly expanded our work on the topic in the past few years. We undertake global analysis of energy efficiency trends and monitor their impacts as part of our wider analysis of the global energy system. We also support governments through research and dissemination of policy best practice, exchange and collaboration. We work directly with many governments, including the United States, to support their understanding of energy efficiency issues and their development and implementation of appropriate policies. We appreciate this opportunity to discuss this topic further and I hope the information contained in this statement is of value to the Committee.

1 – The global dynamics of energy efficiency

Where and how is energy used

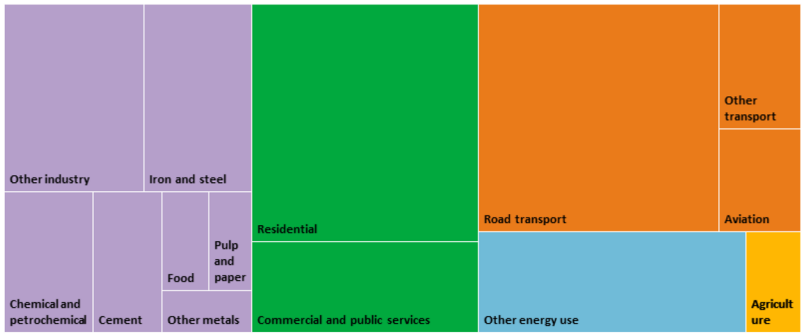
The following charts provide an overview of the world's main energy consuming countries and sectors.

Figure 1. **Largest energy consuming countries or regions, 2017**



Source: IEA (2019), *World Energy Balances* (database).

Figure 2. **Distribution of global final energy use, by sector, 2017**

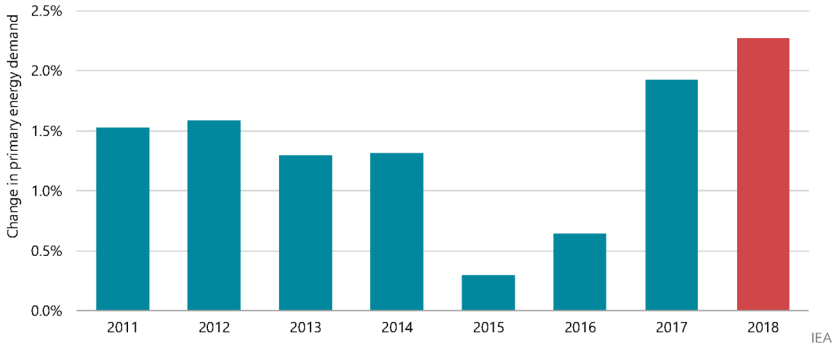


Source: IEA (2019), *World Energy Balances* (database).

Global energy use and intensity trends

In 2018, global energy demand grew by over 2.3% – its highest level since 2010. This followed similarly strong demand growth in 2017, after markedly lower growth in 2015 and 2016 (Figure 3). As the largest economies, the United States and China accounted for over 60% of this growth between them.

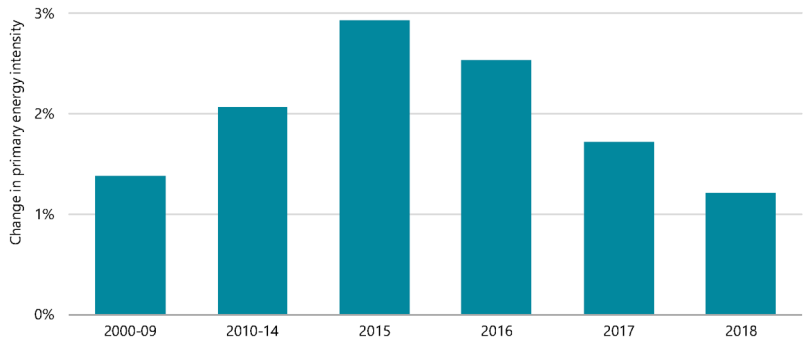
Figure 3. **Changes in global primary energy demand, 2011-18**



Source: IEA (2019) *World Energy Balances 2019* (database) and IEA (forthcoming) *World Energy Outlook 2019*.

Global energy intensity – energy demand per unit of gross domestic product (GDP) – is a commonly used global indicator to track annual changes in energy efficiency. In 2018, this indicator showed that global energy intensity had improved by 1.2%; in other words, 1.2% more value was extracted from each unit of energy than in the previous year. However, this rate of improvement has been slowing since 2015 (Figure 4). Had the world stayed on track with the 2015 rate of improvement, the equivalent additional value extracted from global energy use would have been $8 trillion in 2018.

Figure 4. Annual improvement in global energy intensity, 2000-18



Sources: IEA (2019), *World Energy Balances 2019* (database) and IEA (forthcoming), *World Energy Outlook 2019*.

Why are we experiencing slowing energy intensity improvements?

The recent slowdown in global energy intensity improvement rates is explained by a number of key factors, the most important of which are:

1. **Short-term phenomena** were important in effecting a slowdown in efficiency gains. These include recent strong growth in industrial output from energy-intensive heavy manufacturing. For example, Chinese steel output has grown strongly (8% in 2017 and 6% in 2018) after contracting in 2015 and remaining essentially flat in 2016. A second short term phenomenon is exceptional weather, which in 2018 increased demand for heating and cooling at different times of the year in several major economies. A relatively cold winter in parts of the US led to an increase in gas demand for home heating.

2. **Longer-term trends** have also played a role in influencing year-on-year changes in energy intensity improvement. While technologies and processes are becoming more efficient, structural and behavioural factors are dampening the impact of these technical efficiency gains on demand, and slowing global energy intensity improvements. In transport, for example, consumer preferences for larger cars combined with lower vehicle occupancy are driving up the energy intensity of transport, offsetting improvements in vehicle efficiency. In residential buildings, while building technologies are becoming more efficient, homes across the world are becoming larger, with more appliances being used more often. Many of these trends enhance quality of life, but their energy demand implications are outweighing the gains made though technical efficiency improvements.

3. Another major cause of the efficiency slowdown is the ongoing **slow rate of action on policy**, and the consequent flat progress in the level of energy efficiency investments. The coverage of mandatory efficiency policies, for example, increased only slightly in 2018, and almost exclusively due to existing policies rather than new ones. Similarly, overall total investment in energy efficiency has remained flat for the past few years, and well below the levels required to harness the cost-effective opportunities available.

2 – The opportunity for energy efficiency gains

The global potential of energy efficiency

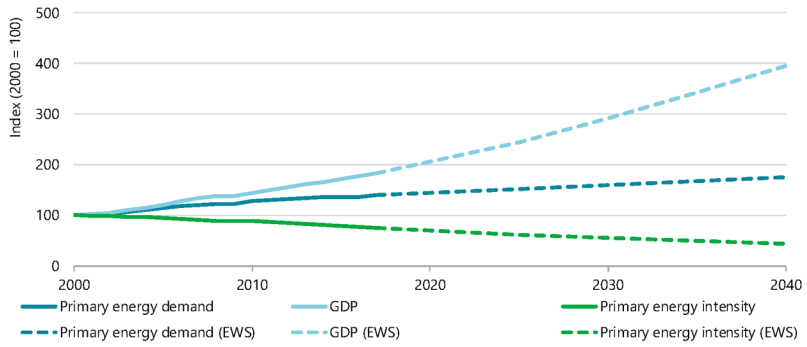
What can we hope to obtain from improvements in energy efficiency if all cost-effective and technically available opportunities were deployed by 2040? What would be the economic, social and environmental benefits?

To address these questions, the IEA has undertaken modelling to determine what would happen if global policy makers deployed all available, cost-effective efficiency measures. The results of the modelling provide the basis for the IEA's Efficient World Strategy, which outlines the potential of energy efficiency for economies and societies, and the measures required to achieve it.

Global energy intensity could be halved by 2040

Stepping up action on energy efficiency could see global energy intensity improve by an average annual rate of 3%. With this kind of improvement, the size of the global economy could double by 2040 for only a marginal increase in energy demand (Figure 55). Greenhouse gas emissions could be substantially lower, consumer bills reduced, and global energy security greatly enhanced.

Figure 5. Global primary energy demand, GDP and intensity, 2000-40



Source: IEA (2018), Energy Efficiency 2018.

Energy use could be avoided and emissions could fall

Capturing these efficiency opportunities could mean 20% less energy use in 2040 than otherwise would be the case. Energy efficiency alone could achieve an immediate peak in global energy-related carbon dioxide (CO_2) emissions, and then see levels fall 12% lower than today by 2040. This represents over 40% of the emissions abatement required under the goals of the Paris Agreement; demonstrating the key role played by energy efficiency in achieving global climate targets.

Financial benefits could flow to economies, sectors and households

At a national level, efficiency gains could reduce the need for energy imports and associated expenditure, as well as improve trade balances and energy security. By 2040:

- China, India and the European Union could avoid expenditures of about USD 700 billion in fossil fuel imports;
- Global industry could avoid about USD 600 billion in energy spending; and
- Household savings could amount to about USD 550 billion in energy spending.

Opportunities for efficiency gains

Developing an understanding of the technologies and energy-uses which could yield the largest energy savings provides a clearer view as to which policies and measures can unlock the potential of energy efficiency. The opportunities for efficiency gains in transport, buildings and industry are summarised in the following sections.

Transport energy demand could stay flat despite doubling activity levels

Global transport energy demand could stay flat between now and 2040, despite a doubling in activity levels. Efficiency measures in the transport sector offer the largest energy savings, with road transport, particularly cars and trucks, having the greatest potential. In 2040, today's most efficient hybrid cars could be the norm, and as much as 40% of the global car fleet could be composed of electric vehicles. Between now and 2040 the efficiency of trucks could improve by 2.5% annually, much higher than historical rates, and aviation and shipping could improve by 3% annually.

Behaviour change to shift existing transport patterns could yield significant additional benefits. Examples include encouraging people to use public transport instead of cars, which in many countries has been incentivised in various ways. Introduced in 2003, the London congestion tax levied a daily charge for driving or parking on congested roads, and resulted in noticeable behaviour change and other impacts. This included a 20% reduction in traffic; a 16% reduction in vehicle emissions; and over 40 million litres of avoided fuel consumption (C40, 2011).

Building space could increase by 60%, with no additional energy use

The deployment of the most efficient technologies could mean that global buildings energy use could remain flat between now and 2040, despite an increase of 60% in total building space. Heating and cooling could provide the majority of potential savings, and global heating energy use could be cut in half, despite the growth in building stock.

Industry could produce twice as much value for each unit of energy

Recent improvements in overal global industrial energy efficiency have been linked to new, highly efficient factories that have been built in emerging economies. Technological changes and automated control have also made it possible for current equipment to make efficiency gains. There remains considerable opportunity for further gains, such that by 2040, cost-effective efficiency potential could result in industry producing twice as much gross value added for each unit of energy.

While energy efficiency has improved in the largest, most energy-intensive sectors, less intensive sectors, such as food and beverage manufacturing, have not seen the same level of improvement and therefore hold the most potential for efficiency gains. Significant potential can be unlocked through the widespread adoption of more efficient technologies, and improving the efficiency of electric motors and the systems they drive.

An important opportunity for industry is the increased adoption of energy management systems, which provide ways for industry to manage and optimise energy use. Incentives are often used to promote the adoption of energy management systems. In Germany, tax reductions are provided to eligible industrial firms implementing an energy management system and contributing to sector-wide efficiency gains. This has led to Germany having the highest adoption rate of such systems in the world (IEA, 2018).

Investment must rise to unlock potential efficiency gains

A substantial scale-up in investment will be needed to unlock the potential benefits of energy efficiency between now and 2040. Average annual energy efficiency investment will need to double from the current investment level of about USD 240 billion (unchanged since 2014) to about USD 600 billion between now and 2025, and then double again to 2040.

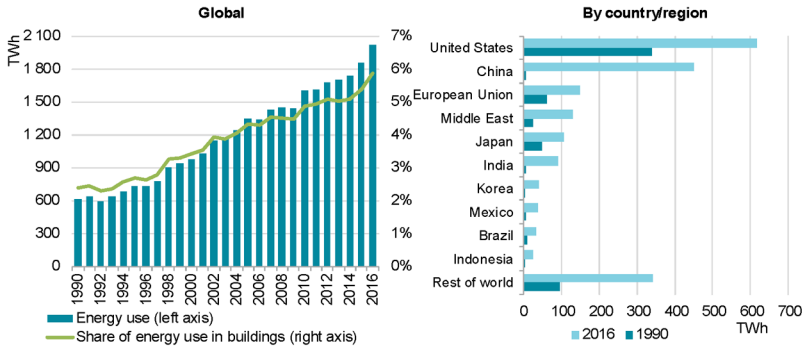
It is important to emphasise that all the efficiency measures included in the IEA's Efficient World Strategy will achieve a positive return on investment. Across all sectors, each dollar spent on improving energy efficiency will, on average, pay back by a factor of three. This is only based on energy savings, and does not include some of the other benefits of energy efficiency, many of which deliver additional financial returns.

While efficiency investments are financially attractive, there are important barriers to increased spending, including the complexity and variety of energy efficiency projects. Energy efficiency investment is highly varied, and ranges from individual appliance replacement to major retrofits of commercial buildings. These larger projects are also complex, involving multiple technologies and systems, and may deter major investors as many of these efficiency investments are either too small or too complex to be appealing. The implication is that there is no 'one size fits all' approach to increasing investments in efficiency.

The importance of cooling energy use

The fastest growing source of energy demand in buildings, globally, is space cooling. This reflects both the increased ownership of air conditioners across major economies and warmer weather conditions. Global space cooling energy use more than tripled between 1990 and 2016, with its share in total building energy use also rising from 2.5% to 6%. While the largest overall increase has been in China, air conditioner energy use is remains highest in the United States (Figure 66).

Figure 6. Growth in air conditioner energy use



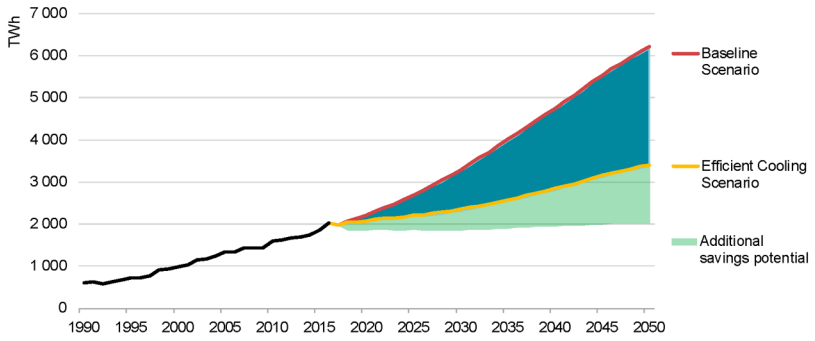
Source: IEA (2018), The Future of Space Cooling, OECD/IEA, Paris

Growing demand for space cooling is most apparent when considering its impact on peak electricity demand. In countries where there is demand for space cooling throughout the entire year, such as Singapore, Australia or countries in the Middle East, the share of air conditioning in peak electricity load can exceed 50%.

Without greater policy action to improve both the efficiency of space cooling equipment and the performance of buildings, the impact on the global energy system could be significant. IEA projects a potential threefold increase in space cooling energy demand between 2016 and 2050, which would result in a doubling of associated emissions. This increase is linked to greater air conditioner ownership in large emerging economies, particularly India and Indonesia, where space cooling could represent nearly half of total peak electricity demand by 2050.

However, the IEA estimates that greater efforts on efficiency could see the average energy efficiency of the global stock of air conditioners could more than double between 2019 and 2050. This would result in energy demand growing at a much slower rate, to be 45% lower in 2050 than would otherwise be the case, with additional savings also possible from improving building performance to minimise the need for space cooling. The savings on investment in electricity infrastructure required to meet peak demand would be particularly significant. These efficiency gains, combined with increased penetration of renewable power generation, could see emissions from space cooling fall to levels below that estimated in 2016.

Figure 7. Contribution to global energy savings from energy efficient air conditioners and additional potential energy savings



Source: IEA (2018a), *The Future of Cooling*

While the use of air conditioners in buildings will underpin future demand for space cooling, its impact also extends to the transport sector. Air conditioners in cars, buses and trucks currently consume the equivalent of 1.5% of global oil consumption, representing around 420 million tonnes of greenhouse gas emissions. Without further policy action, this energy consumption could nearly triple due to increased vehicle uptake in countries with warm climates. However, efficiency gains limit this impact. IEA estimates that improved technology and vehicle design could limit the increase in energy demand to be half what is currently projected (IEA, 2019b).

Digitalisation has the potential to unlock greater efficiency gains

Digitalisation will undoubtedly change the future landscape of energy efficiency. The following sections highlight three digitalisation trends that have the potential to lead to dramatic efficiency gains in buildings, transport and industry.

Smart buildings

Digital technologies and enhanced connectivity have led to the concept of a 'smart' building. A smart building is one in which devices are connected through a building (or home) energy management system, which gathers data from these devices, as well as external data, such as weather conditions and local grid requirements, to control and optimise building energy use.

The benefits of smart buildings will vary depending on the type of building, the appliances used and the market structures incentivising action. Some studies indicate that home energy management and automation technologies can reduce energy use by up to 30% (IEA 4E EDNA, 2018). For the global building stock, forecasts indicate that greater levels of digitalisation between now and 2040 could lead to average annual savings of around 10% of current global buildings energy use (IEA, 2017a).

Shared mobility

Digitalisation has the potential to significantly influence the global transport sector. Among its benefits and potential applications are vehicle automation; optimisation of freight logistics; and enhanced route planning. Another application, shared mobility, has also gained significant attention.

Shared mobility – the shared use of a vehicle, motorcycle, scooter, bicycle, or other means of travel – has been greatly enabled by the considerable growth in digital technologies, particularly smartphones. The extent to which shared mobility will enable additional efficiency gains will depend on several factors, most importantly whether it moves people away from single-occupancy car journeys. Greater penetration of electric vehicles in shared mobility could limit energy and emissions impacts.

Smart manufacturing

Digital technology has long been used within industry to improve process control, safety and overall productivity. The concept of smart manufacturing – characterised by greater levels of connectivity and the use of advanced software to carry out analysis and improve performance and productivity – is being enabled through recent technology advances. Energy and material cost savings of 3-5%, along with reduced maintenance costs and production downtime, have been estimated as potential benefits across various industry sectors (Schneider Electric, personal communication).

Artificial intelligence (AI) algorithms are also being used to optimise complex industrial processes; analyse data collected from a wide variety of sources; 'learn' and predict the future performance of industrial equipment; as well as alert operators to potential faults before they disrupt production. While still in early stages of deployment, AI algorithms are reported to be yielding energy savings of up to 10% in energy-intensive industry sectors (IBM, 2019).

Additive manufacturing (3-D printing) is also becoming more common within industry. As a technology, 3-D printing has the potential to significantly reduce material waste, and facilitate the production of more complex parts and components. This, in turn, could improve the efficiency of appliances and equipment using these parts and components.

From end-use efficiency to systems efficiency

Digital technologies are opening up greater potential for energy efficiency and shifting attention away from the use of energy in specific appliances or equipment towards the entire energy system. This is of particular interest in electricity systems, where electrification of energy loads combined with greater levels of renewable energy deployment is seen as an important strategy for decarbonisation in many countries. In this context, system balancing and optimising the use of renewable resources is enhanced when the demand-side can play a more active role in modern energy systems.

Digital technology can improve the flexibility of energy demand, and ensure that energy-using equipment can respond in real time to changes in supply and market conditions. Such actions, referred to collectively as demand-side management, can enhance energy security and affordability by reducing the need for additional sources of energy supply. The challenge for policy makers is to ensure that markets are established and structured in ways that recognise and capture the benefits that demand-side actions can bring to modern energy systems. This is a fast-emerging dimension of energy efficiency and energy transition thinking that could profoundly transform approaches to energy efficiency in a systems' context.

3 – Efficiency Policies in Action

Introduction

Decades of accumulated global experience demonstrate that well-designed and well-implemented policies to enhance energy efficiency can bring huge social and economic benefits.

The following examples illustrate how forward-looking efficiency policies and private sector engagement can enhance competitiveness, enable job creation and energy access, and improve energy security. They are only a glimpse into the huge potential offered by energy efficiency policies. Emerging trends in digitalisation offer even greater potential: connected devices, data and analytics are transforming traditional efficiency value propositions, with tremendous untapped opportunities for policy makers and market actors alike.

Lowering costs and enhancing competitiveness by making technology more efficient

Minimum energy performance standards (MEPS) are a well-known instrument in efficiency policymaking. They regulate the amount of energy consumed by technologies, such as air conditioners or motors. To date, over 80 countries have adopted MEPS covering more than 50 different types of technologies. MEPS have been proven to be cost effective, with evaluations showing that benefits typically outweigh any additional costs by a factor of 3 to 1 (IEA 4E, 2015).

MEPS have been used effectively by policy makers in the **United States** to allow consumers to obtain more value from refrigerators. Since the introduction of the first MEPS for refrigerators in 1978, consumers spend on average two-thirds less (based on 2010 USD values) for refrigerators than they did forty years ago. In addition, due to MEPS, refrigerators sold in the United States today have larger volumes but use over 75% less energy (ACEEE, 2014).

Well-designed MEPS can also be used to drive innovation among equipment manufacturers to improve the competitiveness of industries and economies, especially if they form part of a wider economic policy agenda.

Japan, for example, encourages companies to compete with one another to obtain the official 'Top Runner' label, which is widely recognised by consumers to denote that a product performs best in its class in terms of energy efficiency. The programme covers a range of products, from passenger cars to refrigerators. Performance standards are dynamic, so that every few years the most efficient devices are set as the new standard for everyone to meet. In operation since 1999, Top Runner has increased the international competitiveness of Japanese companies, and given consumers access to efficient highly cost-effective equipment.

Deploying efficient technologies quickly

There are many efficient technologies that are ready to be scaled up and could have a strong impact, but which are unable to reach the necessary scale of use. This may be due to their cost, or they are not familiar to consumers or installers. Equally, some very good efficiency standards are in place but will take many years to have a full impact due the time required to fully phase out inefficient equipment.

Efforts to rapidly get efficient technologies into the hands of millions of consumers can accelerate their benefits. One effective means of achieving this is through the **bulk procurement** of efficiency services or products to accelerate their deployment. Bulk procurement creates economies of scale, decreasing the costs of services and products, and in some cases encouraging the development of new or spin-off markets.

India, for example, is procuring millions of efficient lights through a national programme called UJALA, which has already delivered more than 330 million lamps across India in the past four years. While the programme receives no public subsidy, consumers are able to pay for the lamps partly upfront and partly out of the ongoing savings. The purchasing power of the large programme means that consumers pay only 70 rupees (1 USD) for an energy efficient LED light bulb (EESL, 2019).

Creating an efficiency culture

Countries often deploy a range of information and awareness-raising measures to build support and encourage consumers to make more energy efficient purchasing decisions.

China, for example, introduced the **China Energy Label** in 2005 to improve energy efficiency and meet a target of a 20% decrease in energy consumption per unit GDP by 2010. According to surveys, the China Energy Label has been seen and recognised by 97% of China's urban population, and 75% of them understand how the label helps them compare the efficiencies of competing products. In 2016, the Chinese government improved its labelling approach by introducing a QR code on the labels. The QR code allows consumers to easily access relevant information using their phones, including comparisons of difference appliance prices and running costs, manuals, repair options and end-of-life recycling options (CLASP, 2017).

In **Japan**, social norms influencing energy use have been tackled through the multi-year **Cool Biz Campaign**. The campaign encourages raising temperature settings on air conditioners, while allowing office workers to wear lighter and less formal clothing. Launched in 2005, the campaign took on urgency following the Fukushima Daiichi nuclear disaster of 2011. National leaders sought to encourage new behaviours by being pictured wearing more casual clothes. Significant energy and carbon savings were achieved and have been sustained (Japan Times, 2019).

Information measures can also be used to encourage a shift in established market practices, such as the sale or lease of commercial real estate. **Australia's** Commercial Buildings Disclosure (CBD) programme, for example, requires energy efficiency information to be provided when commercial buildings are sold or leased. Before offering their office space for sale or lease, buildings owners must obtain a mandatory building energy efficiency certificate with an efficiency star rating (CBD, 2019). Since the implementation of the CBD

programme, the energy efficiency of Australia's commercial buildings has increased consistently. The CBD programme has also ensured that efficiency is a selling point in commercial real estate, and it has encouraged owners of poorly performing buildings to make energy efficiency improvements.

Incentives can promote efficiency in industry and beyond

Given the high energy costs for many manufacturing sectors, energy use in industry has been a focus of attention for many years. The range of policies that have been applied include voluntary agreements, financial incentives, and legally binding targets.

Germany uses a combination of information and incentives to encourage industries to adopt the globally recognised **ISO 50001** standard for industrial energy management. Companies that achieve ISO 50001 certification and specific energy performance improvement rates are eligible for a tax exemption. Using an independently verified certification makes the programme much easier to administer. As a result of the scheme, Germany has the largest number of ISO 50001 certifications of any country. Energy management systems also unlock additional energy and cost savings, such as improvements in staff awareness and staff accountability (IEA, 2018).

Financial incentives are also deployed in other sectors. More sophisticated policies seek to establish the right incentive structure while minimising the burden on the state. In **France**, government incentivise consumers to purchase more efficient cars, while stabilising tax revenues from changing patterns in vehicle sales. This is done through a policy called Bonus-Malus, which reduces taxation on more efficient cars and raises them on less efficient ones. To adjust to shifting consumer preferences, the Bonus-Malus policy is updated every year to ensure that revenue from the scheme is neutral relative to previous vehicle taxation schemes (ICCT, 2018).

Transforming inefficient buildings

For many countries, energy and climate targets will not be met without addressing inefficiencies in their existing building stock. However, retrofitting existing buildings, even if financially viable, is beset by many practical challenges. Although insulation, double-glazed windows, or more efficient heating systems are readily available, a number of barriers prevent these technologies from being more widely installed, especially in residential buildings. Homeowners may be unwilling or unable to pay large sums upfront to make long term energy savings. They may have to vacate their homes during building projects, or they may not know which solutions are right for them.

Governments frequently use grants to overcome these barriers and to incentivise homeowners to adopt efficiency technologies. However, grants can prove expensive and, rather than stimulating the development of a retrofit market, they may simply make homeowners dependent on grants. All this has meant that many efforts to encourage large-scale efficiency retrofits of homes have often proven unsuccessful.

A pioneering approach launched in the **Netherlands** addresses some of these persistent barriers through a different kind of residential retrofit business model. Known as Energiesprong, the model is based on a one-week efficiency intervention featuring pre-fabricated facades, rooftop solar and new heating installations. Energiesprong focusses on entire neighbourhoods rather than individual homes, and no upfront payments are required. Instead, the service is guaranteed and paid over time through energy and maintenance charges (Energiesprong, 2019).

Energiesprong has provided a trove of important learnings on the use of prefabricated building facades for residential retrofits. Because local companies are involved in manufacturing and installing facades and other technologies, the model has the potential to create jobs and spur innovation in building materials supply chains. Energiesprong has also shown promising potential in terms of scalability and replicability, with spin-

offs being created in numerous other jurisdictions across the globe. A number of US States are also implementing innovative ways to finance home upgrades to try to stimulate the market.

Another initiative that is advancing residential energy efficiency in neighbourhoods, with important implications for energy system resilience, is Alabama Power's Smart Neighborhood™, with support from the **United States** Department of Energy (US DoE, 2018). The initiative involves a range of public and private sector actors to develop a community-scale micro-grid. It relies on efficient homes, to reduce the overall demand for energy and support the resilience of the system, and on digital technologies that enable energy using equipment in homes to 'interact' with one another as well as with energy providers.

Digitalisation is taking energy efficiency to the next level

The previous example from United States is only one of a rapidly growing number of cases that illustrate how digital technologies, supported by energy efficiency, offer a potential step-change in how energy is used, and how government can play an enabling role in market development. Indeed, the **United States** has been a pioneer in this area. A number of states have led the way in terms of developing **demand response** programmes, which reduce stresses on grids by incentivising consumers to reduce their electricity consumption at peak times (SEPA, 2019).

While demand response has been used for some time, digital technologies – such as smart meters, which monitor energy use remotely and in real time, appliances that can be remotely controlled, and electric vehicles that can store excess grid electricity – allow energy efficiency to be better integrated within a wider range of demand-side measures. In an age of fast-growing deployment of clean, affordable renewable energy sources, particularly on electricity grids, a vital goal is not just to maximise efficiency of specific energy end-uses, but rather to optimise the efficiency of the whole system. In modern electricity grids, the value of end-use efficiency is fundamentally different at times when solar and wind power is plentiful and essentially free, as opposed to times when the grid is operating at maximum capacity and deploying expensive, often carbon-intensive electricity generation to meet demand.

City governments are also exploring the powerful combination of energy efficiency and the use of digital technologies to achieve both energy and non-energy related outcomes. **Barcelona** leveraged its conversion to LED street lighting as an opportunity to test 'smart city' functionality. Instead of merely rolling out new street lights, the city is using some of its lighting infrastructure to deploy pollution and noise sensors, and enable the expansion of Wi-Fi networks and electric vehicle charging stations (CityOS, 2019).

Numerous other cities across the globe have been developing and testing similar approaches. These city governments are realising that digitalisation presents an opportunity to transform a 'pure' efficiency intervention, i.e. converting to a more efficient street lighting technology, into an opportunity for large-scale digital technology deployment that provides a wide range of benefits to citizens (IEA, 2017a).

Digital technologies are also enabling new approaches to providing energy access to communities where the electricity grid does not reach. In **Rwanda and Kenya,** the company BBOXX has deployed solar home systems since 2014, providing first-time clean electricity access for over 77 000 rural households. BBOXX offers a range of packages, including mobile charging accessories, televisions and LED lights, combined with a solar panel and a battery. The service is made possible through ultra-efficient devices and digital technologies to control monitoring, maintenance and payment via mobile phone networks (BBOXX, 2019). This is one of many examples showing how the private sector is at the forefront of leveraging digitalisation trends in energy efficiency.

Many companies are now in the process of transforming their energy and energy efficiency business models, and moving away from focussing on technology sales to selling software as a service; customer value and commercial profits are increasingly being based on data-based analytics and insights.

Policy makers can draw on a wealth of global experience to best leverage effective efficiency policies and digital tools to meet a range of objectives. Now is the time to open a new chapter in the story of a more sustainable energy future. Efficiency can take a leading role in this story, supported by smart and effective policies.

References

Alliance to Save Energy (ASE). (2018). Alliance to Save Energy CAFE Standards. Retrieved from https://www.ase.org/resources/corporate-average-fuel-economy-cafe-standards#targetText=The%20CAFE%20standards%20were%20passed,a%20specific%20average%20of%20fuel%20economy.&targetText=Fuel%20economy%20roughly%20doubled%20from,27.5%20mpg%20ten%20years%20laterChina Electricity Council (2019), *Data/Statistics: Monthly Statistics of China Power Industry*, China Electricity Council, english.cec.org.cn/No.110.index.htm

Australian Government. (2019). Commercial Building Disclosure. Retrieved from http://cbd.gov.au/

BBOXX. (2019). Retrieved from https://www.bboxx.co.uk/

C40 (2011), *London's Congestion Charge Cuts CO2 Emissions by 16%*, C40, https://www.c40.org/case_studies/londons-congestion-charge-cuts-co2-emissions-by-16Cisco (2019),

California Independent System Operator (CAISO). (2019). Retrieved from Demand response and energy efficiency roadmap: http://www.caiso.com/informed/Pages/CleanGrid/Demand_Response.aspx

Cisco Visual Networking Index: Forecast and Trends, 2017-2022, https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.html

Cisco (2016), *The Zettabyte Era: Trends and Analysis, July 2016*, https://webobjects.cdw.com/webobjects/media/pdf/Solutions/Networking/White-Paper-Cisco-The-Zettabyte-Era-Trends-and-Analysis.pdf

CityOS Foundation (2019, *Smart City Barcelona*. https://cityos.io/view.competitor/28428/Smart-City-Barcelona

CLASP. (2017). China Launches Digital Energy Label & App. Retrieved from https://clasp.ngo/updates/2017/china-launches-digital-energy-label-app

Clewlow, R., and G. Mishra (2017), *Disruptive Transportation: The Adoption, Utilization and Impacts of Ride-Hailing in the United States*, University of California Davis, Institute of Transportation Studies, Research Report UCD-ITS-RR-17-07, https://itspubs.ucdavis.edu/wp-content/themes/ucdavis/pubs/download_pdf.php?id=2752ENTSO-E (2019), *Monthly domestic values* (database), ENTSO-E, www.entsoe.eu/data/power-stats/monthly-domestic/

Energiesprong. (2019). Retrieved from https://energiesprong.org/

Energy Efficiency Services Limited (EESL) India. (2019). About Ujala. Retrieved from https://www.eeslindia.org/content/raj/eesl/en/Programmes/UJALA/About-UJALA.html

IBM (2019), *Cognitive Manufacturing: An Overview of Four Applications that are Transforming Manufacturing Today*, IBM, www.ibm.com/downloads/cas/VDNKMWM6

IEA 4E. (2015). Achievements of appliance energy efficiency, a global assessment. Retrieved from https://www.iea.org/publications/freepublications/publication/4E_S_L_Report_180915.pdfIEA (2019a), *Energy Technology Perspectives* (buildings model), OECD/IEA, Paris, www.iea.org/etp/etpmodel/buildings/

IEA. (2017). Energy Efficiency 2017. Retrieved from https://www.iea.org/publications/freepublications/publication/Energy_Efficiency_2017.pdfInternational Energy Agency (IEA) (2019), *World Energy Balances* (database), OECD/IEA, Paris, www.iea.org/statistics

IEA (2017a), *Digitalization and Energy*, OECD/IEA, Paris

IEA (2018), *Energy Efficiency 2018*, OECD/IEA, Paris

IEA (2018a), *The Future of Cooling: Opportunities for energy-efficient air conditioning*, OECD/IEA, Paris

IEA. (2019). Data centres and data transmission networks. Retrieved from Tracking Clean Energy Progress: https://www.iea.org/tcep/buildings/datacentres/

IEA (forthcoming), *World Energy Outlook 2019*, OECD/IEA, Paris

IEA (forthcoming), *Energy Efficiency 2019*, OECD/IEA, Paris

IEA 4E Electronic Devices and Networks Annex (EDNA) (2018), *Intelligent Efficiency: A Case Study of Barriers and Solutions – Smart Homes*, IEA 4E EDNA, www.iea-4e.org/document/413/intelligent-efficiency-a-case-study-of-barriers-and-solutions-smart-homes

International Council on Clean Transportation (ICCT). (2018). Practical lessons in vehicle efficiency policy: The 10-year evolution of France's CO2-based bonus-malus (feebate) system. Retrieved from https://theicct.org/blog/staff/practical-lessons-vehicle-efficiency-policy-10-year-evolution-frances-co2-based-bonus

Japan Times. (2019). Japan kicks off Reiwa Era's first energy-saving Cool Biz casual wear campaign. Retrieved from https://www.japantimes.co.jp/news/2019/05/07/business/japan-kicks-off-reiwa-eras-first-energy-saving-cool-biz-casual-wear-campaign/#.XX-hPSgzaUk

Malmodin, J., and D. Lundén (2018), "The energy and carbon footprint of the global ICT and E & M sectors 2010-2015", *Sustainability (Switzerland), 10(9), 3027*.

METI. (2015). Top Runner Program. Retrieved from https://www.enecho.meti.go.jp/category/saving_and_new/saving/data/toprunner2015e.pdf

Ministry of Economy, Trade and Industry (METI) of Japan. (2015). Top Runner presentation. Retrieved from https://www.kansai.meti.go.jp/3-genetai/downloadfiles/shoenesympohaihusiryou/29fy/29fy_sesakusetsumei.pdf

National Oceanic and Atmospheric Administration (2019), *Climate at a Glance: Global Time Series* (database), NOAA, Silver Spring, Maryland, www.ncdc.noaa.gov/cag/global/time-series

Secretariat of Energy (SENER) of Mexico. (2018). Secretaría de Comunicaciones y Transportes, Programa de Trabajo para la Transición a la Televisión Digital Terrestre. Retrieved from https://www.gob.mx/sener/articulos/concluyo-el-programa-ahorrate-una-luz-con-la-entrega-de-39-799-447-lamparas-ahorradoras

Schaller, B. (2018), *The New Automobility: Lyft, Uber and the Future of American Cities*, Schaller Consulting, http://www.schallerconsult.com/rideservices/automobility.htm

U.S. Energy Information Agency (2019), *Natural Gas Consumption in the United States 2014-2019*, U.S. Energy Information Agency, www.eia.gov/naturalgas/monthly/

World Steel (2019), *Total production of crude steel*, World Steel, www.worldsteel.org/steel-by-topic/statistics.html

The CHAIRMAN. Thank you, Dr. Motherway. We look forward to our questions.

Mr. Bresette, welcome.

STATEMENT OF DANIEL BRESETTE, EXECUTIVE DIRECTOR, ENVIRONMENTAL AND ENERGY STUDY INSTITUTE

Mr. BRESETTE. Good morning. Thank you for the opportunity to discuss energy efficiency and its potential to reduce greenhouse gas emissions and make our transition to a decarbonized clean energy future more affordable and accessible.

I'm the Executive Director of the Environmental and Energy Study Institute which declared 31 years ago that addressing climate change is a moral imperative. Today we're fully engaged in the climate policy debate and committed to working with this Committee to find solutions to the terrible problem of a rapidly warming planet.

The urgency of climate change requires immediate action at home and abroad. Energy efficiency provides the easiest source of measurable emissions reductions. It is the secret weapon against climate change because we already have what we need to do. Every kilowatt-hour saved today will make future commitments easier to attain. The missing piece is the magnitude of our commitment which falls short of the enormity of the challenge.

Congress should reassert U.S. leadership in global efforts to reduce emissions. For those concerned that a burden could fall unfairly on domestic interests, I suggest instead that we will have more authority to lead if we do ourselves what we ask of others. This starts with energy efficiency as it pertains to federal buildings. There is a backlog of energy efficiency measures worth over $8.6 billion that would reduce emissions, often by leveraging private sector capital at no taxpayer expense. That list of idle projects could start disappearing tomorrow if Congress passed the Murkowski/Manchin Federal Energy and Water Management Performance Act that this Committee approved last month. The contributions of emissions from buildings is under appreciated. The building sector accounts for about 40 percent of U.S. greenhouse gas emissions and about 30 percent of energy used in commercial buildings is wasted.

The Federal Government's current commitment to climate change action falls short, but state and local governments are rising to the challenge and reducing U.S.-sourced emissions by adopting updated building energy codes. Congress should support building energy codes as a key pathway to net zero construction by 2050 by passing the Portman/Shaheen Energy Savings and Industrial Competitiveness Act to encourage states and local governments to go beyond the model building energy code and train code officials to improve compliance.

One area of innovation of interest to EESI is energy efficiency financing which could be administered by special entities like green banks. States and local governments have an abundance of creativity but are often constrained by a lack of capital to initiate financing for underserved or hard to serve populations or establish credit enhancements to leverage private sector capital. Pending before Congress are bills that would support financing such as the

Chairman's proposal to expand eligibility of the Department of Energy's existing loan guarantee program and Portman/Shaheen which includes the SAVE Act to ensure homeowners realize a return on energy efficiency investments.

EESI knows that many costs incurred in the race to address climate change could unfortunately impact people and communities least able to access the benefits of a decarbonized clean energy economy. Rural Americans, on average, pay about 40 percent more for energy than those in urban areas. We must do all we can to avoid this negative outcome.

EESI's experience with on-bill financing programs offered by municipal utilities and electric cooperatives shows how cost-effective retrofits facilitated by low interest loans can reduce upfront costs of improvement and lower monthly energy bills. Participants, including those with lower incomes or who live in disadvantaged communities, gain more affordable and sustainable housing. The policy implications are far-reaching, including lower emissions, healthier homes and even beneficial electrification of heating equipment and personal vehicles.

EESI works today with many utilities and cooperatives to implement on-bill financing. For example, in Juneau, Alaska, a non-profit community partnership is collaborating with local government and stakeholders to deploy financing for high-efficiency heat pumps. Many homes in greater Juneau have oil or electric resistance heaters and suffer from air leakages and insufficient insulation. Together with cold climate heat pumps and basic weatherization, on-bill financing could lower utility bills for Alaskan families and help Juneau meet its climate goals. EESI's experience suggests that this program design could be deployed overseas, especially where credit is scarce and incomes are low. In addition to unlocking savings, these programs finance measures that offer resilience benefits like better thermal performance of walls and windows.

Lastly, I would like to step back and make a broader point. Energy efficiency offers benefits, but it works best as an element in a full set of clean energy solutions. I encourage the Committee to consider energy efficiency along with policies to stimulate advancements in renewable energy, transmission and grid modernization, storage and other clean energy technologies. In addition, climate adaptation and resilience legislation is complementary to these efforts to safeguard the energy system and critical infrastructure from disasters and extreme weather.

It is commonly said that energy efficiency should come first. Yes, but it should not go alone.

Thank you for the opportunity to discuss how energy efficiency can deliver near-term, achievable emissions reductions. I'm happy to answer questions and provide additional information for the record.

Thank you.

[The prepared statement of Mr. Bresette follows:]

Testimony of Daniel Bresette
Executive Director
Environmental and Energy Study Institute

U.S. Senate
Committee on Energy and Natural Resources
Full Committee Hearing on Energy Efficiency Efforts in the United States and Internationally

October 22, 2019

Thank you, Chairwoman Murkowski and Ranking Member Manchin, for the opportunity to join you today to discuss energy efficiency and its potential to reduce greenhouse gas emissions, stimulate innovation and new economic growth, promote climate adaptation and resilience, and help make our transition to a decarbonized, clean energy future that is more affordable and accessible for all Americans. I hope we all agree that energy efficiency is not about sacrifice. Instead, energy efficiency is how we make something work as well or better while consuming fewer scarce resources and generating less harmful pollution and waste.

I am the executive director of the Environmental and Energy Study Institute, which was founded in 1984 on a bipartisan basis by members of Congress to help educate and inform policymakers, stakeholders, and the general public about the benefits of a low-emissions economy. In 1988, EESI declared that addressing climate change is a moral imperative--a sentiment that has since guided our work. Today, we are fully engaged in the climate change policy debate and committed to working with members of this committee, your fellow senators, and your colleagues in the House of Representatives to find solutions to the terrible problem of a rapidly warming planet.

The urgency of climate change requires immediate action at home and abroad. Energy efficiency provides the easiest, quickest source of significant, measurable emissions reductions. According to a recent report, optimizing energy efficiency "…can slash U.S. energy use and greenhouse gas emissions by 50% by 2050, getting us halfway to U.S. climate goals."[1] And this report also emphasizes one key reason energy efficiency is the secret weapon in the fight against climate change: we already have what we need—in terms of policies, technology, techniques, and program design—to do what we need to do and make those remarkable gains. Building energy codes; minimum standards for appliances, equipment, and lighting products;

[1] "Halfway There: Energy Efficiency Can Cut Energy Use and Greenhouse Gas Emissions in Half by 2050." American Council for an Energy-Efficient Economy, 18 September 2019, https://aceee.org/sites/default/files/publications/researchreports/u1907.pdf.

software and controls; high-performance building materials and standards; sustainable design practices; and the list goes on. The missing piece is the magnitude of our commitment, which currently pales in comparison to the enormity of the challenge.

Congress has the ability to reestablish U.S. leadership in global efforts to reduce greenhouse gas emissions. For those concerned that the burden of efforts could fall unduly or unfairly on the U.S. and domestic interests, I suggest instead that we will have more authority to lead if we do ourselves what we ask of others. And this starts with energy efficiency—especially as it pertains to federal buildings. There is simply no excuse for inefficient federal buildings that needlessly waste scarce taxpayer dollars. As Americans, we have every right to expect our departments and agencies to exercise good judgment, make good investments, and spend our collective resources on good uses. Wasted energy hardly meets any of those criteria. Considering only energy efficiency measures identified in professional audits of federal facilities, there is a backlog of over $8.6 billion in measures that would lower utility bills and reduce greenhouse gas emissions if implemented (often by leveraging private-sector capital at no cost to taxpayers).[2] That list of idle projects could disappear tomorrow if Congress chose to reassert federal leadership in energy efficiency by passing, for example, legislation proposed by this committee's leadership and members.[3]

The building sector accounts for about 40% of U.S. greenhouse gas emissions.[4] According to the U.S. Environmental Protection Agency's ENERGY STAR® program, about 30% of energy used in commercial buildings is wasted.[5] The contribution of emissions from buildings is often underappreciated in climate policy conversations. So too is the potential for widely-available, cost-effective energy efficiency to deliver meaningful, near-term savings. I appreciate the committee's interest in this important topic by calling this hearing. And, in fact, there are a number of policy proposals, including many bills already considered and approved by this committee, that would reduce greenhouse gas emissions and set the U.S. on a track to meet global commitments while lowering utility bills for American homeowners, consumers, and businesses. Every kilowatt and kilowatt-hour saved today, if these bills were passed and enacted, would make future commitments to address climate change easier and less expensive to attain.

Although the federal government's current commitment to climate change action falls short of its traditional leadership role in world affairs, state and local governments are rising to the challenge to reduce U.S.-sourced greenhouse gas emissions. For example, the U.S. Conference of Mayors has repeatedly and explicitly endorsed updated building energy codes as a key

---

[2] "Performance Contracting Measuring Success." Federal Energy Management Program, 8 November 2018, www.energy.gov/sites/prod/files/2018/11/f57/22-fupwg_fall_18_vallina.pdf.
[3] See S. 1857, the Federal Energy and Water Management Performance Act of 2019, introduced by Chairwoman Murkowski on June 13, 2019.
[4] "About the Building Technologies Office." U.S. Department of Energy, https://www.energy.gov/eere/buildings/about-building-technologies-office.
[5] "Save Energy." U.S. Environmental Protection Agency, ENERGY STAR, https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy?s=mega.

pathway to net-zero buildings by mid-century and a low- or no-cost source of emissions reductions in the meantime.[6] The next version of the model building energy code—the International Energy Conservation Code—is currently in development. The outcome of this process is uncertain, but governors and mayors understand that setting cost-effective energy efficiency requirements for new homes and commercial buildings is among the lowest-cost policy options at their disposal to reduce emissions and save residents and businesses billions of dollars over the next two decades and beyond. This committee recently approved legislation now on the Senate calendar that would encourage states and local governments to go beyond the model building energy code and provide technical and financial assistance to train code officials to improve compliance and enforcement—and therefore help ensure expected emissions reductions are actually realized.[7]

Many states and local governments are aiming even higher, leveraging the potential of energy efficiency to set the leading edge in climate change and clean energy policy development, as well as resilience, adaptation, and mitigation. California, to name one of many examples, has set aggressive emissions reductions goals that involve increased energy efficiency in new and existing buildings along with ambitious renewable energy deployments.[8] In the latest ranking of state energy efficiency efforts, the trend is clear: "[a] rising number of states are showing U.S. leadership on clean energy by adopting ambitious goals and energy-saving rules for buildings, appliances, and vehicles…."[9]

One area of state and local government innovation of special interest to EESI is the expansion of energy efficiency financing programs, which in some cases are administered by quasi-governmental entities (i.e., "green banks"). States and local governments have an abundance of creativity, but are too often constrained by a lack of seed capital to initiate financing programs for underserved or hard-to-reach segments (e.g., single-family homes, multifamily housing) or establish credit enhancements to leverage private-sector capital. In this case as well, legislation either approved by or pending before this committee would help financing programs proliferate and encourage investments in energy efficiency. One such bill is the chairwoman's own proposal to expand eligibility of U.S. DOE's existing loan guarantee program to state energy financing institutions.[10] A second is the provision of the Energy Savings and Industrial Competitiveness Act—a version of the Sensible Accounting to Value Energy (SAVE)

---

[6] "Adopted Resolutions—87th Annual Meeting." The United States Conference of Mayors 87th Annual Meeting, June and July 2019, https://www.usmayors.org/the-conference/resolutions/?category=a0D4N00000FCe8zUAD&meeting=87th%20Annual%20Meeting.

[7] See S. 2137, the Energy Savings and Industrial Competitiveness Act, introduced by Senator Rob Portman on July 17, 2019.

[8] "Welcome to California!" California Energy Commission, National Association of State Energy Officials Annual Meeting, 16 September 2019, https://annualmeeting.naseo.org/data/energymeetings/presentations/McAllister-Opening.pdf

[9] "The State Energy Efficiency Scorecard." American Council for an Energy Efficient Economy, https://aceee.org/state-policy/scorecard.

[10] See S. 2399, a bill to amend the Energy Policy Act of 2005 to improve State loan eligibility for projects for innovative technologies, introduced by Chairwoman Murkowski on July 31, 2019.

Act—that would help ensure homeowners realize a fair return on their investments in building envelope improvements, high-efficiency equipment, and other cost-effective measures.

EESI is acutely aware that many costs incurred in the race to address climate change could unfortunately impact people and communities least able to afford or access the benefits of a transition to a decarbonized, clean energy economy. Earlier this year, at a Capitol Hill briefing hosted by EESI, energy efficiency experts described a dire situation for many rural Americans who on average pay about 40% more for energy compared with their fellow citizens in urban areas.[11] It is imperative that we do everything we can to avoid this very negative outcome. Some efforts like the Weatherization Assistance Program, which has helped improve home energy efficiency for seven million low-income American families, are too resource-constrained.[12] To reiterate an earlier point, we have the tools we need. What we lack is a commitment to provide the resources to achieve the necessary greenhouse gas reductions. Once again, energy efficiency provides a cost-effective solution to a difficult problem, especially when implemented with funding provided by carefully-administered financing programs.

EESI's experience with "on-bill financing" programs offered by municipal utilities and electric cooperatives to their customers is illustrative of how cost-effective energy efficiency retrofits, facilitated by low-interest loans, can reduce the up-front cost hurdle for homeowners and renters of improvements that deliver lower monthly energy bills. In on-bill financing programs, monthly savings from cost-effective energy efficiency measures are directed back to the utility (or program administrator) using an energy bill line-item charge to repay the loans extended to customers. The end result for participating customers, including those with lower incomes or who live in rural or disadvantaged communities, is more affordable and sustainable housing without costly or restrictive debt obligations. The policy implications are far-reaching, including lower greenhouse gas emissions, increased access to money-saving home improvements, healthier homes, and in some areas beneficial electrification of heating equipment and personal vehicles.

Municipal utilities and electric cooperatives across the country are today in various stages of developing and implementing on-bill financing with support and technical assistance from EESI.[13] For example, in Juneau, Alaska, a non-profit community partnership—Alaska Heat Smart—is collaborating with the local city and borough governments, Juneau Commission on Sustainability, Juneau Economic Development Council, Alaska Electric Light and Power, and other partners to deploy innovative financing to accelerate high-efficiency heat pump adoption. As the chairwoman knows, thousands of homes in greater Juneau are heated with expensive oil or inefficient electric resistance baseboard units and suffer from air leakages and insufficient

[11] See summary of comments from Mary Shoemaker, "Equitable Solutions to Rural Energy Burdens." Environmental and Energy Study Institute, 16 July 2019, https://www.eesi.org/briefings/view/071619ruralenergy.
[12] "Weatherization Assistance Program." U.S. Department of Energy, https://www.energy.gov/eere/wipo/weatherization-assistance-program.
[13] According to EESI's research, there are currently more than 100 on-bill financing programs offered by utilities in the U.S. The considerable majority of these programs are operated or administered by rural electric cooperative and public utilities. See https://www.eesi.org/obf/map.

insulation. Together with cold-climate heat pumps and basic weatherization measures, this undertaking has the potential to lower utility bills for Alaskan families and help Juneau meet its climate and clean energy goals.

In Hawaii, with support from the state's green bank, the Green Energy Monday Savers program features an on-bill financing mechanism for energy efficiency, solar water heating systems, and renewable energy installation. There are many examples of on-bill financing programs in the Lower 48 as well, including the Orcas Power and Light Cooperative's Switch it Up! Program that serves the San Juan Islands in northwest Washington. Much of the recent activity in on-bill financing stems from the U.S. Department of Agriculture's Rural Energy Savings Program and its ability to streamline its application process and deploy appropriated funds as no-interest loans to rural utilities. While not subject to the committee's jurisdiction, this is another example of state and local innovation made possible by federal policy and funding.[14]

EESI's experience with on-bill financing programs in rural areas suggests that this program design could be deployed overseas as well, especially in regions where credit is scarce and monthly incomes are low. In addition to savings, the measures financed by these programs often offer considerable resilience benefits including better thermal performance of walls and windows Improved building energy efficiency will also help limit demand increases that will follow more widespread installations of cooling equipment to provide relief from rising temperatures.

In conclusion, I would like to step back from the details of energy efficiency and ask for your consideration of a broader point. While energy efficiency offers unique benefits, its potential is best viewed as an element in a full set of clean energy solutions. I encourage the committee to consider the compounding effect of stacking energy efficiency policies along with other decarbonization and clean energy policies to stimulate advancements in and greater deployments of renewable energy, transmission and grid modernization technologies, storage, and the full host of complementary sources of emission reductions. In addition, climate adaptation and resilience legislation is complementary to these efforts to safeguard the energy system, and other critical infrastructure, from the impacts of disasters and extreme weather. It is commonly said that energy efficiency should come first. I agree, but that does not mean it should go alone.

Thank you for the opportunity to discuss the potential of energy efficiency, enhanced by available policies and implemented using widely-available technologies and techniques, to deliver near-term, achievable greenhouse gas emissions. I appreciate the committee's focus on this critical issue. I would be glad to answer any questions today and provide any additional information for the record at your request.

---

[14] RESP was first authorized as part of the 2014 Farm Bill (Agricultural Act of 2014, P.L. 113-79, 128 Stat. 649). Congress has appropriated funds for RESP each fiscal year since then, on an increasing basis because of the program's popularity and the demand by rural utilities for no-interest loans for on-bill financing programs.

The CHAIRMAN. Thank you, Mr. Bresette.
Ms. Layke, welcome.

STATEMENT OF JENNIFER LAYKE, GLOBAL DIRECTOR FOR ENERGY, WORLD RESOURCES INSTITUTE

Ms. LAYKE. Thank you, Chairman Murkowski, Ranking Member Manchin and members of the Committee for the opportunity to testify here today at this hearing. It's an honor to be here.

I'm Jennifer Layke, Global Director for Energy at the World Resources Institute, a research organization working at the intersection of development and environment to improve people's lives.

Energy efficiency is a matter of economic competitiveness. It is the lowest cost energy source that we have. From my current work at WRI and from my work, private sector work on energy efficiency, the evidence is clear, we can easily end, we must cost-effectively reduce our energy waste if our economy is to continue to grow at its potential.

The steps are known and the technologies are proven. Three things immediately can make our journey more effective.

First, we need to ensure the Department of Energy delivers on its statutory obligation to review and update performance standards for equipment and appliances. I can't state strongly enough the importance of these energy performance standards. Households today save approximately $500 annually as a result. The Administration should not be rolling back our progress on commonsense technology improvements.

We must look, secondly, at the more wide-reaching provisions of bills like S. 2137, the Portman/Shaheen bill, passed out of the Committee last month. I urge the Full Senate to take up this bill.

We must, thirdly, continue to accelerate the investment into efficient technologies of the future, that includes reintroducing Senate bill 224.

Let me share a few observations on critical areas where the U.S. may be out of step with the global opportunity and action.

The building sector is one such area. In my written testimony I provide examples of mandatory building energy performance codes. And along with building labeling, these can be very effective at stimulating the market. China is moving swiftly toward requiring building performance standards, Tokyo already cap and trades its building performance and we have the opportunity to look at more innovative, systematic approaches to building performance.

Many of these investments pay back within five to seven years and offer better cash flow for their owners and occupants, yet many building owners and homeowners are forced to purchase inefficient equipment because there is no mechanism to allow them to overcome the first cost barrier—the fact that sometimes, efficient equipment may cost more. Can you imagine our economy if we were not offering low interest loans and leasing for automobiles?

My second focus is on industrial efficiency and equipment manufacturing. In 2018, Senators Kennedy and Carper introduced Senate bill 224, the American Innovation and Manufacturing Act. This bill would provide American manufacturers the policy certainty they need to make cooling and refrigeration product investments that shift away from hydrofluorocarbons. This phasedown is al-

ready agreed to internationally by the Montreal Protocol under the Kigali Amendment and the U.S. market must move in alignment with this international effort. I urge Senator Cassidy, as a co-sponsor of that bill, to reintroduce the legislation to Congress as soon as possible.

Let me offer an example of how this plays out. Right now, there are 675 multinational companies that WRI and the larger coalition of organizations are working with. One hundred thirty of those are in the United States. They've committed to science-based targets to improve their own performance alongside the science and what's required. These companies will be measuring and managing their carbon footprint and the equipment they buy will not just be judged on the quality and the price, it will be judged on the carbon performance. U.S. technology must be able to compete in this race for the future.

But this Committee is also interested in the energy efficiency efforts around the world. The American Council for an Energy Efficient Economy releases a scorecard, and in 2018 the United States ranked tenth alongside Canada but behind China and behind Taiwan. Many of the leaders are European countries that have had strong policy drivers for efficiency. The U.S. can connect this global energy efficiency effort and Senator Murkowski, thank you for joining the Commission and helping support this interaction between the U.S. efforts and global efforts. WRI is doing the same. We joined with the IEA and many other partners around the Three Percent Club. I hope we have an opportunity to discuss that further. It's a global effort—15 countries and over 40 organizations are supporting that effort.

We also work on buildings through our building efficiency accelerator and in conjunction with the United For Efficiency under the Sustainable Energy for All banner, we're working to ensure that the building sector has access to the latest technology. In fact, the doubling of energy efficiency improvement is somewhere that the U.S. is off track, the Business Council for Sustainable Energy reports, along with BNEF, that our productivity declined in the United States, energy productivity declined by 0.4 percent last year.

Yesterday, I spent with the FERC Chairman Chatterjee, who convened stakeholders at the University of Kentucky to discuss today's electricity system and the challenges and opportunities. Utilities, regulators, policymakers, technology advocates spoke about the opportunities for clean, affordable, reliable electricity, yet energy efficiency was not mentioned as part of that agenda.

It is critical that we provide Americans with an integrated set of solutions and technologies, both on the supply and the demand side, and increasingly these two areas overlap.

We look forward to opportunities to work with you all and the Congress and the Administration to ensure that Americans are unburdened from high energy cost.

[The prepared statement of Ms. Layke follows:]

Written Testimony of Jennifer Layke
Global Director for Energy, World Resources Institute

U.S. Senate Committee on Energy and Natural Resources
International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States
October 22, 2019

Thank you for the opportunity to submit a written statement to the U.S. Senate Committee on Energy and Natural Resources' October 22 hearing on *International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States*. We applaud the Committee for examining international best practices and how these can inform U.S. efforts on energy efficiency.

A focus on improving energy efficiency through federal, state, and local actions is already helping to reduce energy waste and lower energy costs across the economy. Energy efficiency reduces energy bills for families across the nation; redoubling efficiency efforts can put even more money in the pocketbooks of all Americans. There are much more cost-effective energy savings that can be achieved. In addition, efficiency can deliver half of the GHG reductions needed by 2050,[1] with a strong economic return ($700 billion in lower energy bills).

The federal government has a number of levers it can use to ensure the market recognizes the important opportunity efficiency presents. This can be through equipment performance standards, tax treatment and fiscal incentives, leadership by example through public procurement and funding research, development and deployment programs. These different levers ensure that U.S. manufacturers continue to innovate and deliver the most competitive products for both domestic and international markets.

Many efficient technologies are already commercially available and can be deployed at scale. These technologies may have a higher first cost but lower lifecycle cost, underlining the importance of efforts this committee is considering incorporating lifecycle costs into investment requirements. These include the All-of-the-Above Federal Building Energy Conservation Act of 2019 (S. 1245) co-sponsored by Senator Hoeven and Senator Manchin, and the Federal Energy and Water Management Performance Act of 2019 (S. 1857) co-sponsored by Senators Murkowski, Manchin, Portman, Shaheen, Gardner, and Hirono.

The U.S. has seen success in scaling energy efficient technologies when federal, state, and local governments include energy efficiency specifications in their procurements or utilize Energy Savings Performance Contracts (ESPCs) via qualified energy service companies. Utility programs and state policies – alongside federal efficiency standards - can play an important role in providing consumers rebates to overcome possible hurdles consumers face in purchasing efficient appliances.

Efficiency is a matter of economic competitiveness. Without standards and incentives for U.S. manufacturers to innovate, there is a risk they will get left behind in global markets. As of September 2019, 675 multinational companies – 130 from the U.S. – have publicly committed to setting greenhouse

[1] S. Nadel, L. Unger, *Half-Way There*, American Council for an Energy Efficient Economy, September 19, 2019, https://aceee.org/research-report/u1907

gas emissions reduction targets grounded in climate science. Science-based target setting is rapidly becoming accepted as a signal of corporate leadership. Efficiency is the first and most cost-effective step to achieve these targets. This initiative now spans 38 countries and 45 sectors, representing at least $10.8 trillion USD in market capitalization. These businesses are going to be purchasing equipment based on energy productivity along with the traditional attributes of quality and price. In this landscape, U.S. companies risk being locked out of markets if products and equipment manufactured in the U.S. are not as efficient as possible.

Energy Demand and the Case for Urgent Efficiency Action

The U.S. Energy Information Agency projects in its baseline scenario that global energy demand will grow by 50% between 2018-2050.[2] In non-OECD countries the growth is projected to be 70%. Meeting the aspirations for economic security and improving the quality of life is greatly assisted if we focus on two simultaneous goals: first, ensuring that in the U.S. and around the world, people are not "locked in" to high monthly energy requirements, and second, linking their energy requirements to supplies of energy that are decarbonized and do not harm their health and the climate.

Renewable energy is now an economically viable supply option for electricity supply at increasingly high penetration levels. But our ability to provide the world's people – and Americans – with the quality of life they seek rests on helping them reduce the total amount of energy they must use alongside their ability to access clean technologies for heating, cooling and powering their homes, businesses and transportation systems. Without a focus on energy productivity, the efforts to deploy new clean supply are dwarfed by the growth in demand.

In OECD countries, residential energy intensity is expected to decrease by only an average of 0.1% per year from 2018 to 2050. This means that for many consumers, their ability to decrease energy demand is not realized under a business-as-usual scenario. In non-OECD countries, energy demand is expected to increase on average 1.3% per year.[3] Leading demand growth in this scenario are China, India and other countries in non-OECD Asia. And finally, it is important to recognize that while we have renewable electricity options, energy efficiency also is required to reduce the amount of primary fuel needed outside of the electricity sector. Globally, the industrial sector is the largest part of the energy economy – and expected to grow 30% by 2050.

International Energy Efficiency Policies and Programs

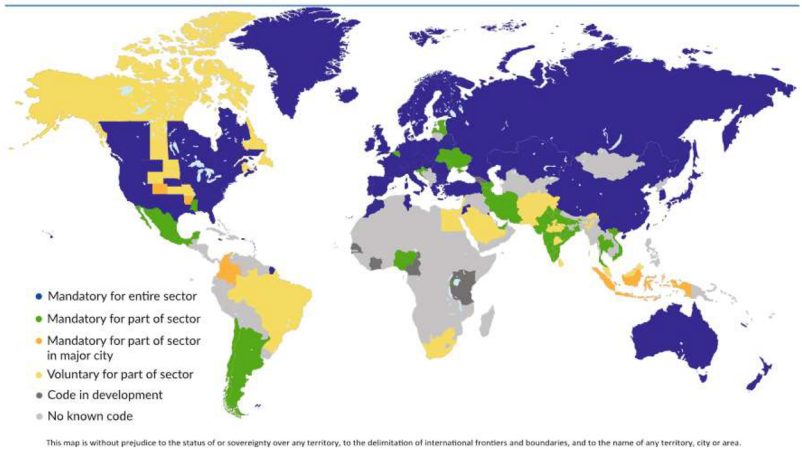
Rising electricity costs, air quality concerns and climate change risks mean many countries are beginning to set targets for energy efficiency improvements. Some countries are seeking dramatic reduction of energy demand from entire sectors of their economy over the next 10 to 30 years. Leading on global efficiency today are: Italy, Germany, France, the United Kingdom and Japan.[4] The U.S. is not in a position of leadership: the policies and actions captured in the 2018 International Energy Efficiency Scorecard show the U.S. tied with Canada in 10th place globally for its energy efficiency policies and actions, behind China and Taiwan.

---

[2] International Energy Outlook, U.S. Energy Information Administration, September 2019, www.eia.gov/ieo
[3] Ibid.
[4] Fernando Castro-Alvarez, Shruti Vaidyanathan, Hannah Bastian, and Jen King, *2018 International Energy Efficiency Scorecard*, American Council for an Energy Efficient Economy, https://aceee.org/research-report/i1801

Recognizing the economic and health issues of energy waste and the need to shift the demand curve to a more sustainable energy demand growth rate, China and India are advancing efficiency policy. As part of **China**'s 13th Five-Year Period (2016-2020), the Ministry of Housing and Urban-Rural Development (MOHURD) released a *Plan for the Development of Building Energy Efficiency and Green Buildings*. This plan encourages provinces and cities to launch pilot and demonstration projects on low-energy buildings and Nearly Zero Energy Buildings, with the goal to identify common techniques for the regulation, design, construction, operation and maintenance of low-energy and Nearly Zero Energy Buildings and to facilitate the improvement of energy saving standards. MOHURD issued voluntary technical standards for Nearly Zero Energy Buildings in October 2018. Local governments are using these standards to put in place local policies on Nearly Zero Energy Buildings and offering subsidies to qualified building developers based on floor area.

The International Energy Agency reports[5] that as of 2018, about one-third of countries have *building energy codes* (see Figure 1): 69 countries have either voluntary or mandatory building energy codes in place and eight other countries have codes under development. In most of these countries, the code has limited strength or is voluntary.



Source: Derived from IEA (2018c), *Energy Efficiency Policies: Buildings*, www.iea.org/topics/energyefficiency/policies/buildings.

Figure 1: Building energy codes by jurisdiction, 2017-2018. International Energy Agency and the United Nations Environment Programme (2018): 2018 Global Status Report: towards a zero-emission, efficient and resilient building and construction sector. https://www.globalabc.org/uploads/media/default/0001/01/0bf694744862cf96252d4a402e1255fb6b79225e.pdf

Some examples of national policies and trajectories on building codes include:

[5] International Energy Agency and the United Nations Environment Programme (2018): *2018 Global Status Report: Towards a Zero-Emission, Efficient and Resilient Building and Construction Sector*. https://www.globalabc.org/uploads/media/default/0001/01/0bf694744862cf96252d4a402e1255fb6b79225e.pdf

- **Canada** has a continuous improvement process and is guided by the target of achieving net-zero energy ready buildings by 2030. The National Energy Code of Canada for Buildings 2017 pushes towards that target with a 10% energy savings compared to the 2011 version.
- The **European Union**'s Energy Performance of Buildings Directive (EPBD) from 2010 requires energy efficiency to be gradually increased to reach "near zero energy" buildings for all new buildings in 2020 and for public buildings in 2018. A 2018 amendment to the EPBD accelerates renovation of existing buildings, with the goal of a building stock that is highly energy efficient and decarbonized by 2050 in a cost-effective transformation to nearly zero energy buildings. Member states have until March 2020 to transpose provisions into national law.
- **India**'s model Energy Conservation Building Code has covered large commercial buildings since 2007 and a residential building version was recently developed in 2018. These model codes can be voluntarily adopted and implemented by state and local governments, which is not common.
- In **Mexico**, the federal government published a national model code, the Energy Conservation Code, in 2016. This code links legal language for new buildings and standards for existing building. It is not mandatory until local governments adopt it in their local building regulations, which is not common.

85 countries have adopted *building certification programs*, most of which are voluntary. Many building certifications are used among high-end buildings to add value. There is still a lack of large-scale adoption of full mandatory certification programs outside the European Union, which limits the tracking and disclosure of building energy performance over time. ENERGY STAR provides a voluntary certification program in the U.S.

In the **European Union**, the Energy Performance in Buildings Directive (EPBD) requires energy performance certificates to be issued when a building is sold or rented, and they must also be included in all advertisements for the sale or rental of buildings. The EPBD encourages member states to link financing measures for energy efficiency improvements to the energy savings, notably using energy performance certificates to compare energy performance before and after renovation.

International Partnerships on Energy Efficiency

Several international efforts aim to increase action on energy efficiency, especially through commitments and awareness-raising of government officials. At the same time, most international efforts incorporate public-private collaboration, in which public sector action is bolstered by private sector commitments and collaboration across these approaches.

Energy Efficiency

The **Three Percent Club** was launched on 23 September at the UN Climate Action Summit in New York by a coalition of 15 countries and over a dozen businesses and institutions working together to drive a 3% annual improvement rate in global energy intensity. This initiative builds on International Energy Agency research showing that the right energy efficiency policies could deliver over 40 percent of the emissions cuts needed to reach the goals of the Paris Agreement, without requiring new technology. The Three Percent Club aims to significantly increase global momentum on energy efficiency, a critical concern since global energy efficiency progress has been slowing since 2015. The coalition will concentrate on accelerating the deployment of available energy-efficient technology and materials in buildings, transportation, appliances, lighting and district energy. Such improvements will lower carbon

emissions, reduce energy costs and air pollution and create local jobs. Delivering on the three percent target would bring household energy savings of $500 billion per year by 2040.

The **Global Commission for Urgent Action on Energy Efficiency**, and the new public-private **Energy Efficiency Global Alliance** are good examples of multi-sectoral leadership efforts designed to focus on scaling efficiency efforts.

The Sustainable Energy for All **Global Energy Efficiency Accelerator Platform**, launched in 2014, promotes public-private collaborations to scale up energy efficiency policies, action and investment in order to double the global rate of improvement in energy efficiency by 2030 – resulting in a target similar to that of the Three Percent Club. This alliance of partners is committing to new and expanded actions to accelerate energy efficiency in specific sectors, including buildings, lighting, appliances, district energy systems, industry and transportation. The Platform promotes stronger collaboration between the public, private and civil society sectors which cover the whole range of policy and regulatory frameworks, technology standards, financial solutions, incentives and public education that together can accelerate action.

One example of the programs within the Global Energy Efficiency Accelerator Platform is the **Building Efficiency Accelerator (BEA)**. This partnership, for which WRI is the Secretariat, comprises 52 cities in 24 countries around the world all working to accelerate policy and program action on building efficiency. Over 50 global organizations, companies, and multilateral institutions – along with dozens of local companies and organizations – provide technical assistance to support actions like improved building codes, retrofits, and targets. In 4 countries (Colombia, India, Mexico, and Turkey), concerted efforts are underway to improve alignment and coordination between national, state, and local governments, especially to learn from leading cities and scale their successes to other local governments within these countries.

Through the **Zero Carbon Buildings for All** initiative, also launched at the UN Climate Action Summit in New York, developing and industrialized countries commit to decarbonize their building sector by 2050 with a goal for all new buildings to be zero carbon by 2030. Four countries have joined this initiative to date, along with more than 15 financial institutions, leading private sector companies, and civil society partners.

Closely linked to this, the **Net Zero Carbon Buildings Commitment** run by the World Green Building Council provides a pathway for businesses, organizations, cities and states to meet these same building sector decarbonization targets. Launched in 2018, this initiative already has commitments from 31 businesses and organizations and 32 cities, states and regions aiming to achieve these goals.

Energy Efficiency in Cooling

Advanced and integrated cooling solutions are a critical portion of a comprehensive energy efficiency strategy. Global markets for air conditioning and refrigeration technology represent a big export opportunity for U.S. manufacturers, and manufacturers that lead on energy efficiency will see market growth for efficient technologies as countries around the world raise standards for cooling technologies to lower costs and carbon emissions. In addition to efficient technologies, integrated cooling strategies are critical to reduce the need for cooling technologies through systems solutions like improved ventilation, building envelopes, and cool roofs. Service providers like Energy Service Companies (ESCOs), many of which are U.S. based companies, are well-positioned to deliver these strategies which will be more important and in higher demand.

The Kigali Amendment to the Montreal Protocol was agreed upon in October 2016 and entered into force in January 2019. Under this amendment, 197 countries committed to cut the production and consumption of hydrofluorocarbons (HFCs)—potent greenhouse gases used in refrigeration and air conditioning—by more than 80 percent over the next 30 years. This effort has the potential to avoid up to 0.5° C increase in global temperature by the end of the century.

A set of initiatives have arisen to support implementation in line with the Kigali Amendment, with the largest to date being the **Kigali Cooling Efficiency Program (K-CEP)**. K-CEP focuses on increasing the energy efficiency of cooling in conjunction with replacing HFC refrigerants with better alternatives by strengthening and accelerating energy efficiency efforts, supporting policies, standards, and programs on cooling efficiency, exploring finance for efficient cooling, and increasing access to cooling. Since its inception in 2017, K-CEP has allocated approximately $48 million to projects in 44 countries, including technical assistance to 27 countries that have committed to include efficient, clean cooling as part of their national development plans. K-CEP includes both energy efficient technology approaches and some focus on integrated cooling strategies.

The **Global Cooling Prize** seeks to spur innovation for a residential cooling solution that will have at least five times less climate impact than standard residential room air conditioners in the market today. The Global Cooling Prize will award up to $3 million in total prize money through the competition. Perhaps more importantly, the prize incentivizes innovation in a market that is expected to grow to 4.5 billion units in use globally by 2050 compared to only 1.2 billion today, providing an enormous market opportunity for manufacturers that can meet this need.

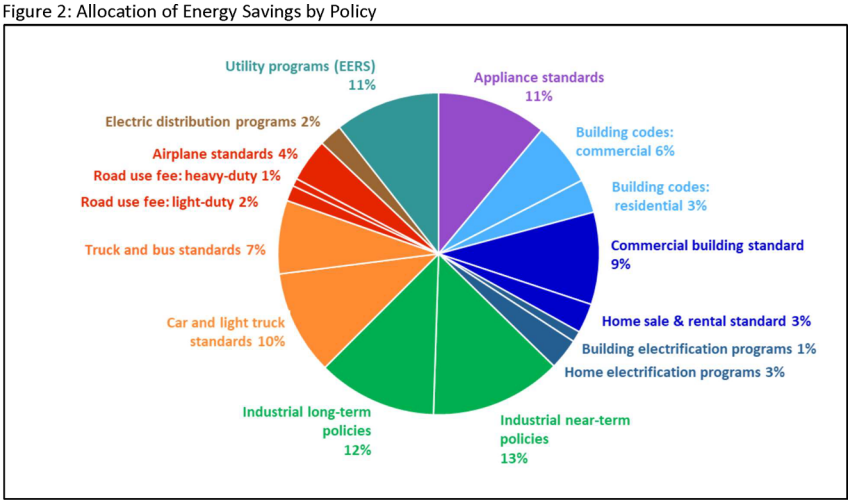
With a similar approach on integrated cooling strategies, the **Million Cool Roofs Challenge** (which is a project under K-CEP) is a $2 million global competition to rapidly scale up the deployment of highly solar-reflective "cool" roofs in developing countries suffering from heat stress and lacking widespread access to cooling services. In a building without air conditioning, replacing a dark roof with a white roof can cool the top floor of the building by 3.5 to 5.5 degrees Fahrenheit. In a one-story building with air conditioning, a white roof can reduce the net annual energy use by up to 20 percent. This approach avoids or minimizes the installation of additional energy-using technologies while keeping buildings cool, and companies providing this service are likely to see significant market growth in the coming years.

Opportunities to Advance Energy Efficiency in the United States through Federal Action

Energy efficiency policy can avoid the lock in of decades of waste. The American Council for an Energy Efficient Economy's analysis of the efficiency policy levers estimated savings that could be achieved in the main segments of the U.S. energy economy: the electricity sector itself, buildings, industry, and transportation. They conclude that with 11 policy actions, the US could reduce its energy burden by 47% by 2050 – which would keep the US aligned with the climate science and keep our economy competitive. Figure 2 depicts the allocation of energy savings by policy.[6]

[6] S. Nadel, L. Unger, *Half-Way There*, American Council for an Energy Efficient Economy, September 19, 2019, https://aceee.org/research-report/u1907

Figure 2: Allocation of Energy Savings by Policy



The federal government has an important role to play, particularly through standards, fiscal incentives, grantmaking, technical assistance, and programming in four main areas:

1) Energy codes and standards (*"setting the floor"*)

Appliance and Equipment Standards

National energy efficiency standards for appliances set minimum energy and/or water efficiency levels for more than 60 products ranging from residential refrigerators, clothes washers and hot water heaters to commercial and industrial equipment like boilers, transformers and motors. These products represent about 90 percent of home energy use, 60 percent of commercial building energy use, and 30 percent of industrial energy use.

These standards are required to be cost-effective for consumers, resulting in cost savings over the product's lifetime. **The average household saves approximately $500 on energy bills annually** due to these efficiency standards. The standards currently in place are expected to save 70 quadrillion Btu (quads) of energy by 2020 and 132 quads through 2030, equivalent to more than a year's worth of energy consumption for the entire country. Additionally, standards increase product innovation and consumer choice. This is evidenced by the lighting market in which consumer choice has multiplied over the past 10 years.

Unfortunately, the **Department of Energy (DOE) has missed statutory deadlines** to review the standards for 18 products (as of June 2019)—including refrigerators, clothes dryers, water heaters, and room air conditioners—and is on track to miss another dozen deadlines by January 2021. Worsening

matters, in February 2019, DOE proposed rolling back standards for light bulbs and changing DOE's standards-setting process, making it more difficult to establish strong and effective national standards.

This failure to act is costing households and the economy. A 2016 ACEEE/ASAP report, Next Generation Standards, found that updates to existing appliance standards could save consumers and businesses about *$43 billion each year* on their utility bills by 2035. Inversely, failure to update these standards will impose this cost burden of *$43 billion each yea*r, and more if standards are rolled back. DOE's proposed rollback of lighting efficiency standards alone would cause consumers to lose $12 billion per year in savings.

Congress should act to hold DOE accountable for the failure to meet these deadlines as required by law.

Building Codes

Building codes establish the minimum level of energy efficiency for new and altered residential and commercial buildings. They improve efficiency and consumer value by mandating good energy performance through careful construction and proper selection of building components.

Codes save businesses and families money. Existing model energy codes are projected to save 12.82 quadrillion Btus of energy and $126 billion in energy costs between 2010 and 2040. Updates that improve these codes could save 2.6 trillion kWh of electricity and 5.6 quadrillion Btu of natural gas by 2040 (about two-thirds and one-fifth of total U.S. annual use respectively) and provide consumer savings of $61 billion.

In this area, the federal government sets a national framework, conducts analysis and makes recommendations for updated codes, but it is up to states to adopt and implement to receive the economic benefits. The federal government has a critical role in providing assistance to states, helping them to update the most recent code and implement and enforce their policies. The Portman-Shaheen bill (S. 2137) would **expand federal assistance to states** on energy codes and could result in savings of 30 quadrillion Btus and $60 billion in consumer savings over 25 years.

2) Fiscal approaches and financial incentives (*encouraging faster adoption*)

Policies also change the economics of acting on efficiency and encourage adoption of technologies that go beyond minimum standards. Congress has passed several **tax incentives** for energy efficiency in the past few decades. These incentives reduce the upfront cost of efficiency making improvements affordable to more families and businesses. Tax credits for efficient equipment such as geothermal heat pumps, solar hot water systems, and combined heat and power remain in effect. Unfortunately, some important ones encouraging comprehensive building improvements have recently expired.

Recent changes in tax law now allow businesses to expense or **depreciate the cost of new, efficient investments** all at once. This eliminates a previous bias in the tax code that disincentivized capital investments and led to inefficient equipment being kept in use well after it was out-of-date.

The federal **Weatherization Assistance Program** has helped to ensure that low-income individuals are also able to obtain the benefits of energy efficiency. It has been highly effective at reducing energy cost burdens for those families participating, but there is still great demand for further implementation.

Beyond federal action, **state policies** set targets for efficiency improvements and require **energy utilities** to implement cost-effective programs (ranging from simple appliance rebates to more involved retrofit

assistance programs) to meet them providing efficiency to their customers. In 2018, $8 billion was invested in efficiency through these programs resulting in 27 million MWh in new electric savings (equivalent to 0.73% of total sales) and 46 trillion Btus in new natural gas savings (equivalent to 0.47% of total sales). A unit of energy not used is the cheapest energy source, as these programs have shown. Over the years, efficiency programs have consistently been able to maintain a lower levelized cost of energy than new supply. WRI's *Seeing Is Believing* study found that these programs regularly save $2 for every $1 invested, and sometimes up to $5. And their benefits go far beyond just cost savings—extending to public health, job creation, and climate mitigation and resilience. Unfortunately, there is a big gap between where leaders are here (2% or more savings per year) and lagging states.

3) Assistance and recognition (*celebrating and encouraging leadership and early adopters*):

Finally, Congress and federal agencies have over the past few decades built the world premier set of programs to assist homes and businesses to make energy improvements, provide recognition for leaders, and build professional and industrial capacity to provide efficiency products and services. These include:

- Leading by example in government buildings through the Federal Energy Management Program, as supported by the Federal Energy and Water Management Performance Act of 2019 (S. 1857) recently reported out of this Committee;
- Assisting small and medium businesses implement energy management systems, like ISO50001, through Industrial Assessment Centers;
- Providing information on and recognition of the most efficient buildings and products through ENERGY STAR; and
- Sharing best practices for improving efficiency for all kinds of new and existing buildings and recognizing through the Better Buildings Initiative.

These programs and tools provide the foundations for many state efficiency programs and are central to the business models of many firms providing efficiency services or products. It is essential that Congress continues to invest in these programs and, by extension, American capacity to innovate and improve.

The United States can lead on energy efficiency. Doing so will safeguard the ability of our citizens to enjoy clean air and avoid the burdens of high energy bills due to fuel charges. In buildings, industry and transportation, global growth and economic development represent market opportunities for our businesses. U.S. products and technology must remain on the cutting edge of efficiency if we are to compete in emerging markets and with multinational companies' product expectations. The Senate Energy and Natural Resources Committee has the opportunity to chart a course using data and information on the best available policy options and help ensure that our efforts on RD&D, fiscal and tax policy, equipment and appliance codes and standards and, leading by example, chart a course to global competitiveness and secure Americans' energy future.

The CHAIRMAN. Thank you, Ms. Layke.
Mr. Tew, welcome.

STATEMENT OF W. SCOTT TEW, EXECUTIVE DIRECTOR, CENTER FOR ENERGY EFFICIENCY & SUSTAINABILITY, INGERSOLL RAND

Mr. TEW. Thank you, Chairman Murkowski and Ranking Member Manchin, and good morning to all of the members of the Committee. It's a pleasure to be here with you today.

My name is Scott Tew, and I lead the development of Ingersoll Rand's global positions with regard to energy, energy efficiency, climate and sustainability. Through our climate-based businesses, Thermo King and Trane, we heat, cool, and automate homes and buildings and keep transported food and perishables safe and fresh. We're also playing a key role in the evolution of innovation as a catalyst for energy efficiency.

As our planet continues to face the ongoing challenges brought about by urbanization, resource constraints, workforce dynamics and, of course, climate change, Ingersoll Rand and Trane and Thermo King are developing and unleashing solutions that help. We've been at this a very long time.

When our company was founded nearly 150 years ago, Ulysses S. Grant was President. The great State of Alaska was still 88 years from officially becoming a state. With time has come experience and we believe, also, credibility and at the heart of everything we do is a commitment to efficiency and sustainability, a greater purpose that allows us to make a positive impact on the world.

At Ingersoll Rand we set and deliver on energy efficiency and climate commitments. We delivered our first-generation commitments well ahead of time. In 2014, we set out to reduce the greenhouse gas refrigerant footprint of our products by 50 percent by the year 2020. Our efforts, though, actually yielded a 53 percent reduction, two full years ahead of schedule. We also pledged in 2014 to reduce our operational greenhouse gas footprint by 35 percent and, again, we were able to reduce that impact by an even greater number, 45 percent, also two years ahead of schedule. We're also on pace to fulfill a pledge to invest $500 million in product-related innovations by 2020.

We have much to be proud of, but also much work remains to be done. To that end, we recently launched a 2030 commitment with new environmental targets. Here are three of them. One, we plan to transform our global supply chain. Two, we plan to reduce our customer's carbon footprint by one gigaton of carbon, something we call the Gigaton Challenge. It is the largest customer facing climate commitment ever made by a company. In case you're wondering, a gigaton is equivalent to the annual emissions of Italy, the UK and France combined. It's large. Number three, we're increasing the opportunity for all by strengthening the economic mobility and bolstering the quality of life, not only of our workforce but also in the communities where we have major investments.

From our advantage as a leader in the business of sustainability, we believe there are a few key points to keep in mind as policymakers, regulators and industry work together to identify future energy efficiency solutions.

First, energy efficiency is good for business. It's good for consumers, it's good for the health of the climate and that's why energy codes and appliance standards remain the bedrock of an effective building energy policy in developed economies like the U.S. Improvements in appliance standards for air conditioning and equipment now mean that our products use 35 percent less electricity, providing the same cooling capacity with no tradeoffs. These policies not only save consumers money and reduce greenhouse gas emissions, they also allow us to manage the energy use of our products which, in turn, modernizes the energy infrastructure. Ultimately, U.S. leadership on energy efficiency standards means that we can focus our innovation for North America while seeking opportunities to bring those technologies to countries developing their own standards elsewhere.

The second point I'd like to highlight is that future building policy must recognize system interactions within buildings and the environment. So while there will always be a place for robust energy codes and appliance standards, we have to begin thinking beyond energy performance of components at the individual product level because that's where the biggest opportunity for energy savings will come from in the future.

Great care must be taken when it comes to crafting codes and standards so that solutions that improve overall efficiency at the systems level, remains available to consumers. The potential opportunity does not stop at the building system level either, buildings can be assets in our infrastructure. Building management systems can respond to signals from the grid and can automate any connected subsystems at the component level. That is the essence and the calculus of energy efficiency, determining the desired energy outcomes for improvement, assigning metrics to measure their progress and implementing policies that encourage solutions.

Looking ahead, the work remains challenging but incredibly exciting. I'm privileged to work in this industry that continues to transform the planet, our communities and lives for the better.

Thank you again, Chair Murkowski, for allowing me to make my comments.

[The prepared statement of Mr. Tew follows:]

Before the
Committee on Energy and Natural Resources
United States Senate

Hearing on
"Energy Efficiency Efforts in the United States and Internationally"

Statement of W. Scott Tew
Executive Director, Center for Energy Efficiency & Sustainability
Ingersoll Rand

W. SCOTT TEW, Ingersoll Rand **October 22, 2019**

Summary of Key Points

- Ingersoll Rand, and its strategic climate brands Thermo King and Trane, are playing a key role in the evolution of innovation as a catalyst in the area of energy efficiency.
- As the world continues to face the ongoing challenges brought about by urbanization, resource constraints, workforce dynamics, and climate change, we are developing and unleashing solutions that will help our planet.
- Ingersoll Rand makes energy efficiency and sustainability commitments designed around our global supply chain and operations, our industry-leading products, systems and services, and quality-of-life enhancements.
- At Ingersoll Rand, we set and deliver on our energy efficiency and climate commitments, and delivered our first generation commitments one year ahead of time.
- Earlier this year, we launched our '2030 Sustainability Commitments' with new environmental targets that include:
    - Transforming our global supply chain;
    - Reducing our customer carbon footprint by one gigaton of carbon dioxide through our heating, ventilation, air-conditioning, and transport refrigeration products and services; and
    - Increasing opportunity for all by strengthening economic mobility and bolstering the quality of life of our workforce and those in the communities where we operate and serve.
- We believe there are a few key points to keep in mind as policymakers, regulators, and industry work together to identify new solutions for our nation's energy efficiency needs.
    - Energy efficiency is good for business, consumers, and the health of our climate.
    - Future building policy must recognize system interactions within buildings and their environments.

Written Testimony of W. Scott Tew, Ingersoll Rand

Thank you Chairman Murkowski, Ranking Member Manchin, and good morning to all of the members of the committee.

My name is Scott Tew and I help lead the development of Ingersoll Rand's global regulatory and industry positions with regard to energy efficiency, sustainability, and climate. Through our strategic climate businesses, Thermo King and Trane – we heat, cool, and automate homes and buildings and keep transported food and perishables safe and fresh. We are also playing a key role in the evolution of innovation as a catalyst in the area of energy efficiency.

We're passionate about building a better future - a world marked not just by progress, but s*ustainable* progress. And as our planet continues to face the ongoing challenges brought about by urbanization, resource constraints, workforce dynamics, and of course, climate change, Ingersoll Rand, and our Trane and Thermo King businesses, are developing and unleashing solutions to help. We've been at this a long time – when our company was founded nearly 150 years ago, Ulysses S. Grant was President, and the great state of Alaska was still 88 years from officially becoming one. With time has come experience and, we believe, credibility. And at the heart of everything we do is our commitment to sustainability, a greater purpose that allows us to make a positive impact on the world.

Chairman Murkowski, I would like to commend you for convening this important hearing today to discuss ways our nation can tackle energy efficiency and

sustainability issues both here in the United States and abroad. We are honored to be a part of the conversation and look forward to working with you and all members of the committee.

For our part, Ingersoll Rand makes energy efficiency and sustainability commitments designed around global supply chain and operations, industry-leading products, systems and services, and quality of life enhancements. They allow us to address global issues like climate change, and to be the brands the world looks to for solutions that reduce energy dependence and emissions while preserving food, water, and other natural resources.

At Ingersoll Rand, we set and deliver on energy efficiency and climate commitments, and delivered our first generation commitments ahead of time. In 2014, we set out to reduce the greenhouse-gas refrigerant footprint of our product portfolio by 50% by the year 2020. Our efforts though actually yielded a 53% reduction two full years ahead of schedule. We also pledged in 2014 to reduce our operational greenhouse-gas footprint by 35%. Again, we were able to reduce that impact by an even greater number, 45%, and years ahead of schedule. We are also on pace to fulfill a pledge to invest $500 million in product-related innovations and development by 2020. So we have much to be proud of, but plenty more to do.

To that end, we recently launched our '2030 Sustainability Commitments' with new environmental targets that include:

1. Transforming our global supply chain to have a restorative impact on the environment by achieving carbon neutral operations and limiting our impact on water supplies.
2. Reducing our customer carbon footprint by one gigaton of carbon dioxide through our heating, ventilation, air-conditioning, and transport refrigeration products and services. We call this 'The Gigaton Challenge,' and it's the largest customer climate commitment ever made by a company like ours. In case you're wondering, a gigton is roughly the equivalent of the annual emissions of Italy, France, and the United Kingdom combined. Trust me, it's a lot. But we will get this challenge done by continuing to invent, innovate, and invest.
3. Increasing opportunity for all by strengthening economic mobility and bolstering the quality of life of our workforce and those in the communities where we operate and serve. This includes gender parity in leadership roles and a workforce reflective of our community populations.

From our vantage as a leader in the business of sustainability, we believe there are a few key points to keep in mind as policymakers, regulators, and industry work together to identify new solutions for our energy efficiency needs. First, energy efficiency is good for business, consumers, and the health of our climate. And that's why energy codes and appliance standards remain the bedrock of any effective building energy policy in developed economies like the U.S. Advancements in this area mean that new U.S. buildings built to code are over 30% more efficient than they were forty years ago.

Improvements in appliance standards for air conditioning equipment now mean that our products use at least 25-35% less electricity, but provide the same cooling capacity. These policies not only save consumers money and reduce greenhouse-gas emissions in their own right, but they also allow us to manage the energy usage of our products, which in turn, modernizes our energy infrastructure. And that's something we need given the challenges we continue to face.

For example, buildings were responsible for 39% of energy use and 36% of carbon dioxide emissions in the United States in 2018 alone. In addition, the heating and cooling of buildings constitute 12% of our total annual emissions, a figure that could double by 2030 as urbanization accelerates and the environment gets warmer. According to the *Rockefeller Foundation* and *Deutsche Bank,* a $279 billion dollar investment in retrofitting residential, commercial, and institutional buildings in the U.S. would yield over $1 trillion in energy savings over 10 years. That represents 30% of the annual spending on electricity in the U.S. and a cut in emissions of almost 10 percent. And it's just one area where we can, and must, continue to focus our efforts in the energy efficiency space.

It is important to remember too that pragmatic and reasonable energy efficiency standards benefit everyone. They ensure that consumers are protected from the costs of higher utility bills that come from purchasing less efficient equipment. And for solution providers like Ingersoll Rand, energy efficiency standards provide business certainty which affords the opportunity to strategize new product development and market accessibility. That is especially important for our

commercial and industrial customers, who value increased predictability and the management of energy costs as reassurances that they can invest confidently in other areas.

Ultimately, U.S. leadership on energy efficiency standards means that we can focus our innovation on solutions designed for the North American market, while seeking opportunities to bring technologies to countries developing their own standards.

Finally in this area, energy efficiency leadership does not stop with codes and standards. By promoting and incentivizing federal programs like ENERGY STAR, even more energy savings will benefit consumers and improve the way we measure, track, and optimize energy consumption.

The second point I would like to highlight is that future building policy must recognize system interactions within buildings and their environments. So while there will always be a place for robust energy codes and appliance standards, we all must begin to think beyond energy performance at the individual product level. Because that's where the bigger opportunity for energy savings will come from – in the way building products and systems interact with one another, are controlled, and respond to constantly changing environmental conditions.

Great care must also be taken when it comes to crafting codes and standards so that solutions that improve overall efficiency at the system level remain available to consumers. To further achieve this outcome, codes and standards need to continue

evolving with the flexibility to incorporate system-level effects, and encourage optimal efficiency in a given application.

The potential opportunities do not stop at the building-system level either – buildings are also assets in our infrastructure and our environment. Building management systems can respond to signals from the grid, and automate any connected subsystem or component to optimize performance. Likewise, connected buildings can respond to external conditions, and adjust operations to maintain a comfortable indoor environment while minimizing impact on the outdoor environment. That is the essence and the calculus of energy efficiency – determining the desired energy outcomes for improvement, assigning metrics that identify progress, and implementing policies that encourage solutions to achieve them.

Looking ahead, the work remains challenging, but incredibly exciting too. And I am privileged to work in an industry that continues to transform our planet, our communities, and our lives, all for the better.

Thank you again Chairman Murkowski for the kind invitation to be here today and I look forward to answering any questions you and the committee members may have.

The CHAIRMAN. Thank you, Mr. Tew, and thank all of you. We appreciate your comments, and I look forward to the discussion.

I am going to defer my questions and turn to Senator Gardner for the first round here.

Senator GARDNER. Thank you, Madam Chair. Thank you for the opportunity to ask questions, I truly appreciate the deferral.

To the members of the panel here, thank you very much for being here today. Chairman Murkowski, Ranking Member Manchin, thank you very much for doing this hearing today.

As we all know, the United States has made great strides when it comes to addressing our emissions and our energy use. Energy efficiency is not only good for our environment, but it is good for our consumers as well. The average American has saved almost $2,500 per year on their energy bills because of the achievements we have made, but more needs to be done, more can be done.

I am proud to have joined both the Chairman and Ranking Member in introducing the Federal Energy and Water Management Performance Act of 2019 which formally authorizes the Federal Energy Management Program so we can leverage the knowledge and expertise of the Department of Energy to help other federal agencies increase their energy efficiency.

I am also proud to have teamed up with Senator Coons to reintroduce legislation that I have been working on for the past several Congresses, the Energy Savings Through Public-Private Partnerships Act of 2019, which will encourage the use of energy savings performance contracts (ESPCs) in federal buildings. Using the ESPC model will allow private companies to use their own money and resources to make energy efficiency upgrades to federal buildings at no cost to the taxpayer. In exchange for making energy efficient upgrades, those private companies receive a portion of the money saved as a result of the increased efficiency. This could save billions of dollars, creating thousands of private sector jobs, all resulting in greater energy efficiency and lower emissions.

One of the things that we have talked about over the past several months has been this statistic that we came across that goes back roughly 15 or 20 years. Over that course of time, 50 percent of the emissions reductions achieved by the United States have been achieved through gains in energy efficiency. So nearly half of our emissions reductions have been achieved through energy efficiency. That's greater than renewable energy emission reductions or fuel switching emission reductions combined.

Now I am under the understanding that most of those savings came from efficiencies in the generation process. So I guess I would just ask, and I don't know who the appropriate one on the panel is to ask this. If that is the case, if we have made such significant strides in energy efficiency through the generation side of things, how can we export that knowledge, those technologies, those efficiency gains in the United States to China, to India, other areas where they obviously have not created those kinds of efficiencies? And what would that mean from a global emissions reduction standpoint in real time? I don't know who wants to take a shot at that?

Dr. Motherway.

Dr. MOTHERWAY. Thank you very much, Senator, for your comments. And I must say, I'm very pleased to hear how much dynamic action is going on in the U.S. at the moment around energy efficiency, and I commend the Senators for the range of activities.

The U.S. has made tremendous strides in energy efficiency in the last couple of decades, and you cite the numbers to support that. And I think there are tremendous opportunities to export technologies, but also, the kind of business models you spoke about in terms of performance contracting and financial innovations and all that goes with that.

And for me, certainly, the next phase will be driven by how digital technology makes that more possible in terms of measuring savings, giving customers and suppliers security.

And I must stress that the number you cite in terms of the gains, in terms of emission reductions from the last couple of decades being nearly half from efficiency, the same will be true in the next couple of decades. According to our analysis, in the next two decades efficiency has the potential to provide almost half the total emission reductions available from the energy sector entirely.

And I think the opportunities for export will be driven by certainly what we see that the global interest in energy efficiency and the available solutions has never been higher. So I must totally agree with your point that the opportunities are very strong.

Senator GARDNER. Thank you.

Yes, Ms. Layke.

Ms. LAYKE. Thank you, sir.

I am encouraged by the conversation of this, sort of, integration of both supply and demand side. This is one of the areas where, I think, there's tremendous opportunity.

And let me point to the long tradition that the United States has had in multilateral and bilateral cooperation efforts both through the EPA, through the Department of Energy and through the Department of State. There are existing efforts underway with the Department of State, for example, to look at grid modernization in India. Those types of programs and the cooperation that the U.S. Government can have in enabling capacity building for these kinds of technological advancements is one of the things that we've done very well in the United States.

I, myself, began my career working on multilateral ozone protection efforts the United States worked on with China and with other countries to ensure the phaseout of CFCs in that first generation. Similar programs could help advance digital technology and modern the grid infrastructure.

Senator GARDNER. Thank you.

Dr. Motherway, going back to your point. Your projections show that, I don't know, the next several years that global energy emission reductions will be achieved at least half by and through energy efficiency. Is that how you said that?

Dr. MOTHERWAY. That's correct, yes, just under half we expect in the next two decades can come from energy efficiency.

Senator GARDNER. Great. Thank you very much.

Thank you, Madam Chair, thank you.

The CHAIRMAN. Senator Manchin.

Senator MANCHIN. I am also going to defer to my friend from New Mexico, Senator Heinrich.

Senator HEINRICH. Thank you, both.

I want to first make the point that one of the frustrations that all of my constituents seem to have is that Congress is not getting a lot done, and I think that is an accurate estimation.

This Committee has been a relative exception, and we have seen legislation marked up on economy-wide energy efficiency. We have seen federal building upgrade legislation. We have seen energy storage legislation.

I hope all of us will take this hearing as an opportunity to go back and push on Senate leadership to get those bills on the Floor, because we can get an awful lot done based on the good work that has gone on from our Chair and our Ranking Member on this Committee.

Mr. Bresette, so much of this discussion, especially around economics, comes down to the tension between short-term economics and long-term economics. I remember when the light bulb standards were first being debated on the Floor of the body on the other side of the Capitol, the U.S. House. A number of our colleagues came to the defense of the economics of their constituents but in a somewhat misguided way trying to protect the incandescent light bulb. I just pulled up a little search of what the life-cycle costs now are of incandescent versus LEDs and for 25,000 hours at the equivalent of 60 watts, the lumen equivalent, an incandescent will cost you $180, and an LED will cost you $30. In effect, what we are doing for those folks who are pushing the protection of incandescent over newer technologies is locking people in to a higher cost of energy per month, six times higher, actually.

We need to find those mechanisms that provide a way to finance the difference between the short-term economics and the long-term economics. You mentioned on-bill financing as a way to do that. Do all of you support that kind of approach and what do you think of other mechanisms, be they property assessment mechanisms or others?

Mr. BRESETTE. Thank you, Senator.

Yes, I think generally speaking, that's, kind of, the magic of financing. It reduces the emphasis on the upfront cost and that allows the beneficiary to focus on the long-term benefits.

You know, it's easy to focus on what's immediate. And when the immediate stops being the cost and it starts being the benefits which accrue from day one, that's really the magic of financing. On-bill financing that ESI works on is typically targeted at rural utilities. That seems to be where there's a lot of interest. But there are lots of other financing mechanisms.

You mentioned property assessed clean energy (PACE), that's a good one. Many states have revolving loan funds for larger commercial projects or multifamily projects. There are also deferred payment programs. These are leveraged, sort of, mostly like consumer credit programs. And then there's also performance contracting which is, at its heart, a financing mechanism.

Senator HEINRICH. Yes.

Mr. BRESETTE. I think one thing that you would notice is that those programs are all fairly targeted to that end user, right, to

that customer. A performance contract may not work for a homeowner. On-bill financing might not work for, you know, given technologies or maybe where PACE would come in.

But financing is really important. As financing importance has increased, I think that's been driven, at least in part, by an awareness that rebates are limited. A lot of the program development in financing and in rebates, of course, is done by the utility sector.

Senator HEINRICH. Right.

Mr. BRESETTE. And rebates are a finite resource. Financing has the ability to constantly be recycled and to spread those benefits wider.

Senator HEINRICH. We have seen the Administration recently roll back the efficient light bulb standards. Do any of you think that that is smart policy?

[Witnesses nod, no.]

Senator HEINRICH. Moving on.

Space cooling.

Senator KING. Let the record note, silence.

Senator HEINRICH. Yes, thank you.

Space cooling is a huge and growing issue, and it is growing, in part, because people in very warm, tropical climates rightfully expect now the kind of lifestyle and basic work environment that we have enjoyed in this country for a long time.

It is also growing because places like Washington, DC, are seeing more and more days above 90 degrees every decade that we move forward. So this is going to be a really critical place.

We have somebody in the private sector. We have Dr. Motherway, who knows this issue very well. What are the role of technologies that are not traditional cooling such as heat pumps in solving this issue, and I am curious, Mr. Tew, if your organization supports the Kigali Amendment to the Montreal Protocol?

Mr. TEW. Thank you for the question, Senator.

And so, a few questions there that you asked. One is about heating and cooling. Obviously, it is a big deal. Buildings represent 39 percent of electricity use, a large portion of that is heating and cooling. And heating and cooling should no longer be viewed as a luxury item, to your point.

It's not about just tropical locations. We sell systems in Alaska just like we sell in tropical locations.

Kigali is important. Kigali is important for several reasons. One is it's about next generation refrigerants, and it's about phasing down the ones that are not climate friendly. Seventy-five nations have already ratified the Amendment.

We think it's important here for one big reason. It really would help us move past a patchwork quilt of standards at a state level. So we need U.S. policy and ratification to help us do that.

To your other point about the connection between heating and cooling and electricity use, it's also climate connection as well, as you know. Indirect emissions from the energy used to power heating and cooling represents roughly 12 percent of emissions in the U.S. So it's significant. It's also overlooked many times. We go after the shiny objects, and many times we don't focus on the built environment that already exists in buildings like this one.

And as we just mentioned, the financing. We fixed a lot of the financing through ESPCs, performance contracts, and other ways. The ROI is there as well, the return on investment, over time.

So I think we've addressed and checked most of the boxes. It's not only good for business and good for building owners, it's also good for the environment.

The CHAIRMAN. Thank you, Senator Heinrich.

Dr. Motherway, you mentioned, and we are all talking about, the extraordinary potential of efficiency, but your recognition of the fact that these gains that we have been making in efficiency, we are starting to see slow down. Obviously that should concern all of us. If we are recognizing that this is the easiest thing to do, the first place we should go, and yet we are slowing down in these gains.

And you note that IEA, one of the things that you do is analyze these trends. So you are seeing it happen.

A couple questions for you.

First, as you are looking at these trends, are we seeing this slow down only in the United States or is this happening around the globe with other countries as well, or are we slowing while everybody else is continuing to move on forward? And then, a bigger question. You note the various ways that we advance policy whether it is through regulatory, mandatory standards, voluntary or market-based driven and you cite the example of the Japanese. I think the Japanese as a culture are probably more amenable to being told "this is what we will require." In this country, as Senator Manchin has pointed out, we are still arguing over the light bulbs here in terms of whether or not we should have options. I guess the question to you is, how do we raise the profile of energy efficiency so more people are excited about it, like they are other energy technologies?

We are always talking about the latest, greatest, innovative thing and we keep the words like "shiny object" out there. Why haven't we been able to make energy efficiency be that cool thing that we are all trying to do?

So two prongs here. Is everybody, kind of, slowing down on the efficiency side? And then, recognizing that, what more can we do to reverse this trend that you are seeing?

Dr. MOTHERWAY. Thank you, Chairman.

So yes, the slowdown is global. Patterns change in different parts of the world, but everywhere we see a decreasing rate of progress.

I want to stress that the world is becoming more efficient each year. We are still extracting more value from the energy we use every year, but in 2015 the rate of improvement was almost three percent. In 2018, it was 1.2 percent. So we're going in the right direction, but at a much slower pace than we were previously. And then, compared to what we could be doing. It is a global phenomenon.

It's driven in many countries by increasing economic growth, increasing economic activity. People are getting access to more energy services. Cars are becoming bigger. Homes are becoming bigger. These are all bringing benefits to people's lives. These are good things.

But energy efficiency policy now needs to work even harder than before to have its impact in the face of these trends and——

The CHAIRMAN. So it is not just that we have gone after the low-hanging fruit. So much of this is being driven by the demand for energy, just writ large?

Dr. MOTHERWAY. Yes.

And there are certain factors such as we see certain sectors, intensive industrial sectors, growing faster than the general economy, but it's not that we are running out of things to do to make the world more efficient, it's more driven by the wider trends.

And I take your point in terms of I confess to having spent several decades failing to make efficiency exciting or sexy, but I'll keep trying. And I think we've heard a lot of very good points made here by the Committee and by my colleagues on the panel that the average person doesn't think about efficiency. They do not say, "I want to be efficient." "I want to buy something efficient." They want good services. They want nice appliances, nice homes. They want low bills. Often, they do want to make their environmental contributions. So I think we all need to stress the wider context for efficiency in terms of its role in enhancing economies, making economies more resilient, making neighborhoods more resilient and, of course, lowering bills and lowering environmental impacts.

So I think we need to focus on how people think about these things, how they make their decisions and stress that efficiency is an ingredient in a wider project of social and economic development.

The CHAIRMAN. It comes back to education.

I will yield my time and turn to my colleague here, Senator Manchin.

Senator MANCHIN. Thank you, Madam Chairman.

To anybody, but I think, Dr. Motherway, it might be more to you. How many people in the world do not have any electricity or energy would you say, of the seven plus billion? Do you have a rough idea on that or?

Dr. MOTHERWAY. It's about a billion people.

Senator MANCHIN. A billion that do not.

Okay, and how many under energize or first-generation energy recipients?

Dr. MOTHERWAY. I would say, one way or the other, the majority of people around the world do not have the full access to all the energy that——

Senator MANCHIN. The reason I am asking the question, I think back to my grandparents and my grandparents coming here at the turn of the century, the 20th century. And I remember my grandmother talking about the first time she got a washing machine or a refrigerator. I can assure you she wasn't worried about how she got it. She wasn't worried about how it was produced, how much pollution was being emitted when she got it. She was just tickled to death to have it.

I was in India and all the rural areas, and you see mostly the females during the day, gathering up manure to heat it, I mean to bake it and then use it as fuel. If they are able to flip the switch or chain on something, they don't care either. How do we incentivize these nations?

If we had a more matured country that could have shown us, they already have technology that even though we are going to be first generation, we are using it in the cleanest fashion?

I am thinking, how do we get India? How do we get some of Asia, some of the developing nations now, to use some of the technology that we have had? How do we do that? What kind of a policy? Do you need a trading policy? You don't want to use a carrot and a stick, but you have to have the carrot, if you don't incentivize them to use a new technology.

I will give you a perfect example. If we'd had scrubbers, low NO_X boilers and baghouses for mercury back in the 1930s, we could have started out in pretty good fashion. That did not happen until 2000, 2010. And I don't know if the world can stand us to go through another cycle with billions of people coming on board using old technology. I think that is it in a nutshell.

Any comments you might have along that which are, and how to make it, or to make it sexier, not just the facts of what we are dealing with?

Dr. MOTHERWAY. I couldn't agree more, Senator, and I think you put it very well. I think one interesting example is the topic of cooling which is something we talk about a lot because it's effectively the fastest growing demand for electricity globally. And the simple reason is here in the United States, nine out of ten households have air conditioning where in India, it's less than one in ten.

And, of course, as they become richer——

Senator MANCHIN. Now look at what China is doing. They are using more now. They are using 70 percent in the last few years for air conditioning.

Dr. MOTHERWAY. Absolutely.

And I think we realize if India were to follow the same path in terms of installing very large amounts of inefficient air conditioning, the economic and environmental costs would be enormous.

And I think that's where your point about the new generation of technologies is really important, not just much more efficient air conditioners, but also, more efficient buildings, much cleaner electricity systems.

In particular what I would stress is countries that haven't fully developed or rolled out these technologies have an opportunity to leapfrog other parts of the world including many of our countries because they can move to much more efficient equipment. But also, as I mentioned, digital technology is making things much more easy to control, to measure, to monitor. It's really rolling out a new generation of technology.

And I think, I see great opportunities to countries like the U.S. to be involved in that global conversation in terms of rolling out expertise and helping others learn from its experience.

Senator MANCHIN. But I am saying, how do you incentivize it?

You might want to talk about that, Ms. Layke and then also Mr. Tew, it comes right down your alley, I think.

Ms. LAYKE. Thank you for the opportunity to respond.

There are three things that, I think, we can learn from.

First, the topic or the theme of energy efficiency is helpful to embed in other characteristics. People are looking for opportunities to improve their lives. They're looking for the best technologies.

They're looking for solutions, whether you are in Africa or you're in the United States, you're going to be, you're drawn to those technologies that you believe have the highest value to you.

So how do we demonstrate that? We can label. ENERGY STAR labeling has worked very well in the United States.

We can talk about the attributes and we can create competition in the market to incentivize these types of things.

Right now, in India and around the world, there's a Global Cooling Prize, for example, where manufacturers and small startups and universities are looking at heating and cooling and how to begin to build a new generation of technologically sound solutions that can help across income spans. So how does that household in India afford this?

But the other area that we could work on is things like integration. So, zero-carbon buildings. Thinking about how you take both the energy supply and the energy demand and you put that together in a way. That's the appeal of an automobile powered by a battery, that it could potentially become your backup in your home. Those are the types of solutions that allow energy efficiency to move forward.

We have been working on a zero-carbon building and announced in September a partnership to look at opportunities for zero-carbon buildings around the world. I do believe this is one opportunity to reframe the building space as both an opportunity for supply and demand to come together to create energy efficient performance.

Mr. TEW. And I'll just make a comment, Senator.

You make good points about India and other developing countries. A lot of studies say that a billion new air conditioners will be put in service over the next decade. Currently, the infrastructure in the developing countries, in particular, maybe our own, can't support a billion new air conditioners unless we begin approaching efficiency at a systems level, to Jennifer's point.

We've got to think about more than just the incandescent light bulb, it has to be the full system. How efficient is the home, is the commercial building? How efficient is the grid that it will pull from? And it all has to be attacked and not just at a component level, but also at the systems level. I think that's just really important to consider.

Senator MANCHIN. Thank you, Madam Chairman.

The CHAIRMAN. Senator King.

Senator KING. Thank you.

Fascinating subject and panel.

I want to go back to something that Senator Heinrich talked about, because I think it is really important. A lot of these decisions are individual and the big problem for individuals is capital and the big issue is financing.

I just got a new iPhone. And it was financed, essentially, in my phone bill. I did not pay any upfront costs; therefore, I really didn't think too much about it. I wanted the new phone, and so it folded right in. Maybe I am not a very good consumer, but it worked. The point is, I think, on-bill financing, we have really got to emphasize that.

Ms. Layke, you mentioned a five- to seven-year payback. For most corporations, that is not good enough.

I used to be in the energy efficiency business, and my clients wanted 1.5- to 2-year payback because they are allocating scarce capital within the corporation and they are looking for a short payback, particularly in the world of quarterly results.

I would urge you, perhaps this would be a question for the record, to give us your best wisdom on financing techniques, particularly as they apply to individuals. Corporations are pretty sophisticated with how they can do financing.

The other piece is interest rates. I used to work with an automobile dealer, and they said that the biggest determinant of car sales was interest rates which really surprised me. Interest rates go down, car sales go up because people are concerned about what their monthly payment is.

Please give us some thought on this because one of the big, at least in the northern tier states, one of the big issues is heat pumps which are very efficient, very good change, but they are expensive. The capital investment is high. So give me some thoughts on that.

Another thought is you mentioned, Mr. Tew, at the end of your comments the grid itself. The grid, itself, is grossly inefficient.

I just looked this morning at the New England grid. At four o'clock this morning it was 9,000 megawatts. At 4:30 this afternoon, it's going to be around 15,000 megawatts. That is a 66 percent swing.

If we can have techniques such as time-of-day pricing, electric vehicles, energy storage in the home during the day, so you draw down your energy at night, use it during the day in terms of things like space heating, we can drastically increase the efficiency of the grid.

We always talk about generation. But in Maine, anyway, the transmission and distribution cost equals the generation cost. In fact, it is somewhat higher.

So that is not, it is not a climate change issue, but it is certainly a cost issue because if you can use the current grid more efficiently, everybody's price per kilowatt-hour goes down because the cost of the grid is spread over the number of kilowatt-hours. I urge you to consider time-of-day pricing.

Mr. Bresette, is that something you guys have looked at or some other incentive to even out that very dramatic curve?

Mr. BRESETTE. Yes, for sure.

And also as some of the technologies that my fellow panelists have talked about, you know, especially with respect to electric vehicles. Electric vehicles become more commonplace in residential settings, then you have this battery on four wheels that can be used to absorb power at different times of the day and then deploy it as a storage device.

Can I make three quick comments with respect to financing?

Senator KING. Please.

Mr. BRESETTE. The first is you hit the nail exactly on the head. Monthly payments are critical.

Senator KING. Could you say that again? I would like that to be in the record.

[Laughter.]

Mr. BRESETTE. Okay.

Senator King, you hit the nail right on the head. Monthly payments are a huge thing. That's how people tend to, how individuals tend to think about what they can afford. Right?

Senator KING. Right.

Mr. BRESETTE. That's why, you know, there are—that's why when you go to a car dealership to buy a new car, the last thing you talk about is financing. Right? You talk about what color it is. You talk about the interior. You talk about pinstriping. You talk about all sorts of stuff. And then at the very end, someone is like, oh, and how are we going to pay for this today? It's almost a forgone conclusion for people with acceptable credit. And for people who don't have acceptable credit, there are options, but they're still able to finance it, maybe not a new car, but something.

The second point I'd like to make is you mentioned simple payback. The one reason why simple payback often comes up in conversations of energy efficiency is because it's difficult to evaluate what an actual return on investment of energy efficiency is. Simple payback is a shortcut in a lot of ways. And until we have a better way to really evaluate the benefits of energy efficiency over time, it's always going to be subjected to a simple payback requirement. And that really puts it at a disadvantage.

In the residential setting, we're always talking about simple payback whether it's with codes or with financing or whatever it is. But what's the simple payback of a new bathroom? What's the simple payback of a granite countertop? What the simple payback of a deck?

Those things don't get, simple payback doesn't get applied to those home improvements because there's a recognition of what the effects of those improvements have on the property's value.

For energy efficiency, that's very difficult to do. Applying new insulate or installing new insulation in walls is very difficult to evaluate. And that's why I mentioned the SAVE Act in my opening remarks and in my testimony because that would help homeowners realize an actual rate of return on their investment.

And then the fourth thing is with respect to individuals. Not only are individuals difficult when it comes to financing, but residential retrofits, the existing homes, every home is an existing home. And an awful lot of them were built before there were building energy codes. And every one of those homes is a huge challenge. You have to have contractors in. You have to have a policy framework.

Senator KING. The people are not going to do that if they have to pay an upfront capital cost.

Mr. BRESETTE. Absolutely, absolutely.

And if you have contractors coming back and you have auditors and you have all of these decisions that you have to make and there's confusion about well, I just installed this great furnace or this great air conditioner and now you want me to do air sealing. I'm not sure why I need to do that now. It's really complicated.

And where we really need to make a lot of progress is allowing retrofits to happen alongside financing with good consumer information, things like ENERGY STAR but also home labeling, disclosure at the time of sale so that people are making decisions about residential energy efficiency the same way they make others.

Senator KING. To go back to the beginning, and I am out of time, but I hope you all will see this as the beginning of this discussion, not the end, and supply us with some thinking, particularly on the issue of financing.

And then finally, I know I am out of time, we can't forget China and India. This has to be, I mean, if we are going to deal with climate change, we have to talk about those countries.

And they are right, I would say, to have the same kind of level of amenities that we have. We can't tell them you can't air condition or you can't have a second car. But how do we help internationally to guide them to be more efficient, because otherwise everything we do is just not going to meet the demands of the world climate situation.

Thank you. Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator King.

Senator Cantwell.

Senator CANTWELL. Thank you, Madam Chair, and thanks for holding this important hearing.

To Senator King's last point, we have been involved in U.S./China clean energy initiatives that were helping the Chinese establish better building codes because, I think, at that point 50 percent of all buildings that were going to get built in the next ten years were going to be built in China. If they are not energy efficient, then they are going to be using way more supply than needed.

I want to thank the Chair and the Ranking Member for including language in the energy bills you have been moving through on energy efficiency in buildings. We spend something like $430 billion a year, and it is something like 40 percent of our total energy use is in buildings.

And so, while I appreciate the conversation we have been having about consumers and homes, there is this huge opportunity with just buildings writ large. And I think that there are better ways to try to get those retrofits to happen, including some of the language that we have in the legislation that is moving through Congress. I hope we can push some of those things over the goal line.

In fact, I remember the Chair coming to Seattle and visiting McKinstry, and it was a great opportunity because we went to one of their control rooms and we were basically watching them monitor energy expenditures in the North Shore School District which was way far north from Seattle, but we were watching their energy consumption and they were basically monitoring it so they could drive down the cost of our school systems.

So we are big believers in the modernization that we think can happen. We think, I personally believe, this is like what we did for automobiles. We need to do for buildings what we did for automobiles and that is, drive that level of efficiency.

On that point, besides the legislation on smart buildings we have been considering, as you guys look at a global view of this, what other initiatives do you think are spurring this kind of development?

A report in the U.S. showed that there is a feedback loop that this sector of clean energy business retrofitting has proven to their customers that you are just going to get whatever savings, 20 percent savings, and you are just going to be able to then put that

back into your competitiveness as business and a sector. So they are getting a lot of uptake on that. But are there other models that you see around the globe that are working that we should be pursuing on smart buildings?

Dr. MOTHERWAY. Thank you, Senator.

I agree with the area of your focus, and I will say that one of the opportunities for energy efficiency is it is a global conversation because all countries are facing very similar issues, the same pressures and using the kind of same technologies and policy instruments to move things forward.

And referring to a couple of comments. I do believe that this system thinking is really important. The concept of smart buildings, not just about being inefficient in themselves, are efficient in themselves, but being part of a whole energy system, you know, helping balance grids, reducing costs on the network, also helping deploy clean energy resources and things like that.

So there are new technology opportunities emerging very quickly. And I would urge anyone to think about it in that more systems way. I think the conventional way of thinking about energy efficiency, about the use in that one building or that one appliance, it needs to change and it's starting to change in different parts of the world.

And I do think financing is clearly very important. I would just make one point which is certainly nobody will upgrade their home without a good financing package, but my suspicion is that most people won't upgrade their home even with a good financing package because it's not like a car, where I get something new in the driveway. It can be invisible stuff in the wall or a changed furnace which I don't really notice the difference until I get my energy bill a couple of months later, that we still need to address how it's marketed.

And so, but also the practical challenges. Maybe it's cost neutral for somebody, but they have to move out of the house for a month or maybe they're getting different advice from different people. So government really has a role in, kind of, building these markets on both the supply and demand side.

When new solutions are being rolled out, people are seeing it in their neighborhoods, and they're saying I want what they have, so, that kind of building scale.

That's where, I think, I would commend the work of this Committee and the work of the government here with a focus on government buildings, in the sense that they can lead by example because then people can see it working, the supply chain of contractors and specifiers and architects and engineers starts to grow. So that kind of leading by example, I think, is a really important area.

Senator CANTWELL. Anyone else?

Mr. BRESETTE. Yes, completely endorse the systems approach, thinking about buildings as machines and not just big boxes full of things is really the right way to do it.

You know, one thing that's happening, you mentioned building codes and Washington State is a leader when it comes to building codes. The International Energy Conservation Code is under development right now, and there's a lot of conversation in that context about what the role of buildings will be.

You know, buildings right now, maybe they're in a moment of transition. In the future buildings will become more integrated in the grid. We've talked about, sort of, systems and we've talked about how storage will be, but also there are proposals, for instance, to make buildings electric vehicle (EV) ready because in the future we won't fuel our vehicles at gas stations the same way we do now. We'll fuel them in buildings, whether they're commercial buildings and homes. And so, I think, thinking ahead to how buildings will be used in the coming decades with the understanding that the buildings we're building today will be around with us for some time.

Senator CANTWELL. I know my time is expired. I also want to thank the Chair for visiting the Bullitt Center which, I think, is probably one of the smartest system-built buildings in the world, and Spokane is building an entire block of net-zero buildings. The same kind of system approach. So definitely a lot of upside for business here.

Thank you, Madam Chair.

The CHAIRMAN. It is just a reminder that there is a lot of really good and innovative things that are happening.

If people can get inside and see them—like the McKinstry, it was fabulous. In Alaska we have the Cold Climate Housing Center. Senator Manchin has been there. To be able to walk through and see how you can make a home and a building 80 percent more efficient in a cold environment is pretty cool and captivates the imagination.

Senator Cortez Masto.

Senator CORTEZ MASTO. Thank you, Madam Chair and Ranking Member for this great conversation, because it is important and this is our future.

But we have to be smart about it. We have to be investing in it at all levels from federal, state, local and the private sector and that, I see, has been the biggest challenge is getting everybody on board with the future that we really should be embracing and it starts with our smart communities because this is the very reason why we need to be really technically sophisticated.

When we bring on 5G, when we are connecting all of our communities, hopefully through broadband, and there are no underserved communities, this is the benefit, what we are talking about today. And this is one piece of it. So I am excited about it.

But I do think to really get us all moving in the same direction, that there is a role for the Federal Government to play and I am curious. You guys are talking about it now, but part of it is the incentives, right? Part of it is this carrot and stick, but most of it is the carrot, is how do we incentivize our communities to get them to continue to invest in this future at all levels?

That is one of the reasons why I have the Renewable Energy Extension Act. And the bill extends the Clean Energy Investment Tax Credit for solar, fiber optic solar, fuel cells, small wind, micro turbines, combined heat and power and geothermal heat pumps that are set to phase down after the year. And I would invite my colleagues to join me as well. But this is really how we incentivize and start moving in this direction.

And I am curious. We have talked about some of those incentives, but what else can we do because I also think it is important we get the private sector on board and that includes individuals, right, that are living, whether you are going to work during the day in a building that should be energy efficient and demanding it is at your workplace or even in your home. What else can we do?

Here is the reason why I am asking. I come from Nevada. Particularly in Southern Nevada, it gets really hot and we rely on our air conditioning units. I know we have talked a little bit about that. What people don't realize, and I was born and raised there and this was astonishing to me, just before Earth Day this year Climate Central, which is an independent organization that conducts research and surveys on climate change, released its list of U.S. cities that are warming the fastest and Las Vegas ranked number one. It has warmed 5.76 degrees since 1970. And if you've ever been to Las Vegas in the summer, it already hits 115 to 120 degrees.

And so, I am curious about your thoughts on what more can we do at the Federal Government level and in industry be doing to help families and businesses weather such extreme temperatures, particularly when we are talking about heat and not just relying on air conditioning to be the answer to address those concerns?

I will open it up to the panel.

Ms. LAYKE. Thank you, Senator.

The important element of heat is that we have non-technical solutions that can also help alleviate heat island effects in cities whether that's cool surfaces, white coatings, other types of surfaces that can reflect heat rather than absorb heat and green spaces and pairing green space and white surfaces or light surfaces can actually, has a demonstrable impact on what the perception of heat is in a city on any given day.

Now, does that help you move from 115 degrees down to it feeling like a 90-degree day? Perhaps it doesn't make that level of difference, but in many communities where there are people living in poverty, India and many other places around the world as well as in the arid West, we can also use evaporative cooling and other types of systems to help, in addition to using traditional air conditioning systems.

I also want to comment that the importance of cities in this, and I applaud your linking the federal agenda to the local agenda. We work with cities around the world, or in the United States and around the world, and currently cities are looking at how to get access to technology for low to medium, low to moderate income families and housing. And this is an area where cooling is one of the biggest priorities, as well as technology and building upgrades.

The Federal Government has allocated, through appropriations, funding in the past through the Department of Energy to state energy offices and those types of appropriations and programming can be extremely effective and important in allowing states to address the local conditions and local circumstances of the citizens in those states.

Senator CORTEZ MASTO. Thank you.

Anyone else?

Mr. TEW. Senator, great, great question, especially the way it was framed.

These extremes, they're happening everywhere though. The U.S. saw 11 percent higher heating days last year, and about equal amount 10.5 percent higher cooling days last year. And those are important because of the heat experience we see nationwide. That is a direct connection to a pull on the grid that is not sustainable over time.

And so, the approach here, as Jennifer just mentioned, it's a systems approach. You mentioned storage. We need all of those things. No longer can we just focus at the component level. It has to be ground sourced heat pumps connected to storage, connected to a cleaner and more efficient grid. All those things are important.

I think financing is certainly a question that we have to not attack it just at the component level. It's more about the systems solution.

Senator CORTEZ MASTO. Right. Thank you.

Yes?

Mr. BRESETTE. Let me make a comment too.

At EESI we think about efficient buildings as resilient buildings. A lot of the technologies, whether they're envelope technologies or window glazing, they allow a structure to be more habitable or hospitable after an event. So when the power goes out, an efficient building is one that you can stand to be in longer, whether in a hot climate or a cold climate. And then also, if every building were efficient there would be less strain and stress on the grid. And, of course, that makes the grid easier to recover, sort of, after the event, during those weeks and days that follow.

Thank you.

Senator CORTEZ MASTO. Thank you.

Thank you, Madam Chair.

The CHAIRMAN. Thank you.

I know my colleagues have heard me speak to one of my pet peeves, but when we think about what happens within our buildings and just the efficiency that we lose when we crank our air conditioning level to just that perfect 68 degrees so that our male colleagues can wear long-sleeved shirts and t-shirts and a tie and a jacket and leather shoes and socks and long pants so that they are comfortable. It costs us a lot more money and we could save a lot more money if we changed the attire around here. Maybe it is because I come from Alaska where, if it is cold out, we are wearing more clothes and we wear them inside too. It is the season now where everyone is wearing a light down jacket inside, you know.

I am not making light of this, but I do think that we overly complicate some things because of the customs that we have adopted as to what is the professional attire here. If we wanted to save a little on our air conditioning and reduce our consumption and be a little more efficient, we might want to think about the temperatures that we keep our buildings at to be comfortable. I know that in Japan during the summertime, they do not keep the thermostats at 68 degrees. It is much, much warmer and they are dealing with that. I am not suggesting that you could turn off all the air conditioning in Las Vegas when it is 100 degrees plus. I am very cognizant of that, but I do think that we get very comfortable in what

we are demanding rather than acknowledging that maybe we just need to accommodate ourselves just a little bit.

Let me turn to Senator Hoeven. I have a few more questions that I wanted to ask about what other countries are doing, but we will turn to Senator Hoeven. You can comment about whether or not you think it is a good idea that men would no longer have to wear all this attire.

Senator HOEVEN. Well, I will tell you, it would be great if we didn't have to wear ties and that would be a good start.

The CHAIRMAN. Alright, we are getting there. I have already got Senator King——

Senator HOEVEN. I am kind of on board here with you. I like that kind of tieless thing that would open the collars, would help a little bit in terms of the heating and cooling.

The CHAIRMAN. You guys would be able to think better, you know, you don't have——

Senator HOEVEN. I agree with that.

The CHAIRMAN. Yes.

Senator HOEVEN. Yes.

The CHAIRMAN. Go ahead.

Senator HOEVEN. Totally.

Thanks, Madam Chairman.

Ms. Layke, in your testimony, I think you referenced the All-of-the-Above Federal Building Energy Conservation Act that I am working on with Senator Manchin, the Ranking Member of this Committee, which would repeal the unworkable ban on natural gas and fossil energy used in federal buildings and then replace it with a commonsense efficiency approach. We have included that in legislation that the Chairman is working on which we hope to pass.

Can you elaborate on why the fossil fuel ban has been unworkable and how it actually runs counter to achieving greater energy efficiency in federal buildings?

Mr. LAYKE. WRI has done analysis on the ability to use and create renewable natural gas over time and using excess renewable energy that could be used for natural gas. An outright ban on natural gas, at this juncture, may foreclose options that are needed in certain technologies and approaches that are not yet commercially viable or available.

So we are looking at the long-term and considering options for how to best create the transition from where we are today to where we need to be in the future. And sometimes that requires imagining the stepwise solutions that would allow us to get there.

Senator HOEVEN. Can you speak to how forward-looking energy intensity reduction targets will drive energy efficiency improvements in federal buildings and also how those targets encourage innovation and help reduce operating costs, that kind of thing?

Ms. LAYKE. I'm sorry, Senator, can you repeat the question?

Senator HOEVEN. Sure.

Talk about how the energy intensity reduction targets will drive energy efficiency improvements and also stimulate innovation and help reduce operating costs.

Ms. LAYKE. Yeah.

There are three things that are really critical.

One is that we continue to measure and monitor our ability to create the performance levels that we expect, whether that's in a federal building, whether that's in a school, a hospital and elsewhere. Allowing for that type of data, the aggregation and the analysis associated with it, will help us make the changes that we need to make and make the investments to get the best returns possible. So first, there's a data and information requirement and approach.

The second thing that I would offer is that the energy intensity metric allows you to balance the different types of energy systems that you have. We've spoken a lot in this hearing already about the need for system level thinking, and that may mean that you look at those opportunities to gather efficiency from different interventions depending on what the approach is that you're looking at. An Air Force Base may be quite a different place than a Federal office building or commercial space.

So energy intensity gives you the ability to manage and intervene with the most cost-effective and technologically appropriate solutions.

Senator HOEVEN. Thank you.

Mr. Bresette, can you discuss programs such as USDA's Rural Energy Savings Program, RESP, and tell me a little bit how it empowers state and local businesses to improve energy efficiency in rural communities?

Mr. BRESETTE. Of course, Senator, thank you.

The program that you mentioned is a program that's offered by the U.S. Department of Agriculture. Right now, I think it's offering about $100 million, about $75 million of those dollars have been loaned out to rural utilities, and those dollars are then used to provide low-cost financing to their customers.

It's done using an on-bill line item so the repayment, rather than getting a separate bill in the mail, the repayment is made as a line item on your utility bill charge. One of the principles of on-bill financing as EESI sees it is that those charges should be bill neutral, so you're always saving more than what your repayment ought to be. And there's a lot of flexibility in the program. RESP, in particular, is very flexible. So we're talking about all of the energy efficiency improvements that we all know and love in our homes—insulation, heating and cooling equipment, lighting—but also potentially renewable energy deployments, electric vehicle chargers, storage installations. It's a pretty flexible program so that, you know, investments in the home can be made, sort of, with a longer, forward-looking perspective.

Senator HOEVEN. Good, thank you.

Dr. Motherway, in your testimony you cite an IEA estimate that maximizing available energy efficiency opportunities could allow the global economy to double by 2040, which is pretty remarkable, with essentially the same energy demand as today.

What infrastructure investments, including tangible assets such as more transmission and distribution lines as well as digital and smart grid improvements are necessary to achieve that? So what infrastructure is it going to take to achieve something?

Both of those, I think, are pretty remarkable. Doubling by 2040 with the same energy demand, I think both of those are certainly

attention-grabbing prognostications, Doctor. And so, what kind of infrastructure and so forth is it going to take to do that? Smart grid improvements, something our Chairman talks about quite a bit.

Dr. MOTHERWAY. I think it's a very good question, Senator, because as I said earlier in this discussion, energy efficiency of the future is different to the past. It's moving away from a focus on reducing the energy of any one individual device into what we've all spoken about in terms of systems efficiency.

And the kinds of technologies you talk about and the kind of investment you're talking about really creates, what I think could be, you know, game-changing opportunities to enhance efficiency in a much more cost-effective way and in a much faster way than in the past.

So I think that, to be frank, our numbers of doubling the global economy for the same energy use, if anything, is an underestimate because that's based purely on technologies that exist today and that are cost-effective today. So as innovators around the world come up with new ideas and come up, particularly in the digital space and in the smart grid space, that potential is only going to grow.

So I think a focus on that system thinking, particularly in electricity, thinking about grids, thinking about integrating supply and demand in intelligent ways so that you're not just optimizing the end use, but you're optimizing the whole system as well the future focus should be.

Senator HOEVEN. Well, it is certainly going to take some smart guys and smart gals to develop that kind of smart grid. Don't you think?

The CHAIRMAN. We are working on it.

Senator HOEVEN. Indeed. Thank you.

The CHAIRMAN. Exciting.

Senator HOEVEN. It is interesting, thank you.

The CHAIRMAN. Thank you, Senator Hoeven.

Dr. Motherway, you said earlier that perhaps your regret is that with all your years of work you haven't been able to make energy efficiency kind of cool and sexy. Maybe it is in the technology? I mean, we are all talking about, do you have an iPhone 10 or an 11, I think I have a 5 or a 2.5 or whatever. But we talk about what we are able to access on our apps, and certainly young people are really very focused on the capabilities that they have at their fingertips now. So maybe that is how we make it cool. And by making it cool, then you realize as you are looking at this, I am actually saving money, I am reducing my carbon footprint. Maybe this technology's time could not come until we could do this in a very smart and technologically advanced way.

I wanted to ask a question to you, Ms. Layke, and this is regarding your testimony that the United States is number ten in terms of where we stack up in leadership on energy efficiency—Italy, Germany and France are in the top there. When we look to the good ideas in other places, what are these nine countries ahead of us doing that we could look to and adapt? Is there anything that stands out to you?

Ms. LAYKE. Thank you for the question, Madam Chair.

There are three areas that really drive the energy intensity of any country: the transportation system, as we have talked about, the industrial infrastructure and the built environment. Those are the three major categories or areas where energy is used. Electricity and energy being separable, some use in primary energy and some use electricity.

But the areas that we see that are driving some of those countries to the top of the list that the United States still needs to consider are around our transportation systems. Transportation emissions are now the largest source of emissions in the United States, surpassing those of other areas.

And that transportation efficiency is something we haven't covered extensively in the hearing today. We'd be happy to submit additional ideas, but using and leveraging the electrification of transportation is also something that other countries are doing more successfully. In Japan, for example, electric trains. China is using train technology as well. So there are opportunities for us to think about those.

The second, industry, is that many countries have an industrial sector that is newer than the United States. Not in Europe but elsewhere. So China, where the ranking is higher than ours today, there may be opportunities for us to really consider how we do industrial upgrades and industrial system improvements. The Chinese have a younger infrastructure. We could match that infrastructure if we were making investments and if our companies and our corporations had incentives and financing to do so.

The third is around buildings, and we've spoken about buildings extensively. In Europe, in particular, many of the labeling and performance certifications that are required there are enforced and are raised in standard. I think Dr. Motherway already laid out that those standards are already increasing in efficiency expectations over time so that builders and others know what to expect. Ours remain flat and constant and then have to go through a revision process which then is negotiated over time. So that incline for efficiency can be built into policy rather than to be reflective of a certain point in time.

The CHAIRMAN. I appreciate that.

Senator King, further questions?

Senator KING. Yes, several.

One, I think it is important, it has been mentioned a couple of times, but funding for innovation is really important.

I can remember when the height of energy conservation for lighting was high pressure sodium replacing fluorescent. And I remember saying to someone at the time, well, that is it. You know, we are not going to be able to do any better than this. And now, of course, we have LEDs which use virtually no electricity. I mean, and that is an amazing change, but it is based upon innovation. So funding for research and the NREL lab and those kinds of things are very important, because one big breakthrough can change the world.

Second, Mr. Tew, you gave some figures that I didn't fully grasp but sounded important about growth of heating costs or heating volume and air conditioning last year was 11 and 7. Could you flesh out was that in the U.S. or worldwide?

Mr. TEW. Yes, that was U.S. numbers based on IEA data. It was the number of heating days versus cooling days. Last year in the U.S. one of the few times this has happened, we had a significant increase in both the number of heating days, 11 percent——

Senator KING. Days that heat is required.

Mr. TEW. Days where you need heating.

Senator KING. Okay.

Mr. TEW. And almost an equal amount, 11 percent, increase in the number of cooling days, days you would need cooling or air conditioning.

Senator KING. But what that means is that we are using more energy to keep ourselves comfortable.

Mr. TEW. Correct. Exactly.

Senator KING. We are moving away from the mean.

Mr. TEW. Correct.

Senator KING. I think that is very important data. I was not aware of that data.

Finally, speaking of data, I think there is a huge energy potential in making data available. I call it the Prius effect. When you drive your Prius and you can see that you are doing 80 miles per gallon instead of 40, you adjust your driving. It is, sort of, a contest with yourself. Just having that information, I believe, is equal to about ten percent of energy savings.

So there is tremendous potential. If you had a screen in your kitchen that showed exactly what was going on in your house in terms of your hot water heater, your furnace, your air conditioning and to your point, if you turn your air conditioning down one or two degrees, what does that do?

I think people, if they have that information, they will act on it now, you know, they have this vague feeling if I turn it down a little, I will save a little.

But I think technology that will give us, and it is all there—smart meters and those kinds of things. I think that is a technique, Madam Chairman, that I think would just, giving people the information about how much energy they are using and how their decisions affect the amount of energy that you are using.

You are all nodding. I presume that means assent.

Alright, thank you, Madam Chair.

The CHAIRMAN. Senator Cortez Masto.

Senator CORTEZ MASTO. Let me just make a comment, because I actually agree. And I am glad you brought up smart transportation because that is something we haven't talked about and it is something I have been pushing as well with this idea that with the internet connectivity of things, this new technology is going to benefit our transportation through our communities, getting more people access, but at the same time we are going to be able to utilize the technology to bring in electric vehicles, electric buses, the infrastructure, charging stations, everything that is needed for this new technology.

I actually had a regional transportation commissioner in Southern Nevada put it this way. She said this new technology for transportation is the asphalt of the future. It really is.

I will just reiterate something my colleague just said is that data is important for this generation. I think this is a way to make it

sexy for them is they like this data. They like to show that they are being energy efficient.

We actually have smart transportation systems in parts of Nevada. One of them is you can pull a car up to a street light and your data on your car will actually read when it is going to turn red. And the intent is to give that person that is behind the wheel a little comfort knowing that pretty soon it is going to turn red or green or red or green and I can go because the data is important and data information is important for so many different reasons. And I think there is a benefit to that.

So that was my only comment.

Thank you. This is a great conversation today, and I really appreciate all of you being here.

The CHAIRMAN. Yes, it really was.

I want to ask one final question and this goes back to the financing aspect of it because, again, as innovative and interesting and cool as it may be, if folks can't afford it up front they just, kind of, look with some amount of envy at okay, maybe one day I will be there. The ways that we could help facilitate access, I think, is going to be important.

I appreciated the conversation about the on-bill financing. I don't remember which one of you mentioned, you know, within Senators Shaheen and Portman's bill we have the SAVE Act there. We have the loan guarantee program. Are there other financing policies that, in your opinion, DOE should be looking to as we talk about their efficiency efforts?

And then, I wanted to ask on that, on the on-bill financing, in my home state we recognize that the Weatherization Assistance Program has been extraordinarily invaluable to families, but it, again, has that upfront cost that can be prohibitive for so many. Do you think the on-bill financing would work, would have application to that program as well as something that we could look to? But what else within DOE might we do other than loan guarantee?

Mr. Bresette.

Mr. BRESETTE. Thank you, Senator, Madam Chairwoman.

Yes, I think that's right and especially in a place like Alaska where there's, you have, like I mentioned, oil and resistance heat. You can use the financing that's provided by on-bill to provide capital for equipment replacements and then you always want to do your weatherization measures whether that's funded by the Weatherization Assistance Program or whether it's financed at a market rate by a local contractor, you always want to do air sealing, duct sealing and insulation. Those are the three things you always want to do in addition to making an equipment replacement.

Weatherization has served about seven or a little bit more than seven million homes. But the need of weatherization is much, much more than that, tens of millions of homes are qualified for weatherization. And frankly, the appropriations are not where they need to be. There are weatherization authorization bills that are before Congress, including one, I believe, that passed out of this Committee a few months ago. It's an incredibly important program. One thing that weatherization does as well is it really encourages a local network of contractors who are qualified to make these improvements. So you have what weatherization does, yes, it makes

improvements to peoples' homes, but it also ensures that in pretty much everywhere in the country, there's a cadre of people who are qualified to make those improvements and quality installation is very, very important.

With respect to other things DOE could do, we always want to give a shout out to the State Energy Program. A lot of really remarkable innovation is done in state energy offices. And especially since the stimulus of 2009 to 2012, a lot of state energy offices have looked very carefully at financing. How do we leverage private capital? How do we craft programs? How do we work with partners to reach underserved communities or multifamily buildings or segments of the building sector that might be a little bit difficult to reach with, sort of, traditional programs?

So I think increased support for state energy programs, weatherization, are two good examples of things you could do that would have, sort of, a positive tangential effect on financing availability.

The CHAIRMAN. Dr. Motherway.

Dr. MOTHERWAY. Thank you, Chair.

And I think the focus on finance is absolutely correct and when you look around the world there are some interesting innovative policies emerging in terms of some countries are now using bulk procurement to drive down the cost of innovative technologies. Some countries are wrapping up the financing with the wider deployment at a community scale. So they're trying to not treat every upgrade as an individual project which can be more expensive but maybe get neighborhoods to work together.

And as I mentioned earlier, I think public sector leadership is often very strong here because it can be the first mover to show what can be done.

When I see finance fail to solve the problem, it's usually when it's done in too much isolation and assuming that if all that you do is make financing available, then things will work. But then, things like training of the installers, helping people make the right choices, making sure the right technologies are coming on to the market. It needs to be done in that wider sense where finance is an absolutely essential ingredient but won't solve the problem on its own. And that kind of wider capacity building, market development work, really is a key to success, I think.

The CHAIRMAN. That is a good point. That is a good point.

I am reminded. I mentioned earlier the Cold Climate Housing Research Center that we have in Alaska. It has made just a tremendous, tremendous difference with regards to building more energy efficient homes in Alaska and pioneering some technologies that, we think, are really, really cool.

Part of the challenge that they are facing right now as a nonprofit is reaching outside audiences, yet for the Arctic nations who deal with cold climate, having this level of expertise and knowledge shared with them is extraordinarily important.

When I asked the question about how, what are other countries doing that we can learn from? You know, making sure that places like Cold Climate Housing are able to reach that broader audience, making sure that the technologies that we can put in place in cold places can be equally applicable in hot places, as you, kind of, think about, okay, what is the inverse here? But making sure that this

information is shared. The financing is absolutely key, but as you point out there are other things. How do we make sure that others know about it? How do we make sure that we've got the training, the technology sharing?

So this has been, as I anticipated it would be, a fascinating discussion. I think we recognize that this is one of those areas that, boy, if there was ever any area in the energy space that should be bipartisan, it is like, why wouldn't it be efficiency?

In my view, it is probably the most conservative of policies. Don't use something, right?

[Laughter.]

How we build on this is so important. And again, the opportunity to focus on it, not only in our country, but recognizing that we have a big Earth here that we are all paying attention to and making sure that everyone is learning from this is important.

I appreciate the opportunity to have this discussion today. If there are other bright ideas that any of you have that you would like the Committee to consider, please, please, let us know because we want to try to do more.

I don't like the fact that we are sitting here at number ten in terms of world leadership when it comes to efficiency. Has this been pointed out?

It should be the easy things. We should not see this trend going down for us right now. I want to figure out how we get going back to a better place. So we will work on that with your assistance.

To my colleagues, know that this will continue to be an important focus for me and for us on the Committee.

With that, the Committee stands adjourned.

[Whereupon, at 11:48 a.m. the hearing was adjourned.]

APPENDIX MATERIAL SUBMITTED

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Dr. Brian Motherway

Questions from Chairman Lisa Murkowski

Question 1: At a Senate Energy and Natural Resources Committee hearing in May, the Alliance to Save Energy noted that U.S. households pay on average $2,000 per year for energy and that energy expenses disproportionately affect low-income families. In the U.S., there are several efficiency tools and programs in place designed to help these households, ranging from the Weatherization Assistance Program to the State Energy Program to minimum efficiency standards for common household appliances. What are the gaps in efficiency programs that need to be addressed either the U.S. or globally?

Policy makers tend to address social equity issues related to energy efficiency in several ways. Grant or rebate based measures like the Weatherization Assistance Program (WAP) are common, and indeed effective in terms of getting efficient equipment into the hands of lower income families. The United Kingdom has a fuel poverty strategy featuring a target of ensuring a large number of homes achieve a higher efficiency rating by 2030. Governments also commonly use preferential loans. Germany's KfW bank, for example, provides a range of lending options across efficiency sectors, including residential homes, to enable affordable access to finance.

Governments can also obligate and/or incentivise utilities to act as key implementing partner in such programmes, delivering energy savings advice as well as technologies as part of their energy services offerings. The Energy Efficiency Resource Standards in many US states are an example of this kind of policy measure. Some municipalities have also been experimenting with revolving funds, re-allocating savings from energy efficiency projects to low income households. Information and capacity building measures are an important complement to regulatory, finance and incentive based measures.

The most effective way to avoid programme gaps is to ensure that governments deploy the right or appropriate combination of the above measures consistently and during a sufficient timeframe to deliver impacts at the household level. While there is certainly room for policy innovation, a sound combination of tried and proven grants, loans, market mechanisms, etc. should provide policy makers with a reliable set of tools to address social equity issues around energy efficiency. Policy makers can avoid gaps if they fund, monitor and implement a combination of programmes in a consistent manner while providing certainty to market actors (e.g. utilities, equipment installers) implicated in programme delivery.

Question 2: Your written testimony highlighted some of the potential financial benefits from efficiency gains that could flow through to economies, sectors, and households. What percentage of those gains and associated benefits would directly impact low-income communities and households?

The increased adoption of cost-effective energy efficiency measures between now and 2040 could save households over half a trillion dollars in energy spending in 2040. These benefits will flow to all households across socio-economic sectors. Households are already seeing the benefits of energy efficiency, with improvements since 2000 saving US households about $200 per capita in 2017, equivalent to around 10% of their home and travel energy costs.

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Dr. Brian Motherway

Energy efficiency also enables other multiple benefits within the residential sector beyond avoided expenditure. Foremost among these is the health benefits linked to improved building weatherisation, through investments in insulation and window glazing that reduce air and heat leakage. Such actions improve health outcomes for occupants by reducing exposure to cold conditions and the likelihood of illness that can result.

Greater levels of efficiency also improves levels of access to energy services for low-income households. With more efficient appliances and equipment, along with improvements in building performance, homeowners will be more able to afford the running costs for energy services, particularly heating and cooling. As such, low-income households may be able to gain access to these services for the first time, or use them more frequently, which will improve both comfort and health outcomes.

Question 3: You cited use of cooling technology as a growing area of future global energy use. Can you elaborate on what the most promising technologies are to significantly reduce energy use on cooling air, and which companies or organizations are currently leading the development those technologies?

According to IEA analysis, significant improvements in the efficiency of space cooling can be realised with currently available technology, meaning rapid technological innovation or change is not necessarily required to realise substantial efficiency gains. Globally, across both industrialised and developing nations, best available AC equipment is up to three times more energy efficient than the market average without necessarily being more expensive.

With the right policy measures to ensure more efficient technologies are deployed at scale in markets, the potential rise in global space cooling energy demand could be 45% lower in 2050 due to a doubling in the efficiency of the global stock of air conditioners. In parallel to more efficient ACs and cooling equipment generally, better building design and envelope improvements, e.g. insulation, can reduce the overall demand for space cooling.

That said, there are several areas where the efficiency of AC technologies could be improved, including aerodynamically efficient fan blades, more efficient compressors, improved inverter technology, and the use of variable speed drives on fan motors. In the longer term, research, development and demonstration is expected to focus on reducing the cost of highly efficient advanced vapour-compression systems and emerging non vapour-compression systems that do not use refrigerants.

Question 4: Are any of these new technologies applicable to lower cost heating in addition to cooling?

Reversible heat pumps are the most common type of technology currently available on markets that delivers both heating and cooling in a highly efficient manner. Electric heat pumps have the potential to achieve step-change improvements in energy efficiency and, when combined with renewable electricity supply, to deliver zero carbon space heating. The typical efficiency of heat pumps has increased steadily since 2010, to the extent that these technologies are commonly three times more efficient that condensing gas or oil boilers. It is even common for heat pumps to reach efficiency levels that are four or five times higher than conventional heating technologies, especially in relatively mild climates such as the Mediterranean region and central and

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Dr. Brian Motherway

southern China. Conversely, in extremely cold climates such as northern Canada, low outside temperatures reduce the energy performance of currently available heat pumps, although they are still twice as efficient as an electric resistance heater or a condensing gas boiler.

Much like in the area of cooling, innovations around specific technologies are more effective if accompanied by other measures to improve the efficiency of buildings, e.g. envelope and the performance of energy using equipment such as appliances used inside the building.

Questions from Ranking Member Joe Manchin III

Question 1: Energy efficiency is the fastest growing area in the energy sector nation-wide as well as in West Virginia, employing over 6,000 people in a state dominated by traditional energy jobs and hit hard by the downturn in the coal industry. Are there particular energy efficiency policies or combinations that are the most helpful if economic development and job creation is the top objective? Are there approaches we should avoid in states like West Virginia?

It is estimated that over 2.3 million people work in whole or in part on energy efficiency within the United States, making it the largest employer within the US energy sector.[1] Policies that help homeowners to weatherise their homes and improve performance are associated with actions that are more labour-intensive and therefore link to the creation of jobs for installers and equipment providers. Policies to support these measures include the provision of grants, rebates, low or no interest rate loans, or on-bill finance that reduce the upfront cost of efficiency measures.

If properly designed these measures can be effective, but it is important for governments to be cautious with the funding approach. If the amount of funding available is too low, homeowners may not be motivated to apply for the support available. However, if support provided is more generous, it may receive interest from homeowners, but public budgets may not be able to sustain that level of support over a sufficient time. Such issues can undermine success of these policies and risk the financial viability of smaller installers and equipment providers that are often the source of new job creation.

It is also important to recognise that it is not feasible for government grants to continuously finance the upgrading of all buildings to improve efficiency. For the purpose of ensuring sustainable activity it is necessary for a true energy efficiency market to be created. Policy again plays an important role in establishing such a market. Specifically, energy efficiency obligations, such as the energy efficiency resource standards established in 26 US states, place an obligation on energy utilities to obtain a specified amount of annual energy savings. In doing so, there is a demand for the energy savings required for these utilities to meet their obligations, which can lead to the creation of new businesses and subsequent jobs.

Question 2: We've made great strides in driving up energy productivity with energy efficiency measures so that we can get more value out of each unit of energy we put into the economy. I support continued investment in energy efficiency but I know that in some areas we're reaching the limit of cost-effectiveness.

[1] https://www.e2.org/wp-content/uploads/2019/09/Energy-Efficiency-Jobs-in-America-2019-Full-Report.pdf

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Dr. Brian Motherway

What's the next frontier in energy efficiency, in terms of either innovative technology or innovation in tools we use to deploy energy efficiency technologies like financing?

It is true that, due to technological innovation and efficiency policy, energy using equipment and appliances are more efficient than ever. However, there remains room for further efficiency gains from existing technologies, with policy again playing an important role. In many countries, the gap between market average or stipulated minimum levels of performance for energy-using appliances and equipment, particularly ACs, remains well-below best available technology.

That said, digitalisation is heralding a new era for energy efficiency, which will create new opportunities for efficiency gains and business model innovation. Digitalisation can enable a shift in how we think about energy efficiency – from the energy performance of individual technologies to the performance of the entire energy system. For example, digitalisation can increase more than ten-fold the capacity of demand response mechanisms, e.g. the use of energy efficiency as a resource on grids alongside traditional supply resources (both fossil and renewable).

Digital technologies also enable energy efficiency services and the financing of those services. Rather than just delivering energy (e.g. electricity or gas), energy service companies (ESCOs), traditional utilities or energy providers are increasingly offering the services provided by energy, e.g. light, heating or cooling. Digital tools allow for a highly accurate, real time measurement of service performance, which in turn can help to reduce risks for both service providers and financial institutions.

Question 3: Growing demand for space cooling will increase demand for electricity during peak hours. What do you estimate will be the impact to the reliability of the electric grids around the world? How do we spread out the demand curve to keep costs down for electricity rate payers?

According to IEA analysis, without policy intervention, the amount of additional electricity generation to meet the growth in space cooling demand by 2050 would be greater than the total current electrical generation capacity of the United States, Europe and India combined. Peak demand for cooling – meaning times of the day or night when grid electricity consumption is at its highest – is set to rise significantly in hot emerging economies. In India, the share jumps from 10% today to 45% in 2050; in Indonesia, it jumps from around 15% today to 40% in 2050; in Mexico it jumps from 10% to 25%; and in Brazil, it nearly quadruples to 30%. This will place significant additional strain on grids, especially in cases where these infrastructures are decades old and are in need of repair or replacement.

Policy actions are critical to minimise the potential impact of the growing demand for space cooling on energy demand and electricity grids. Global space cooling energy demand could be 45% lower in 2050 due to a doubling in the efficiency of the global stock of ACs. In parallel, demand side management enabled by digital technologies (e.g. smart thermostats and building controls) can also help limit the impact of cooling demand. Digitalisation can help shift demand to periods when system demand is lower or output from variable sources of electricity supply (e.g. renewables) is greater. Recent technological improvements can allow air conditioners to be remotely deactivated or run at lower load in a manner that does not significantly affect the comfort of the building occupant.

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: *International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States*
Questions for the Record Submitted to Dr. Brian Motherway

Strategies to shift demand away from peak periods are also linked to the concept of pre-cooling, in which home air conditioners are activated prior to peak load periods. If the home is unoccupied and the building has reasonable performance (i.e. is weatherised) pre-cooling can be provided at above average levels, reducing the need for cooling during later periods when the home is occupied and electricity demand is peaking. IEA analysis for China in 2030 showed that, on top of a reduction of 15% in peak demand due to efficiency measures, the employment of connected, responsive air conditioners that could be used as part of a pre-cooling strategy, would be able to reduce peak electricity demand by a further 20%.

Question 4: If you could redesign our buildings, transportation, and the U.S. industrial sector using today's technologies, what would you change?

As a starting point, it would be ideal to construct all key infrastructures in these sectors to the highest possible efficiency level, using the best available technologies as well as design innovations, such as the use of natural cooling opportunities for buildings in cities with high average temperatures, for example. This would ensure that subsequent efficiency gains are much more cost effective, and would avoid the need for complex and expensive retrofitting.

In addition, and rather than thinking in terms of individual technologies and sectors, a systems thinking approach would ensure that transport infrastructures, industrial sites and buildings 'interact' to capture all possible efficiencies. Waste heat from industry, for example, is an excellent potential source of heating for offices and homes, assuming the necessary connecting infrastructures are in place. After the fact, however, it may be very costly to construct the necessary heat transfer infrastructures to get heat from industrial sites into commercial and residential buildings. Another example is the challenge of decarbonising the energy system using only renewables, electric vehicles (for storing excess renewable energy production) and fully digitised demand management. While this is technically feasible, it is much more costly to retrofit the existing energy system rather than to build a fully integrated low carbon system 'from scratch'.

Questions from Senator Maria Cantwell

Question 1: Historically, standby power was estimated to account for 5-10% of residential electricity use in most developed countries and roughly responsible for 1% of global carbon dioxide emissions. I understand that more recent technology advances and government policies may have reduced standby power loads but that some of that progress may have been mitigated by the growing number of connected electronics all of us have in our homes today.

- Can you please share your thoughts on standby power—both about the scope of the problem and whether we should be doing more about it?

- Please share any specific policy measures you think the Committee should consider that could help address standby power losses.

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Dr. Brian Motherway

- The IEA launched the One Watt Initiative in 1999 to ensure through international cooperation that all new appliances sold in the world would only use one watt in standby mode by 2010. Can you give us an update on the One Watt Initiative and lessons learned from that program?

While policies have been effective in reducing standby power demand on the level of individual devices, increased uptake of appliances and equipment, changes in usage patterns and increased connectivity means that standby power remains an issue. It is projected that the stock of all network-connected devices could increase from an estimated 15 billion in 2018 to 46 billion in 2030. This would mean that global network standby energy use could double.[2] There remains opportunities for significant energy savings to be realised from reductions in standby power. Key actions include: implementing and strengthening mandatory policies; increasing the coverage of voluntary agreements; setting requirements for products being shipped with energy management settings as a default; and supporting research and development towards near zero standby power.

The One Watt Initiative was launched by the IEA in 1999 as a challenge to all governments to take action and adopt the goal to reduce standby consumption to below 1 watt. Following the initiative, several countries took measures to ensure a reduction of standby power, which transitioned to governments initiating regulation and voluntary codes to address energy waste in low power modes.

The IEA Technology Collaboration Platform on Energy Efficient End-use Equipment provided an international platform for sharing policy experiences and researching potential policy approaches developed during the One Watt Initiative. These include:

- The need for strong leadership and visible government commitment in realising lasting policy outcomes;
- Cooperation across national jurisdictions is essential to changing the standby power use of globally traded products;
- Voluntary programs can assist markets to respond quickly, but regulation delivers lasting results; and
- Monitoring and reviewing regulatory interventions is important to ensure that they protect consumers, ensure a level playing field for global industry, while also conserving energy.[3]

More recent work on standby power started in 2015 following IEA analysis that examined the impact of network standby[4], which led to establishment of the Connected Devices Alliance (CDA). The CDA, is a network of more than 350 government and industry participants that have come together to work on the energy efficiency opportunities provided by networked devices. These include opportunities for device standby mode energy savings, as well as energy savings enabled by device connectivity ("intelligent efficiency").[5]

[2] IEA 4E EDNA (2019) Total Energy Model for Connected Devices
[3] IEA 4E https://standby.iea-4e.org/
[4] IEA (2014) https://www.iea.org/publications/freepublications/publication/MoreData_LessEnergy.pdf
[5] https://cda.iea-4e.org/about-the-g20

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: *International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States*
Questions for the Record Submitted to Dr. Brian Motherway

Question 2: Last year the International Energy Agency published a report that found that space cooling energy intensity per floor area increased by 71% in China and 42% in India. And this trend is also occurring in Southeast Asia, where space cooling energy use increased by 66%. The same report also found that space heating, cooling and water heating offer 60% of potential savings.

Can you tell me more about those potential savings and what kind of policies it will take to make that happen and reduce this substantial new source of energy demand?

There are actions that can be taken to minimise the potential impact of the growing demand for space cooling. The potential rise in global space cooling energy demand could be 45% lower in 2050 due to a doubling in the efficiency of the global stock of ACs. Such an improvement is based on the introduction and strengthening minimum energy performance standards (MEPS) that could see the average energy performance of the global stock of air conditioners more than double. Savings can be further enhanced by measures to improve the performance of buildings and reduce the need for space cooling. Improving building performance will be aided by policies such as codes that cover both the construction of new buildings and the renovation of existing buildings, as well as incentives to support building owners to undertake upgrades.

Other policy measures to improve the efficiency of space cooling technology and mitigate its potential impact on future energy demand include:

- developing and implementing a comprehensive national policy on cooling, such as that recently launched by India and China, which set targets for space cooling energy demand and efficiency, and outline policy mechanisms intended to achieve that outcome;
- improving the quality and availability of information provided to consumers, so that they are able to make informed purchasing decisions; and,
- building greater levels of collaboration on cooling research and development, such that technology transfer can be enhanced and countries with the greatest demand for cooling can access the most efficient technologies.

Questions from Senator Angus S. King, Jr.

Question 1: The federal government and large corporations have access to sophisticated financing options that allow them to leverage private financing to make sweeping energy efficiency investments and upgrades with little to no upfront costs. Households and individuals however, lack access to capital and financing opportunities that help them meet the large upfront costs of energy efficiency improvements. Can you expand more on potential innovative financing options (ie. on-bill financing, loan guarantees, green banks, etc.) that could be applied on a large scale for household and individual access?

Preferential loans by local lenders are a common starting point for financing household efficiency improvements. To enable below market interest rates or longer term repayments, guarantees by governments or multilateral financial institutions may be needed to make efficiency investments more attractive to

households over non-efficiency alternatives. In parallel, dealer financing, whereby customers can obtain efficient equipment for little or no money down and repay the purchase directly to the equipment provider over time, is available in some markets. Microfinance is a further option worth consideration. While this kind of small-scale finance is usually deployed in developing economy contexts, it may be applicable in very low-income segments of the US population where access to traditional bank or dealer financing is either unavailable or too costly.

Green banks and green mortgages are slightly more complex mechanisms for financing household efficiency. The United States has been a global leader in exploring these kinds of options to finance efficiency improvements at a large scale for households and individuals, notably through Fannie Mae's Green Rewards programme. Green mortgages have also been a key driver for the development of green bonds. While green bonds are certainly a more complex type of financing option than preferential loans, they also offer an opportunity to increase considerably the scale of investments in household energy efficiency. Between 2014 and 2018, global green bond issuance soared to just over USD 45 billion, suggesting that this type of financing option has gained some footing in financial markets.

On-bill financing, i.e. using the utility bill as a repayment mechanism, has been used extensively in the United States, with lending amounts exceeding USD 2 billion across at least 25 states. Property tax based mechanisms fall into the same broad category of using a regular billing mechanism, rather than upfront expenditure, to make households more efficient. Once again the United States has been a leader in the field with the Property Assessed Clean Energy (PACE) investment scheme, which has to date been the most successful example of property tax based repayment.

Question 2: The way we use our grid today is grossly inefficient. If we can flatten out the curve of grid use throughout the day, everybody's price per kilowatt hour will go down. Techniques like time-of-day pricing can incentivize consumers to make changes to their actions, but having access to real-time energy and price data will make those changes easier to comprehend. What does a package of policies, standards, and technologies that would allow for effective and applicable time-of-day pricing and consumer data access look like?

Policies to ensure the availability of technologies that allow consumers to know and control their energy use in real time are important first steps for any time-of-day pricing mechanism. These technologies include smart meters, in-home displays, home energy management systems and remotely monitored and controlled appliances. Mechanisms that are used to encourage or drive adoption are increasingly associated with utility or publically funded roll-outs rather than voluntary mechanisms. However, for some technologies, adoption still relies on purchases from engaged consumers, although some utilities are providing them to consumers, for the purpose of trialling their adoption to understand what impact they have. There is also a role for equipment and appliance standards to ensure that technology can be remotely controlled by energy users. In Australia for example, regulations require air conditioner labels to indicate whether the appliance has demand response capability, meaning that its operation can be remotely controlled.

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: *International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States*
Questions for the Record Submitted to Dr. Brian Motherway

The decision of whether to roll out time-of-day pricing on a mandatory basis or through voluntary measures is an important consideration. A mandatory approach will increase the potential impact of time-of-day pricing, but may affect those consumers not fully prepared to engage. A voluntary approach, which can be transitioned to mandatory, may slow the realisation of potential impacts, but allow policymakers to learn from experience and improve market structures, while minimising impacts from less favourable market design. The variation in prices across the day is also an important consideration. If variations are too low consumers may not have sufficient motivation to switch energy use to lower price periods. However, if price variations are too high, it could expose some consumers to high price periods, impacting affordability. Tariff design that ensures motivation is high, but that negative impacts for low-income households are minimised, is therefore central to realising potential benefits from time-of-day pricing.

The topic of smart grids and digitalisation in the wider energy market is a growing area of interest and could herald a new era for energy efficiency. The IEA has noted this through its special focus on digitalisation in the recently released *Energy Efficiency 2019* report and will be expanding on this work alongside the government of Italy, who recently agreed to support a work stream that will examine the policies, technologies and business models required to realise the potential of smart grids.

Question 3: We can't forget China and India if we're going to talk about climate change. We also can't tell them that they aren't allowed to have air conditioning or have a second car. What sort of incentives or guidance should be in place to help developing countries access and utilize the most efficient technologies?

It is indeed the case that any discussion about global progress on energy efficiency and the energy transition needs to include major emerging economies, particularly India and China. However, it is important to acknowledge that both China and India are making large strides in improving energy efficiency. Since 2010, China's annual energy intensity improvement has averaged over 4% and India nearly 3.5%. This is well above the 2.1% average annual rate of improvement observed globally.

Action on energy efficiency policy has been a critical driver of these outcomes. For example, both countries have some the most comprehensive mandatory industrial energy efficiency policies in the world. In China, the Top 10 000 Programme placed mandatory energy intensity improvement targets on the country's largest industrial energy users, resulting in a step change improvement in the energy intensity. For India, its Perform, Achieve, Trade policy also sets mandatory energy savings targets for large industrial energy users and rewards companies that implement additional efficiency measures, by allowing extra savings to be sold to those industrial companies that are not able to meet their obligations. China and India are also some of the first countries in the world to introduce mandatory fuel economy standards for freight trucks and have also recently released national cooling strategies to build on existing policy efforts.

The IEA has been actively engaging with China, India and other emerging economies, through the Energy Efficiency in Emerging Economies (E4) Programme, which is a key pillar of the IEA's Clean Energy Transitions Programme. Exchange of policy best practice and experience are key components of the IEA's work with major emerging economies. At the heart of this is the IEA's E4 training events, in which energy efficiency policy best practice is discussed amongst policymakers from emerging economies. To date, these training weeks have reached more than 1500 policy makers from 130 countries. Exchange of best practice on

policies is intended to help policymakers understand the benefits of particular measures and how they can be developed, implemented and evaluated in their country and region.

Responses to Questions for the Record
Daniel Bresette
Executive Director
Environmental and Energy Study Institute

U.S. Senate
Committee on Energy and Natural Resources
Full Committee Hearing on Energy Efficiency Efforts in the United States and Internationally

Hearing Date: October 22, 2019 **Responses Submitted: November 15, 2019**

Thank you for the opportunity to provide more information about the potential of energy efficiency to reduce greenhouse gas emissions and deliver savings for American households, consumers, and businesses. My responses to the questions for the record asked by committee members are provided below. Please feel free to be in touch with me at your convenience with any additional requests or clarifications.

Ranking Member Joe Manchin III

1. *Energy efficiency is the fastest growing area in the energy sector nation-wide as well as in West Virginia, employing over 6,000 people in a state dominated by traditional energy jobs and hit hard by the downturn in the coal industry. Are there particular energy efficiency policies or combinations that are the most helpful if economic development and job creation is the top objective? Are there approaches we should avoid in states like West Virginia?*
    - As you know, energy efficiency is the fastest-growing and largest contributor of jobs in the clean energy sector. The latest figures put the number of West Virginians employed in energy efficiency jobs at more than 6,800. In all, you and your colleagues serving on the Committee on Energy and Natural Resource represent states that account for about 476,000 energy efficiency jobs.

Senator	State	Jobs	Senator	State	Jobs
Lisa Murkowski *Chairwoman*	Alaska	4,617	Joe Manchin III *Ranking Member*	W.Va.	6,844
John Barrasso	Wyo.	7,528	Ron Wyden	Ore.	42,547
James E. Risch	Idaho	8,747	Maria Cantwell	Wash.	63,877
Mike Lee	Utah	31,798	Bernard Sanders	Vt.	11,035
Steve Daines	Mont.	8,673	Debbie Stabenow	Mich.	85,061

Bill Cassidy	La.	22,152	Martin Heinrich	N.M.	5,636
Cory Gardner	Colo.	34,342	Mazie K. Hirono	Hawaii	5,850
Cindy Hyde-Smith	Miss.	15,403	Angus S. King, Jr.	Maine	8,647
Martha McSally	Ariz.	43,418	Catherine Cortez Masto	Nev.	11,155
Lamar Alexander	Tenn.	53,006			
John Hoeven	N.D.	5,425			
Total Energy Efficiency Sector Jobs: 475,761					
Job estimates courtesy of Environmental Entrepreneurs (E2) and E4TheFuture, "Energy Efficiency Jobs in America," September 2019, https://www.e2.org/reports/energy-efficiency-jobs-in-america-2019/. Last accessed November 15, 2019.					

- Many of the states with the most energy efficiency jobs are also those with policies in place to encourage private- and public-sector investments in energy-saving measures. The federal government can be an important partner in state (and local) efforts to promote energy efficiency. For example, Congress could approve funding increases for the State Energy Program (SEP) and Weatherization Assistance Program (WAP). State energy offices, which generally implement SEP-funded efforts, are tremendous sources of expertise and creativity that help ensure programs are designed in response to state and local needs and therefore conducive to sustainable economic growth.
- WAP services improve the energy efficiency of homes for low-income families, which lower their monthly energy bills while reducing energy consumption, pollution, and greenhouse gas emissions. In addition, WAP is cultivating the skilled workforce needed for the huge task of retrofitting existing homes and buildings to reduce building-sector energy use. The program provides training based on the latest building science and best practices to ensure WAP contractors and technicians are qualified to install energy-efficient heating and cooling equipment and whole-house improvements like insulation, air sealing, and duct sealing. Unfortunately, most states have a waiting list for WAP services. More robust and consistent federal funding for WAP and SEP will help states meet their climate change mitigation and pollution-reduction goals, create jobs, and grow their economies.
- There are many examples of successful state efforts to increase energy efficiency jobs and promote a strong workforce. Perhaps the biggest mistake policymakers can make is to abandon their efforts too soon. The transition to a clean energy economy requires some patience from policymakers to allow energy efficiency workforce development to take hold. We are encouraged by the legislation you introduced with Senators Heinrich and Booker (S. 2393, the Clean Energy Jobs Act of 2019) and a similar, bipartisan House bill offered by Representatives Rush and Hudson (H.R. 4061, the Blue Collar and Green Collar Jobs Development Act of 2019) that was approved by the Energy and Commerce Committee.

2. *The IEA reports that cost-effective and technically available energy efficiency measures alone could achieve 40% of the total emissions reductions needed to meet the Paris agreement goals. Are current U.S. policies (federal, state, and utility) sufficient to make*

this impact or would more investment be required? Can you provide specifics about what policies would need adjustment and to what levels and what new policies might be required?

- In my written testimony, I stated that: "…energy efficiency is the secret weapon in the fight against climate change [because] we already have what we need—in terms of policies, technology, techniques, and program design—to do what we need to do…. Building energy codes; minimum standards for appliances, equipment, and lighting products; software and controls; high-performance building materials and standards; sustainable design practices; and the list goes on. The missing piece is the magnitude of our commitment, which currently pales in comparison to the enormity of the challenge." I stand by those comments. With respect to increases in funding for federal programs, EESI and a broad range of businesses and advocacy organizations support increases across the board in Fiscal Year 2020 for the Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE). (The latest EERE funding support letter submitted to appropriators is attached for your reference.)
- In addition to increased resources, Congressional oversight is critical to ensure DOE EERE meets all of its statutory obligations (including setting and updating energy conservation standards), distributes funding on schedule, and carries out activities along the full research, development, demonstration, and deployment spectrum.
- I cited federal building energy efficiency in my testimony as a near-term, achievable source of emissions reductions. Immediate passage and enactment of the legislation you introduced with Chairwoman Murkowski is a practical step Congress can take now to lower emissions. Along with increased funding for the Federal Energy Management Program ($45 million in FY2020), your legislation would set new, forward-looking energy-intensity- reduction targets for federal buildings to, harness and leverage even more private-sector capital, and create a stronger market for workers who install, maintain, and manage the new equipment in improved facilities.

3. *If you could redesign our buildings, transportation, and the U.S. industrial sector using today's technologies, what would you change?*
    - First, thank you for asking me such a fun question to answer.
    - Second, in response, beginning with the building sector, I would:
        - Enact the SAVE Act as part of S. 2137, the Energy Savings and Industrial Competitiveness Act, to help ensure homeowners realize a return on their investments in energy efficiency improvements.
        - Update the applicable criteria for federal grants and procurement; planning, financing, designing, constructing and operating buildings and infrastructure; and economic development to ensure that outcomes are economically, environmentally and socially sustainable.
        - Incorporate strategies in federal spending considerations to ensure energy affordability and equity, resilience to climate change impacts, and net-zero energy consumption.

  - Support the work of the National Renewable Energy Laboratory, Pacific Northwest National Laboratory, and other federal laboratories that are working with the U.S. building industry to advance best practices in building science.
  - Ensure that siting for power generation and transmission, buildings, transportation, and industrial facilities does not adversely affect at-risk and frontline communities.
  - Provide incentives as well as requirements in federal procurement criteria to achieve "net-zero energy" or "zero-energy-ready" new buildings and existing building renovations. These incentives should also support other important outcomes such as good indoor air quality by utilizing best practices in building science.
- For the transportation sector, I would:
  - Reinstate the Corporate Average Fuel Economy standards for light-duty vehicles previously set to take effect in 2022.
  - Require new homes to be "electric vehicle-ready" ("EV-ready") to allow low-cost installations of Level 2 chargers by providing the circuitry, wiring, and electrical panel capacity at the time of construction.
  - Require EV-ready parking spaces for new multifamily and commercial buildings along with "EV-capable" parking spaces that provide only the conduit and raceways for wiring later installations of Level 2 or fast chargers.
  - Promote research and development efforts that support the electrification of the U.S. light duty fleet.
  - Ensure that transportation investments encourage sustainable personal mobility, including by preventing highways from dividing neighborhoods but instead enabling convenient walking and bicycling.
  - Prioritize funding for public transportation, including urban light rail and interstate high-speed rail, to ensure high quality, safety, and continuous innovation.
- For the industrial sector, I would:
  - Expand and enhance DOE's Industrial Assessment Center program to provide technical assistance to small and medium-sized manufacturers.
  - Establish new research, development, demonstration, and deployment (RDD&D) programs to focus on industry-transformative processes for the most carbon-intensive sectors.
  - Provide incentives for RDD&D activities to support renewable heat technologies, including biogas, sustainable biomass, geothermal, and solar thermal at scale for used across the industrial sector. (For reference, the House of Representatives Select Committee on the Climate Crisis held a hearing on "Reducing Industrial Emissions through U.S. Innovation on September 26 that provided additional information about existing technologies to reduce emissions in the industrial sector.)

Senator Maria Cantwell

1. *Historically, standby power was estimated to account for 5-10% of residential electricity use in most developed countries and roughly responsible for 1% of global carbon dioxide emissions. I understand that more recent technology advances and government policies may have reduced standby power loads but that some of that progress may have been mitigated by the growing number of connected electronics all of us have in our homes today.*
    - *Can you please share your thoughts on standby power—both about the scope of the problem and whether we should be doing more about it?*
        - Standby power refers to the energy used by a device when it is "off" and not actively in use but still connected to a power supply. Many consumer electronics and office equipment have this feature. The Department of Energy (DOE) is required to consider standby mode energy consumption when establishing test procedures and energy conservation standards. And I understand that you are very familiar with Section 524 of the Energy Independence and Security of 2007 (EISA), which sets a federal procurement requirement to purchase "eligible products" that use one watt or less in standby mode. The proliferation of "smart" features means many more products in our homes and businesses are "connected" than ever before, which increases the risk of wasted energy consumption because of active wired or wireless connectivity. It is difficult for me to imagine a future where we have fewer smart and connected products, which will mean this issue requires more attention going forward. I have two recommendations for your consideration as you continue to investigate standby power.
    - *Please share any specific policy measures you think the Committee should consider that could help address standby power losses.*
        - I respectfully encourage the committee to hold DOE accountable for overdue energy conservation standards. Perhaps the highest-profile standard involves the common light bulb and the rollback of a rule issued in 2017, but there are dozens more delayed or at risk of delay. DOE has also undertaken unnecessary program reforms, including a series of changes to the "process rule" that will likely result in fewer standards, infrequent updates to existing standards, and less-efficient appliances and equipment--including products with standby mode features--that will cost homeowners, consumers, and businesses more to operate.
        - A corollary of this recommendation involves new and updated standards for products that contribute to "miscellaneous electric loads" in homes and commercial buildings. Miscellaneous electric loads--commonly shortened to "MELs"—are, according to the Energy Information Administration (EIA), a "growing portion of delivered energy consumption in residential commercial buildings" and have "offset some of the efficiency gains made through technology improvements and standards in major end uses such as

space conditioning, lighting, and water heating." EIA has estimated that MELs could account for a third of home energy consumption and about 40% of commercial building energy consumption by 2030. When you consider that MELs include what EIA describes as "entertainment, computing, and convenience" products, again, it is difficult to imagine a future with fewer of these energy-consuming devices in our homes and businesses. Congress should ensure that DOE's energy conservation standards program keeps pace with the energy use of MELs.

- *I authored Section 524 of the Energy Independence and Security Act of 2007 which required that any federally-procured product use one watt or less in standby mode. Do you have a sense of the impact of that provision to date?*
  - In general, I support federal initiatives that encourage the purchase and use of energy-efficient products. The Federal Energy Management Program (FEMP) issues guidance to agencies to inform acquisition decisions consistent with the low-standby-power requirements codified in EISA. To my knowledge, agencies are complying with the law, which is a good indication that the requirement is having the intended effect. I am not currently able to quantify the kilowatt-hours saved or reductions in greenhouse emissions that have since resulted.

Senator Angus S. King, Jr.

1. *The federal government and large corporations have access to sophisticated financing options that allow them to leverage private financing to make sweeping energy efficiency investments and upgrades with little to no upfront costs. Households and individuals however, lack access to capital and financing opportunities that help them meet the large upfront costs of energy efficiency improvements. Can you expand more on potential innovative financing options (ie. on-bill financing, loan guarantees, green banks, etc.) that could be applied on a large scale for household and individual access?*
   - Access to affordable financing is essential for reaching large numbers of homeowners and unlocking the many benefits of energy efficiency. In the residential sector, many factors prevent energy efficiency financing from flourishing. One is a lack of focused financing options that encourage home energy efficiency investments, perhaps because financing institutions underestimate the growth opportunity. As a result, it is difficult for individuals to secure loans for energy efficiency improvements. Some states have created special-purpose financing entities—often termed "green banks"—that can help fill this gap by providing alternative sources for state, local, and utility programs as well as credit enhancements that leverage private-sector capital that might otherwise sit on the sidelines.
   - Another involves a more fundamental question: How best to help consumers realize the benefits from energy efficiency investments. Historically, programs have primarily relied on electric and gas utilities to develop and manage efficiency incentive programs, which mostly offer rebates for a percentage of the

cost of measures implemented. Most utilities have traditionally shied away from offering financing to customers. But a growing number (particularly among rural electric cooperatives) recognize the limits of rebates and other traditional incentives. Financing is a logical solution, and utilities can leverage their unique relationship with consumers to create "on-bill financing" programs. As I described in my written testimony, utilities (perhaps in partnership with a third party) cover the upfront costs for customers to install cost-effective home upgrades such as energy efficiency measures and renewable energy systems. Customers then repay the utility via a recurring charge on their now-lowered monthly bill. The repayment obligation can be structured as a loan or a voluntary tariff charge. By focusing on cash-flow positive projects and using proven alternative approval methods, on-bill financing can make clean energy savings accessible to all households.

- On-bill financing is already used by more than 100 utilities, though program structures vary widely. EESI strongly supports those programs that are designed to be as inclusive and equitable as possible while delivering deep energy savings. (Please refer to my response to Senator Hirono's first question for more information about these principles.) These programs offer several important benefits, including:
  - Affordability—on-bill financing can make energy improvements extremely affordable to participating consumers by offering lower rates and longer terms, which ensure monthly payments are less than average monthly utility bill savings.
  - Increased access without increased risk—on-bill financing programs increasingly use utility bill payment history as an alternative underwriting method. This allows the program to serve more customers by removing credit checks or income verification requirements. Despite this, well-designed on-bill financing programs are very low risk. Evaluations of on-bill financing programs currently in operation across the country show default rates are very low, between zero and three percent, regardless of the metrics used to assess creditworthiness. The use of alternative underwriting allows program administrators to offer more attractive financing (e.g., lower interest rates, longer loan terms, higher loan amounts) than would otherwise be available, which expands the number of consumers that can qualify for improvements.
  - Better customer experience—in addition to the up-front costs for home energy improvements, a lack of information and high transaction costs are common hurdles for homeowners to overcome. On-bill financing programs help lower these hurdles by integrating the improvement and repayment into each customer's existing billing and customer service relationship with their utility as well as adding the convenience of loan repayment as a the monthly utility bill line-item.
  - A solution for landlords, tenants, and other short-term occupants—on-bill financing programs can be structured to tie repayment obligations to the

meter, which can be assigned to subsequent occupants. This feature is especially enticing to customers who are want more energy-efficient homes but expect to move soon. On-bill financing programs can also include rental properties in situations where renters who pay their own utility bills only make repayments while they live at the property and receive the benefits of the upgrade. In these cases, the next tenant will take over the payments when they move in (after receiving proper notification from the property manager). The property owner must still consent to the work done on the property, but otherwise it removes much of the split-incentive hurdle that prevents investments in rental properties.

2. *The way we use our grid today is grossly inefficient. If we can flatten out the curve of grid use throughout the day, everybody's price per kilowatt hour will go down. Techniques like time-of day pricing can incentivize consumers to make changes to their actions, but having access to real-time energy and price data will make those changes easier to comprehend. What does a package of policies, standards, and technologies that would allow for effective and applicable time-of-day pricing and consumer data access look like?*
    - There is a need for new policies to remove the mystery of energy-use measurement and pricing by enabling easy—yet private and secure—access and analyze demand and consumption data. Without this information, it is difficult for homeowners, consumers, and businesses to make informed decisions, including about opt-in to time-of-day pricing and other demand-response programs. Similarly, new policies are needed to encourage investments in energy-efficient homes and commercial buildings. Energy-use disclosure should be a standard element in marketing, appraising, financing, and insuring properties.
    - A policy package could include requirements for utilities to provide easy-to-understand access to demand and consumption data; support for grid-interactive controls, appliances, and equipment and benchmarking tools (i.e., ENERGY STAR® Portfolio Manager). Incentives should be targeted to encourage the installation of advanced metering in homes and commercial buildings, which helps enable the collection of more detailed and incremental energy-use data, as well as sub-meters installations where appropriate. In general, more information leads to greater awareness, knowledge, understanding, and—eventually—action. Greater investment in extended broadband coverage will also promote advanced meter, sub-meter, and data analysis.
3. *We can't forget China and India if we're going to talk about climate change. We also can't tell them that they aren't allowed to have air conditioning or have a second car. What sort of incentives or guidance should be in place to help developing countries access and utilize the most efficient technologies?*
    - On a per capita basis, the U.S. emits 15 metric tons of greenhouse gas emissions compared with China (6.4) and India (1.6). Yet unlike the U.S., China and India remain committed to the Paris Agreement. It is difficult to believe assertions that U.S. climate change commitments will be meaningless unless China and

India follow suit. The current U.S. retreat from global climate policy leadership is an embarrassment and a mistake, which will make it increasingly difficult to have any positive impact on the decision-making of our top competitors concerning air conditioners and light duty vehicles. China and India--not to mention other developed, industrial economies--remain committed to the principles of the Paris Agreement. Unless the U.S. lives up to its global superpower status, accountability to meet climate commitments will be impossible to enforce. Our government has lost any leverage to encourage China and India to increase the ambition of their commitments.

- And let us never forget that while China and India might be the popular examples of top foreign "competitors," Russia, Pakistan, Brazil, Mexico, Indonesia, and dozens of other developing countries have been denied an example of meaningful, trustworthy U.S. leadership to lower greenhouse gas emissions. Not to mention potential foreign aid aimed at encouraging sustainable, low-greenhouse gas development. In response, Congress should send a strong signal to high-emitting countries to increase greenhouse gas emissions reduction goals by passing a resolution that reiterates the previous commitment to meeting the goals of the Paris Agreement regardless of the ill-informed rollbacks of the current administration.

Senator Mazie K. Hirono

1. *Your testimony referred to Hawaii's Green Energy Money Savers, an on-bill financing program intended to make it easier for people to invest in energy efficiency, solar water heaters, and renewable energy for their small businesses and residences. I understand that your organization assisted in the design of Hawaii's program. What advice does your organization typically offer to states, electric cooperatives, and others on the design on-bill financing programs?*
    - EESI assisted the Hawaii Green Infrastructure Authority (HGIA) as it developed the Green Energy Money $aver (GEM$) On-Bill Program. EESI has helped develop on-bill financing programs since 2010 and supported program launches in seven states. Currently, program development is active in many more.
    - EESI shared experiences and technical assistance resources with HGIA that included case studies, document templates, and program development guides. EESI was first in touch with HGIA in 2017. By that point in time, program development leadership already had a strong vision and much of the plan in place. EESI helped sharpen that plan and fill in some gaps. But the HGIA team deserves the credit for making GEM$ a success.
    - In general, EESI provides technical assistance to states, electric cooperatives, and public power utilities to develop on-bill financing programs that expand consumer access to cost-effective energy efficiency and renewable improvements. As with HGIA, EESI works closely with potential program operators to provide firsthand experience and lessons-learned to design programs tailored to meet the customer needs. On-bill financing programs vary

in design, with successful programs taking many shapes and sizes. But EESI generally advises all utility partners to adopt certain design principles:

- Projected average monthly savings from energy upgrades should exceed the monthly repayment.
- A strong quality assurance process that verifies energy savings and holds contractors accountable.
- Encouraging customers to implement (and therefore finance) whole-house energy efficiency and water upgrades.
- Tie repayment of the investment to the utility meter (rather than the individual), which allows the obligation to transfer to next owner or occupant (and provide appropriate notification).
- Use on-time bill payment history in lieu of a credit score to approve applicant to help make programs more inclusive without raising the investment risk.

2. *Your testimony suggested that on-bill financing programs could be deployed overseas. What do you think the federal government should do to help develop such programs overseas?*

- On-bill financing is a versatile tool that could benefit households and small businesses around the world. It can be deployed by any utility or other entity that has a recurring bill with its customers—not just electric utilities. It is broad enough that a majority of federal agencies that manage foreign assistance programs could conceivably offer some type of on-bill financing assistance in a way that would make sense. This could come in the form of pilot funds, case studies, resource experts. Electric cooperatives have been driven much of the innovation in on-bill programs over the past decade. They also have a tradition of exporting the cooperative utility model to developing countries, including sending linemen to help develop infrastructure. Perhaps there is a partnership opportunity for the federal government to collaborate with co-ops to help spread inclusive on-bill financing tools globally.

October 30, 2019

The Honorable Richard Shelby
Chairman
U.S. Senate
Committee on Appropriations
Washington, DC 20510

The Honorable Patrick Leahy
Ranking Member
U.S. Senate
Committee on Appropriations
Washington, DC 20510

The Honorable Nita Lowey
Chairwoman
U.S. House of Representatives
Committee on Appropriations
Washington, DC 20515

The Honorable Kay Granger
Ranking Member
U.S. House of Representatives
Committee on Appropriations
Washington, DC 20515

Dear Chairman Shelby, Ranking Member Leahy, Chairwoman Lowey, and Ranking Member Granger:

On behalf of the undersigned organizations, we are writing in support of funding for energy efficiency programs administered by the U.S. Department of Energy (DOE) in Fiscal Year 2020 consistent with the highest approved levels from the House and Senate. These programs return benefits and savings to American homeowners, consumers, and businesses many times greater than the public's investment. Additionally, energy efficiency is widely viewed as the single most effective solution for addressing climate change. In fact, according to the International Energy Agency, energy efficiency can account for more than 40% of the emissions reductions needed to meet international climate goals. In addition to tackling carbon emissions and delivering a return on investment, these programs have also helped develop an energy efficiency sector that accounts for over 2.3 million jobs.

The importance of DOE programs in research, technical assistance, and market integration efforts that have driven gains in energy efficiency cannot be overstated. DOE energy efficiency programs provide an exceptional value to American consumers and businesses, yielding benefits that far outweigh the relatively nominal outlays appropriated by Congress. As our society grows ever more dependent on energy to power our daily lives, now is not the time to abandon or shortchange the important work carried out by U.S. DOE. To that end, and to ensure these programs continue contributing to improved energy efficiency in our nation's buildings and infrastructure and increased economic and energy productivity as Congress intends, we respectfully urge you to provide FY2020 funding for these programs at the highest approved levels as summarized below:

Program	FY2019 Enacted Appropriations	FY2020 Energy and Water Appropriations
Advanced Manufacturing Office • *Enables the research, development, demonstration and deployment of industrial energy efficiency and advanced manufacturing technologies that will keep U.S. companies competitive in international markets and support jobs in local communities.*	$320,000,000	$380,000,000 (Senate)
Building Technologies Office • *Develops innovative, cost-effective technologies, tools, and solutions that help U.S. homeowners, consumers and businesses achieve peak energy efficiency performance in their buildings across all sectors of our economy.*	$226,000,000	$300,000,000 (Senate) • *$10M for Building Energy Codes (House)* • *$155M for Emerging Technologies (Senate)* • *$55M for Equipment & Building Standards (both)* • *$40M for Residential Buildings Integration (Senate)* • *$50M for Commercial Buildings Integration (Senate)*
Federal Energy Management Program • *Leverages private-sector capital in performance contracts, provides project and policy expertise to all federal agencies, helping them meet Congressional and Executive energy management goals, such as reducing waste in federal agency energy use, spurring innovation and the commercialization of efficient technologies.*	$30,000,000	$45,000,000 (Senate)
Weatherization and Intergovernmental Activities • *Supports energy efficiency and broader clean energy technologies and practices in partnership with state, local, and territorial governments.*	$257,000,000[1] for Weatherization Assistance Program $55,000,000 for State Energy Program	$303,500,000[2] for Weatherization Assistance Program (Senate) $70,000,000 for State Energy Program (House)
Vehicle Technologies Program • *Promotes the development of advanced efficiency technologies for light- and heavy-duty vehicles and transportation system efficiency.*	$344,000,000	$410,000,000 (Senate)
Energy Information Administration • *Provides data collection, analysis and reporting activities on energy use and consumption, including the Commercial Buildings Energy Consumption Survey and the Residential Buildings Energy Consumption Survey.*	$125,000,000	$132,000,000 (Senate)

[1] Funding for the Weatherization Assistance Program includes $3,000,000 for training and technical assistance.
[2] Funding for the Weatherization Assistance program includes $3,500,000 for training and technical assistance.

We also encourage you to once again include clear direction to DOE to obligate and expend funds consistent with Congressional intent and in a timely manner. Both the House and Senate provided clear report language that directs DOE to distribute funds in a timely manner and not prioritize early-stage research and development at the expense of later-stage deployment and demonstration activities. As you reconcile competing (at times very similar, and often complementary) report language in conference negotiations, we respectfully recommend an expansive approach to ensure congressional intent is stated clearly and directly. We encourage you to accept the House-approved language supporting the Department's ongoing role in the ENERGY STAR® program. We also encourage you to accept the Senate-approved language concerning: the Building Technology Office; Industrial Technical Assistance under the Advanced Manufacturing Office, including Combined Heat and Power Technical Assistance Partnerships, technical assistance for energy-intensive manufacturing facilities, and full recommended funding for Industrial Assessment Centers; Workforce Development; the timely disbursement of the full amount of funds for the Weatherization Assistance Program and State Energy Program; and the establishment of and funding for a Performance Based Contract National Resource Collaborative, which we request to be housed under Strategic Programs.

Additionally, as addressed in both the House and Senate report language, the ongoing reduction in staffing and hiring within EERE remains a top concern. We encourage you to accept the Senate report language addressing this reduction in force within EERE and direct the Under Secretary of Energy to report to the Committees on Appropriations of both Houses of Congress a plan for reaching full staffing level needed to responsibly manage a growing portfolio.

We appreciate your leadership and the work by the appropriations committees to follow regular order, avoid controversial policy riders, and consider appropriations for DOE's energy efficiency programs in the FY2020 process. Your work has ensured that Congress is ready and prepared to provide the funding and report language needed for DOE to do its part in the transition to a truly modern, integrated power grid and dynamic energy sector. DOE energy efficiency programs will be a critical driver and catalyst for new technology and innovation during this important time. Respectfully, we urge you and all conferees to support these important energy efficiency programs at DOE in FY2020.

Thank you for your continued strong support for key energy efficiency programs and for your consideration of our request.

Sincerely,

ASHRAE
Advanced Energy Economy
Alliance to Save Energy
American Council for an Energy-Efficient Economy
Building Performance Association
Building Performance Institute
Business Council for Sustainable Energy
California Energy Commission
Combined Heat and Power Alliance

Covestro LLC
Daikin US Corporation
Danfoss
DuPont
E4TheFuture
Environmental and Energy Study Institute
Federal Performance Contracting Coalition
Ingersoll Rand
Institute for Market Transformation
Interfaith Power & Light
International Association of Lighting Designers
International Code Council
International Window Film Association
Knauf Insulation
National Association for State Community Services Programs
National Association of Energy Service Companies
National Association of State Energy Officials
Natural Resources Defense Council
North American Insulation Manufacturers Association
Polyisocyanurate Insulation Manufacturers Association
Rocky Mountain Institute
Signify
The Stella Group, Ltd.
U.S. Green Building Council

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: *International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States*
Questions for the Record Submitted to Ms. Jennifer Layke

Questions from Chairman Lisa Murkowski

Questions: Your testimony touched on the "Building Efficiency Accelerator" operated by the World Resources Institute that provides technical assistance in several middle income countries. What has been the impact on energy efficiency in the buildings and organizations supported by that program? What are some of the lessons learned from providing this efficiency technical assistance?

Answer:
As a public-private collaboration platform, the Building Efficiency Accelerator (BEA) has helped increase the capacity of cities around the world to plan and implement local energy efficiency policies and projects. In many countries, codes are set at national or state level, but the implementation is left to local authorities who often are not trained in building energy code implementation and auditing approaches. For example, in 2015 WRI and the BEA partners convened a multi-stakeholder process in partnership with the Mexico City to review and adapt a national building energy code to the local city context. We worked with the city government to help them understand how to contract for building auditing services, which resulted in the retrofit of the Ministry of Finance building and plan for auditing and retrofitting of other city-owned buildings. The early success of this work led 6 additional cities and states to join the BEA platform over the next 4 years to undertake similar work, enabling these additional jurisdictions to achieve results more quickly using the lessons and methods from Mexico City.

The BEA has laid a strong foundation for enhancing the capacities of the participating cities, so that they can design and adopt appropriate energy efficiency policies and practices in the buildings sector, some doing so for the first time. The many global and national members of the Building Efficiency Accelerator platform share their world-class knowledge, tools and experience directly with peers at the local level.

For example, in Bogotá, Colombia, the city had a goal to implement the national building code, but found that there were technical barriers to doing so. Through the BEA, experts from Pacific Northwest National Laboratory (PNNL) provided technical assistance and guidance to local stakeholders in Bogotá to determine how best to modify the national code for its successful local implementation. Three additional cities in Colombia are now following suit, benefiting from the world-class knowledge of BEA partner PNNL and from Bogotá's experience in leading on implementation.

With an investment of $4 million over 4 years, the Building Efficiency Accelerator is expected to avoid over 8,500 GWh and mitigate over 6.5 million tons CO_2 equivalent by 2035.

Some of the key lessons learned from the BEA are:

- *Political will is critical*: It is important to approach energy efficiency through multi-stakeholder coalitions, which lead cities to prioritize energy efficiency as a part of city goals and advance action. Local stakeholder coalitions across sectors cultivate local leadership, build momentum, and create windows of opportunity, all of which are critical to policy success and can help weather political transitions.

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: *International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States*
Questions for the Record Submitted to Ms. Jennifer Layke

- *Where technical "hubs" are active, local action is more likely*: Most city staff have public policy or urban planning backgrounds, and few are familiar with construction, real estate and energy efficiency. In an environment where the energy savings may be attractive, but there is no technical expertise, the opportunities will not advance out of fear of possible risks. Organizations like the Berlin Energy Agency were established to provide local technical support. The BEA is a hybrid model: bringing local, national and global expertise to its members.

- *Innovative finance and budgeting for efficiency upgrades is not understood or available:* For most cities and corporations, there are clear priorities for capital budget allocations: a new school, or hospital, new roads, etc. Energy is paid for from operating budgets. These budgets are seldom linked. So an upgrade to a boiler, or windows, or HVAC system is an expense from the capital budget, whereas the operational savings are accrued in another department. In the U.S. and in Europe, we have energy savings performance contracts which help overcome these challenges by adding a finance mechanism which keeps the capital budget "whole" and puts the capital costs into the contract for energy services – which is paid for through the savings. These types of contracts are not currently allowed in many parts of the world but could be a powerful tool to increase investment in energy efficiency.

Questions from Ranking Member Joe Manchin III

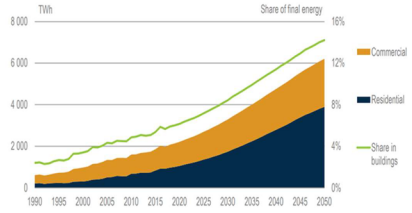
Question 1: Growing demand for space cooling will increase demand for electricity during peak hours. What do you estimate will be the impact to the reliability of the electric grids around the world? How do we spread out the demand curve to keep costs down for electricity rate payers?

Answer:
Under business as usual, energy needs for space cooling (almost all of which is electricity) will more than triple between 2016 and 2050. 37% of global electricity demand growth to 2050 is expected to come from space cooling. According to the IEA:

> "Space cooling can account for a large share of peak demand, placing further stress on the power system, especially during periods of extreme heat. Cooling demand typically jumps during a heatwave, placing greater demands on the power system, the reliability of which can be further undermined by hot equipment increasing the risk of outages. For example, the output of solar panels and gas turbines can drop off at very high ambient temperatures. Electricity networks can also be affected, as high demand and high temperatures heat up power lines, impairing their performance. In some places, such as the United States, space cooling can represent more than 70% of peak residential electricity demand during extremely hot days." *(Source: Forecasts: IEA, 2018, The Future of Cooling: Opportunities for energy-efficient air conditioning. https://www.iea.org/futureofcooling/)*

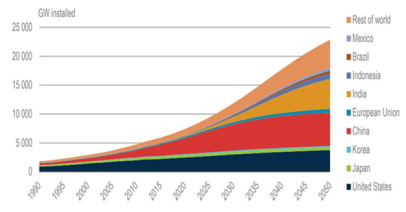
U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: *International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States*
Questions for the Record Submitted to Ms. Jennifer Layke

World energy use for cooling - forecast

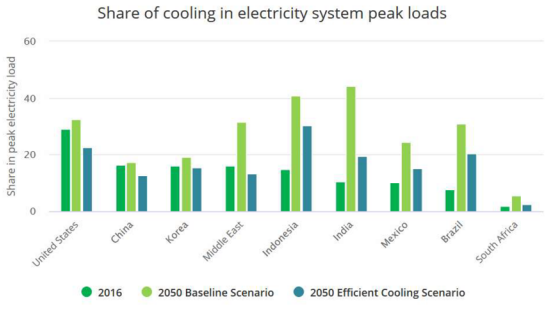


Key message • On current trends, energy needs for space cooling – almost entirely in the form of electricity – will more than triple between 2016 and 2050, driven mainly by the residential sector.

Residential AC capacity - forecast



Key message • China and India account for more than half of the global expansion in the number and capacity of residential air conditioners.



Source for all graphs: Forecasts: IEA, 2018, The Future of Cooling: Opportunities for energy-efficient air conditioning. https://www.iea.org/futureofcooling/

The impact to electric grid reliability will depend on what actions are taken to mitigate this growing demand, and especially growing peak demand. In addition to traditional energy efficiency interventions and passive cooling solutions, time-of-day pricing can encourage load shifting, where users shift some electricity consuming activities that are not time dependent to take place outside of peak hours. Demand response programs can similarly spread out the demand curve by delaying or pausing electricity consuming activities with minimal disruption for consumers. Enhanced solutions on electricity storage via batteries – potentially to include electric vehicles – can also act as demand response. Finally, distributed generation, like residential solar photovoltaic panels, can take strain off the grid by providing power from "behind the meter" when electricity demand for cooling is highest.

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Ms. Jennifer Layke

According to the IEA: "Demand-side management, which has been in use around the world since the 1970s, refers to activities aimed at encouraging electricity consumers to reduce their electricity consumption (load shedding) and/or modify their pattern of electricity usage (load shifting) as a way of lowering the overall cost of providing electricity and ensuring reliable service. In most cases, the goal of DSM is to reduce overall system load during peak hours, or to move the time of energy use to off-peak times such as night-time and weekends. This reduces the need for installing and maintaining additional capacity to meet peak load."
Source: Forecasts: IEA, 2018, The Future of Cooling: Opportunities for energy-efficient air conditioning.
https://www.iea.org/futureofcooling/

Question 2: If you could redesign our buildings, transportation, and the U.S. industrial sector using today's technologies, what would you change?

Answer:

- Build infrastructure to be "smart" through information technology and communications. Incorporate sensors and controls that continuously monitor energy consumption to better understand energy demand and supply, and to optimize systems to use less energy through continuous improvement.
- Make everything more efficient, starting with materials used for building construction. For example, glass buildings have high thermal demands; if starting over with today's technologies, chromatic glass would allow daylighting (to reduce the need for electric lighting) but avoid thermal heat intrusion.
- Design cities and communities for people, rather than for vehicles. Make sure there are public options for transportation that consider last mile concerns for people to commute and access public transit wherever they live. In additional to improving consumer choice, these interventions reduce transportation energy consumption.
- Electrify as many energy end uses as is beneficial to the energy system. Build transportation systems to run on electricity, including cars, buses, and rail for movement of people, goods, and freight. Shift buildings to all-electric energy when feasible. Electric appliances, from cars to heating equipment, are now often the most efficient on the market--a significant change from a few decades ago. Shifting to electric technologies reduces overall energy demand and infrastructure needs while improving health and safety. The U.S. electric grid is now cleaner than ever before, making the environmental and health impacts of electricity smaller than most other fuels.

Questions from Senator Maria Cantwell

Question 1: Historically, standby power was estimated to account for 5-10% of residential electricity use in most developed countries and roughly responsible for 1% of global carbon dioxide emissions. I understand that more recent technology advances and government policies may have reduced standby power loads but that some of that progress may have been mitigated by the growing number of connected electronics all of us have in our homes today.

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: *International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States*
Questions for the Record Submitted to Ms. Jennifer Layke

Can you please share your thoughts on standby power—both about the scope of the problem and whether we should be doing more about it? Please share any specific policy measures you think the Committee should consider that could help address standby power losses.

Answer:
According to a 2015 report from the Appliance Standards Awareness Project: "Standby power, the electricity an appliance uses when it is "off," is a growing portion of all electricity use as the amount of electronics grows. This power is used for continuous displays, waiting for remote controls, networked communications, power transformers, and other functions. Yet many test procedures only included power used in "active" mode. EISA [Energy Independence and Security Act of 2007] section 310 required that test procedures for all products be amended to include standby power (or if that is not feasible, to consider setting a separate standard for standby power for the product). It also set deadlines for addressing standby power in 14 products." *(Source: Bending the Curve: Implementation of the Energy Independence and Security Act of 2007. Appliance Standards Awareness Project, October 2015. https://aceee.org/research-report/e1503)*

The Department has still not completed all of the rulemakings required under the 2007 law and, in recent years, has fallen further and further behind on legal deadlines, including the requirements to address standby power. DOE has missed 18 deadlines for updating various efficiency standards. *(Source: Missed Deadlines for Appliance Standards. Appliance Standards Awareness Project, November 2019. https://appliance-standards.org/sites/default/files/Missed_deadlines_as_of_Nov_2019.pdf)*

Making matters worse, DOE test procedures have ignored the fastest growing portion of standby power – network standby, or the power a device uses while waiting for a signal from a router or other device. As more and more appliances are connected to the internet, network standby is a growing source of potential energy waste. A recent NRDC report found that linking otherwise efficient devices on a network can cause energy waste to skyrocket. NRDC found that setting up a TV that uses only a watt in standby mode for voice activation using a smart home speaker can cause the standby use of the TV to increase 20-fold. *(Source: Are Smart Speakers and Streaming Devices Energy Efficient? Natural Resources Defense Council, August 2019. https://www.nrdc.org/experts/noah-horowitz/are-smart-speakers-or-streaming-devices-energy-efficient)*

Question 2: I authored Section 524 of the Energy Independence and Security Act of 2007 which required that any federally-procured product use one watt or less in standby mode. Do you have a sense of the impact of that provision to date?

Answer: We have not performed analysis that assesses the impact of Section 524 of the Energy Independence and Security Act of 2007.

Questions from Senator Angus S. King, Jr.

Question 1: The federal government and large corporations have access to sophisticated financing options that allow them to leverage private financing to make sweeping energy efficiency investments and upgrades with little to no upfront costs. Households and individuals however, lack access to capital and financing

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: *International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States*
Questions for the Record Submitted to Ms. Jennifer Layke

opportunities that help them meet the large upfront costs of energy efficiency improvements. Can you expand more on potential innovative financing options (ie. on-bill financing, loan guarantees, green banks, etc.) that could be applied on a large scale for household and individual access?

Answer:
In addition to traditional financing like leases and loans, there are several options for specialized financing for households and individuals.

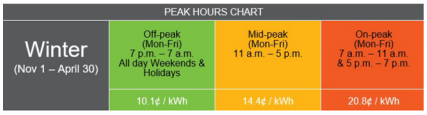
- On-bill financing has been used to extend over 232,000 on-bill loans across the residential and commercial sectors, totaling more than $1.83 billion. *(Source: Current Practices in Efficiency Financing: An Overview for State and Local Governments. Lawrence Berkeley National Laboratory, 2016. https://emp.lbl.gov/sites/all/files/lbnl-1006406.pdf)*
- Property assessed clean energy (PACE) financing has been used by over 200,000 homeowners to make $5 billion in energy efficiency and other improvements to their homes. These programs are typically enabled through state legislation, and authorized at the local government level. *(Source: Property Assessed Clean Energy Programs, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, State and Local Solution Center. https://www.energy.gov/eere/slsc/property-assessed-clean-energy-programs#residential)*
- Energy Services Company (ESCO) models can also be applied to households and individuals, such as through the innovative Pay As You Save (PAYS) model. Through PAYS financing, the utility pays the installer for energy efficiency improvements, then puts a fixed charge on the customer's monthly bill that is less than the estimated savings generated by the upgrade. *(Source: PAYS for Energy Efficiency. http://www.cleanenergyworks.org/pays-for-ee/)*
- For homeowners an extremely important financial consideration is how efficiency is considered in mortgage underwriting. Because efficient homes reduce the total cost of homeownership, this should be considered when the risks and rates for home loans are assessed. This reality has long been ignored in underwriting, but Portman-Shaheen (S. 2137) proposes to correct this oversight by giving recognition to energy costs and efficiency in home mortgage underwriting, and as a result potentially also making it easier to obtain financing for home energy improvements.

Question 2: The way we use our grid today is grossly inefficient. If we can flatten out the curve of grid use throughout the day, everybody's price per kilowatt hour will go down. Techniques like time-of-day pricing can incentivize consumers to make changes to their actions, but having access to real-time energy and price data will make those changes easier to comprehend. What does a package of policies, standards, and technologies that would allow for effective and applicable time-of-day pricing and consumer data access look like?

Answer:
Time-of-day pricing and consumer data access programs are best implemented at a utility level as system design will be impacted by variables such as local rates and local climate considerations. One effective platform for this could be the creation of a national initiative that could be adapted for local implementation.

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Ms. Jennifer Layke

Time of Use (TOU)
Programs should start with a simple time of use (TOU) program that uses either 2 rates (peak and off-peak) or, at most, 3 rates. The simplicity of this type of program minimizes consumer confusion and maximizes consumer buy-in. As one example, more information about a TOU program in Ontario, Canada can be found here: *http://enersource.com/my-home/time-of-use-rates-and-smart-meter-faqs/.* A graphic below shows their example 3-rate TOU program.



TOU programs that use one high rate during peak electricity use (~10 am - 6 pm) and a significantly (30-50%) lower rate for the rest of the day will drive consumer action. A regional platform will provide the best results that reflect the most appropriate local peak and off-peak times to use.

PECO, an energy company in southeastern Pennsylvania, saw a 6% peak load reduction from 2-6 pm during the summer months with a voluntary pilot TOU program for residential customers.
https://www.utilitydive.com/news/inside-the-surprising-lessons-from-pecos-time-of-use-rate-pilot/399629/

As a foundation to implement TOU pricing, programs require the roll out of advanced metering, including paying for the costs of advanced meters. Utilities often need either incentives or other policy support to capture future customer benefits in their cost analysis in order to demonstrate that these benefits justify the costs of transitioning to advanced metering.

In addition, programs must be designed to address potential impacts of TOU rates on at-risk customers such as older customers on fixed incomes and low-to-moderate income customers.

Smart Appliances and Tools to Save Energy through TOU Management
There are multiple technologies to help consumers use electricity more efficiently. Many appliances already have built-in timers, but these are manual timers mainly used for convenience rather than for energy savings. Appliances need to have automated controls that can respond to price signals for load shifting, along with rebates or other financial incentives for customers to purchase them. Federal appliance standards could call for integration of automated controls to enable load shifting within key appliances.

There is also a need for a suite of software with savings optimization built-in, programmable by cell phone, of all major electronic home appliances. This would fill a gap by enabling programmable homes with customized, effective, low-cost software, and could be developed or supported by the Department of Energy.

Energy System Cycling via Utility Smart Meter
Many people keep their air conditioning or heating systems running in their homes all day so that the home is comfortable when they return from work. Energy system cycling enables utilities to turn off the air

conditioning or heating system for about 15 minutes out of every hour, with most programs focusing on air conditioning loads during the summer. The temperature in the home changes very little in that small increment of time, but the aggregated energy reduction for the utility via thousands of customers can be significant.

Xcel Energy has used energy cycling in Colorado through its AC Rewards Smart Thermostat Program: *https://www.xcelenergy.com/programs_and_rebates/residential_programs_and_rebates/heating_and_cooling/ac_rewards_smart_thermostat_program*

On site energy storage or solar+storage solutions can provide a good complement to energy efficiency technologies and electricity markets can create incentives to look at efficiency + renewables + storage options.

Question 3: We can't forget China and India if we're going to talk about climate change. We also can't tell them that they aren't allowed to have air conditioning or have a second car. What sort of incentives or guidance should be in place to help developing countries access and utilize the most efficient technologies?

Answer:
Bilateral engagement and US support for it are critical to help developing countries access and utilize the most efficient technologies. The U.S. Department of State, the U.S. Environmental Protection Agency and the U.S. Department of Energy as well as the U.S. Agency for International Development have longstanding programming to support energy efficiency and the deployment of modern electricity services. These are a critical investment, and Congress should continue to build on our history of engagement around energy. A few examples:

- The U.S.-China Clean Energy Research Center Building Energy Efficiency Consortium formally connects the U.S. Department of Energy and the Chinese Ministry of Science and Technology to jointly work on research, development and demonstration projects focused on building energy efficiency. Both the U.S. and Chinese markets and manufacturers benefit from collaboration and information sharing to improve the energy efficiency of buildings in both markets. *https://cercbee.lbl.gov/*
- U.S.-India Strategic Energy Partnership is a high-level strategic collaboration platform that includes focus on power and energy efficiency as one of its four main pillars. Linking innovation across economies facilitates sustainable growth in both countries. *https://www.energy.gov/ia/initiatives/us-india-energy-cooperation* and *https://pib.gov.in/newsite/PrintRelease.aspx?relid=178727*

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Mr. W. Scott Tew

Questions from Chairman Lisa Murkowski

Question 1: Your written testimony detailed some of the energy efficiency and climate commitments Ingersoll Rand has met and exceeded. What challenges did Ingersoll Rand need to address to achieve these goals?

One of the biggest challenges we needed to address and change was perception – and so we set out to show firsthand that energy efficiency is good for business, consumers, and the health of our climate. We did that by evaluating our company's risk exposure related to climate, and by making energy efficiency and sustainability commitments designed around global supply chain and operations, industry-leading products, systems and services, and quality of life enhancements. They allow us to address global issues like climate change, and to be the brands the world looks to for solutions that reduce energy dependence and emissions while preserving food, water, and other natural resources.

Our '2030 Sustainability Commitments' demonstrate how much we believe in the business of sustainability and we will continue to overcome challenges in this space by continuing to invent, innovate, and invest. Our hope is that perceptions will continue to evolve, and others will follow our lead.

Question 2: Do you see opportunities for the Federal government to streamline any processes or regulations to make it easier for companies to increase their energy efficiency and reduce their emissions?

The federal government can continue to play an integral role in helping to promote a regulatory environment that makes it easier for companies like Ingersoll Rand to increase energy efficiency and reduce emissions. Doing so will open opportunities for the energy savings that comes through systems efficiency – the way building products and systems interact with one another, are controlled, and respond to constantly changing environmental conditions.

Additionally, the federal government should continue to support and refine the Department of Energy's technical assistance programs that:

- ***Implement model building energy codes to make sure new buildings and major renovations are built to the latest industry standards for energy efficiency;***
- ***Foster engagement among large energy users to identify best practices in energy efficiency improvement; and***
- ***Increase emphasis for programs at DOE which create consumer-facing tools designed to help building owners better understand their energy consumption.***

Question 3: You point out in your written testimony that heating and cooling our buildings already constitutes 12 percent of total annual emissions in the U.S., and noted that this figure could double by 2030 due to the changing climate and growing population centers. As the climate changes and demand increases for heating and cooling, are the existing energy efficiency policies sufficient to account for those changes?

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Mr. W. Scott Tew

Existing policies have been sufficient to date, but more action is needed. Many states, cities, and localities have targeted net zero energy buildings within the next 15-30 years in order to mitigate the negative impacts of climate change. To achieve those goals, building energy codes will need to become increasingly clear, defined, and as needed, stringent. Building owners must also be equipped with the tools that will allow them to optimize energy consumption and identify improvements critical for meeting efficiency targets while managing energy costs.

Questions from Ranking Member Joe Manchin III

Question 1: We've made great strides in driving up energy productivity with energy efficiency measures so that we can get more value out of each unit of energy we put into the economy. I support continued investment in energy efficiency but I know that in some areas we're reaching the limit of cost-effectiveness. What's the next frontier in energy efficiency, in terms of either innovative technology or innovation in tools we use to deploy energy efficiency technologies like financing?

We view the next frontier in energy efficiency to be the optimization of buildings that respond to internal and external conditions to leverage efficient technologies, modify operations, and engage distributed energy resources such as storage.

This new frontier will require the substantial renovation of our existing building infrastructure and that means new tools for deployment like financing will also need to be leveraged. In addition, tools such as the Property Assessed Clean Energy (PACE) Program, on-bill financing, green loans, and performance contracts will be increasingly important to help overcome the upfront cost of improvements while ensuring that repayments align with reductions in energy costs.

Question 2: Growing demand for space cooling will increase demand for electricity during peak hours. What do you estimate will be the impact to the reliability of the electric grids around the world? How do we spread out the demand curve to keep costs down for electricity rate payers?

Distributed energy resources, such as on-site generation and storage, combined with energy management and operation, will help flatten load profiles without sacrificing building services. In addition, connecting buildings to the grid to enable responses to price signals or other alerts from the utility will enable buildings to act as resources, maintain reliability, and help keep infrastructure costs down.

Question 3: If you could redesign our buildings, transportation, and the U.S. industrial sector using today's technologies, what would you change?

As you would expect, we would start by designing buildings and vehicles as efficiently as possible with the most energy-efficient technologies available. We would also ensure that our solutions would integrate distributed energy resources where feasible and would include all of the enabling technologies so that they could connect to the grid, respond to signals, and optimize performance.

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Mr. W. Scott Tew

Questions from Senator Maria Cantwell

Question 1: Historically, standby power was estimated to account for 5-10% of residential electricity use in most developed countries and roughly responsible for 1% of global carbon dioxide emissions. I understand that more recent technology advances and government policies may have reduced standby power loads but that some of that progress may have been mitigated by the growing number of connected electronics all of us have in our homes today.

- Can you please share your thoughts on standby power—both about the scope of the problem and whether we should be doing more about it?

- Please share any specific policy measures you think the Committee should consider that could help address standby power losses.

- I authored Section 524 of the Energy Independence and Security Act of 2007 which required that any federally-procured product use one watt or less in standby mode. Do you have a sense of the impact of that provision to date?

Standby power draw can certainly be overlooked in the efficiency discussion, but since it can contribute to energy waste, it is critical to assess its impact. From our vantage, appliance standards for the consumer products we manufacture do include requirements for the allowable wattage draw on our equipment in standby mode. It is also important to keep in mind however that sensors and controls draw electricity in order to stay connected, which enables system optimization and ultimately leads to energy savings.

Future regulatory and legislative proposals should consider differentiating the definitions for "standby" and "connected." Doing so will allow for the determination of a reasonable watt draw required for equipment to remain connected, and will ensure the preservation of functionality.

Questions from Senator Angus S. King, Jr.

Question 1: The federal government and large corporations have access to sophisticated financing options that allow them to leverage private financing to make sweeping energy efficiency investments and upgrades with little to no upfront costs. Households and individuals however, lack access to capital and financing opportunities that help them meet the large upfront costs of energy efficiency improvements. Can you expand more on potential innovative financing options (ie. on-bill financing, loan guarantees, green banks, etc.) that could be applied on a large scale for household and individual access?

All of the financing options you cite have yielded success in various market applications. One way to build on that expand their use and effectiveness is through incentives. For example, a utility could offers on-bill financing as part of a demand-side management program to meet an energy-efficiency resource standard (EERS). And in that case, raising the targets in the EERS directed at low-to-moderate-income housing and expanding the financial incentives for meeting these targets would increase the use of on-bill financing.

U.S. Senate Committee on Energy and Natural Resources
October 22, 2019 Hearing: ***International Efforts to Increase Energy Efficiency and Opportunities to Advance Energy Efficiency in the United States***
Questions for the Record Submitted to Mr. W. Scott Tew

Additionally, one of the most successful financing methods for public sector buildings and large campuses has been the use of performance contracting. Performance contract leverages private financing and guarantees in energy savings to deliver large-scale energy-efficiency improvement projects at little risk to the customer. This mechanism could be applied at the individual scale if a third party aggregator bundled a large number of improvement projects that could be delivered by a single solution provider with access to private financing.

Question 2: The way we use our grid today is grossly inefficient. If we can flatten out the curve of grid use throughout the day, everybody's price per kilowatt hour will go down. Techniques like time-of-day pricing can incentivize consumers to make changes to their actions, but having access to real-time energy and price data will make those changes easier to comprehend. What does a package of policies, standards, and technologies that would allow for effective and applicable time-of-day pricing and consumer data access look like?

Technologies include buildings that have integrated energy resources, robust energy management information systems that can optimize equipment and respond to signals from the grid, and more flexible grid assets that can rely on low-carbon energy generation sources and deploy additional assets (including connected buildings).

Standards include common requirement sets for equipment and building management systems to respond to communication from the grid and make changes accordingly. For example, the AHRI 1380 standard sets communications protocols between a utility and a multi/variable speed air conditioner to ramp down the cooling power it uses.

As buildings and systems become more complex, standards will too. Accordingly, standards should look beyond energy consumption and into carbon emissions. They should incentivize complex systems that have the capability to optimize energy performance for cost-effectiveness and carbon emissions, and allow building owners to understand system capabilities.

Question 3: We can't forget China and India if we're going to talk about climate change. We also can't tell them that they aren't allowed to have air conditioning or have a second car. What sort of incentives or guidance should be in place to help developing countries access and utilize the most efficient technologies?

We should encourage China, India, and others to adopt appliance standards that are as stringent as those in North America, with appropriate modifications for their specific climate conditions. We should also seek opportunities to share best practices in energy efficiency deployment, including technologies such as building energy management and information systems, and financing such as performance contracting.

○