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THE LATEST DEVELOPMENTS AND LONGER-TERM PROSPECTS FOR GLOBAL ENERGY MARKETS, WITH A SPECIAL FOCUS ON THE UNITED STATES, FROM THE PERSPECTIVE OF THE INTERNATIONAL ENERGY AGENCY

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BEFORE THE

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THE LATEST DEVELOPMENTS AND LONGER-TERM PROSPECTS FOR GLOBAL ENERGY MARKETS, WITH A SPECIAL FOCUS ON THE UNITED STATES, FROM THE PERSPECTIVE OF THE INTERNATIONAL ENERGY AGENCY

THURSDAY, MARCH 5, 2020

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

The Committee met, pursuant to notice, at 9:30 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 as we are gathering to hear our friend, Dr. Fatih Birol, who is the Executive Director of the International Energy Agency (IEA), speaking to the latest developments and longer-term prospects for global energy markets with a special focus on the United States.

Dr. Birol, I want to just personally thank you. You have come before the Committee for so many years, and when we invited you this year, I think we were trying to tee it up with other international conferences in the country. Due to the Coronavirus, that conference has been canceled, but you were able to keep your commitment to join us again. Know how much we appreciate not only your effort in being here but really the guidance that you have provided this Committee. It has been instructive as we have worked to develop our Energy Innovation bill that is currently on the Floor. Know that I credit you and your team with so much of the good and helpful information that has allowed us to get to this point.

I also want to thank you for inviting me to serve as an Honorary Member of IEA's Global Commission for Urgent Action on Energy Efficiency. I had an opportunity at the invitation of Dr. Birol to serve as part of that Commission. We had our initial meeting in December. For me, it was particularly eye opening to see and understand the different challenges, but really the many, many opportunities that exist around the world when we think about the first fuel, efficiency being that first fuel. So I am pleased to be included with that and will look forward to the report which is due out this summer.

Again, your perspective before the Committee is very timely today considering where we are with the American Energy Innovation Act. Our bill incorporates dozens of innovation-related provisions that we have discussed in your previous appearances before the Committee and this includes advanced nuclear, carbon capture, energy efficiency and energy storage. As I mentioned to you just a few moments ago, your input and your testimony last year really helped us shape this package and, as always, you have been a great resource for the Committee throughout our legislative process.

We have seen how technological innovation can move the needle in world energy markets. You only have to look back a few years to understand how the shale revolution has changed our energy mix and impacted energy markets around the world, not to mention how it has helped substantially reduce our nation's greenhouse gas emissions. With the provisions included in our bill, we hope to repeat the success of hydraulic fracturing and horizontal drilling and develop new technologies that will further lower emissions and make energy more abundant and more affordable.

We recognize that America's commitment to innovation is in part responsible for our dominant position in global energy markets. Energy dominance is really more than a catch phrase. It has to be more than a catch phrase. It is the trajectory of the U.S. influence in world energy markets. It should also be an aspiration, one that we should seek to build as we prepare for a future of higher, not lower, global energy demand. We know what is happening with that trajectory.

Dr. Birol, the work that you do at IEA provides valuable insights that inform our energy policy. More often that not, something that you have said or a report that IEA has released is referenced in our hearings. So we thank you for your commitment to providing clear and data-driven information. I look forward to hearing more today about the latest developments in the world energy markets, those driven by geopolitical events and, most recently, those that are the result of the spread of the Coronavirus. We look forward to hearing about IEA's latest World Energy Outlook and everything else that you and your team have been working on.

Again, thank you for making this a priority on your schedule. This is one of the hearings that I look most forward to every year. I am pleased that you are back before us.

With that, I turn to my colleague, Ranking Member Manchin.

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

Senator MANCHIN. Thank you, Chair Murkowski, and as you said, we have a lot going on right now. We are in the midst of an energy bill deliberation. I want to thank you on behalf of all of us and reiterate what Chair Murkowski has said, welcome back and thank you for making the effort to be here.

The last time you testified before the Committee, Doctor, it was at the beginning stages of developing the legislation package on energy innovation and your testimony helped us tremendously to work together and look at an all-in energy policy. We are all-in on renewables, but we knew we needed to do a lot more if we wanted

to start cleaning up, truly making a difference in the greenhouse gas emissions, and that is what we took under consideration.

So here we are a year later in the middle of considering our bipartisan American Energy Innovation Act which would be the first in the United States of America, the first comprehensive energy policy update in 13 years. I said 13 years ago the iPhone was just coming out. There have been ten iterations of the iPhone in that period of time, and we have not changed anything in our policy of how we use energy and what direction we are going to be going.

According to the International Energy Agency's most recent World Energy Outlook, global energy demand grew by 2.3 percent in 2018, the largest annual increase since 2010. The United States, China and India together account for 70 percent of this energy demand growth, and energy-related carbon dioxide emissions hit another historic high in 2018, the highest annual increase since 2013. I am sure your figures, if we made some mistakes here you will correct me and I gladly accept that correction. I agree wholeheartedly with IEA's conclusion that meeting rising energy demand while cutting emissions is a formidable task, but we have the opportunity to make that task easier if we set the right conditions for energy innovation and investment.

The American Energy Innovation Act does just that. It gives a significant boost to the development of a broad range of energy technologies that provide affordable, reliable energy and reduces greenhouse gas emissions. The U.S. is in a very strong position. The IEA reports that the U.S. is expected to become a net oil exporter soon after 2020 and that North America will become the world's second largest oil exporter by 2030. By 2025 total U.S. oil and gas output is predicted to overtake total oil and gas production from Russia.

This is good news, but there is still the risk of volatility and disruptions that we must continue to consider. One need only look to the attack last fall at the Saudi Arabia oil facility which caused oil prices to spike or the impact of the Coronavirus on the transportation of oil. Due in large part to increase U.S. shale output from states like mine in West Virginia, the U.S. is estimated to produce more natural gas than the whole of the Middle East between now and 2040. It is unbelievable in that short of a turnaround. Most of that is destined to export. I am proud that West Virginia gas exported as liquified natural gas supports increased flexibility in the global gas trade, which helps to underpin confidence in global gas supply.

Another thing the IEA highlights, and this came up last year too, is that Asia is investing in coal so much that 90 percent of the coal-fired capacity built in the last two decades is in Asia. This results in affordable energy to millions. If 60 percent of the existing global coal fleet is 20 years old or less, then we need carbon capture, utilization and storage (CCUS) technology to help reduce the greenhouse gas emissions. My EFFECT Act, which is included in the American Energy Innovation Act, would invest in the full suite of carbon capture, utilization and storage technology, which IEA acknowledges are important for achieving global emissions goals.

Without question, energy efficiency and renewable generation are also critical for addressing climate change, but the IEA report finds

that there is faltering momentum behind global energy efficiency improvements which would reduce global energy intensity by more than three percent each year. According to the IEA, a significant increase in efficiency improvements is the single most important action that we can take to help reach global sustainability goals. Particularly as electrification progresses, energy efficiency measures, as well as increased renewable resource investment, are important tools to decrease our energy sector's carbon footprint.

We are on our way. Last month, the IEA reported that the U.S. had the largest energy-related emissions decline of any country, but we still have a long way to go.

With that, I appreciate your being here and I look forward to hearing from you.

Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator.

Dr. Birol, again, welcome to the Committee. We welcome your remarks this morning. Know that your full statement will be included as part of the record, but the opportunity to have the back and forth is certainly something that we look forward to. Welcome.

STATEMENT OF DR. FATIH BIROL, EXECUTIVE DIRECTOR, INTERNATIONAL ENERGY AGENCY

Dr. BIROL. Chairman Murkowski, Ranking Member Manchin, distinguished members of the Committee, thank you very much for the support once again. It's a great honor for me and for my agency to appear before you today.

Madam Chair, as you mentioned, I had the opportunity to come and brief you and your Committee several times during the first term of my service as Executive Director. I came several times, and I have just started the second term as Executive Director of International Energy Agency. I hope that I will have the opportunity to come and brief you to support your efforts here.

I also thank you very much, Madam Chair, for coming to Paris, being an honorary member of our Global Commission for Urgent Action on Energy Efficiency together with ministers, business leaders, political leaders around the world. It's very much appreciated and we are looking forward to seeing you in July this year, again, in Paris to have a final meeting of that Commission.

Now I am very happy that I will share with you some of the developments in the global energy markets and the role of United States. I have prepared my remarks, of course, a few weeks ago as I was going to appear in front of such an important forum, but in the meantime, we have a very important development, Coronavirus. So just perhaps a few remarks on Coronavirus. It is affecting, as we all know, first of all, the human health. It's a major public health issue with significant impact on many countries and also significant impact on the economy. International economic institutions, one after another, revising down their economic growth expectations, but energy will be disproportionately affected from the Coronavirus. It is unlike the classical economic shocks—it will be affected disproportionately. The main reason being is that in addition to the economic activity going down, mobility is negatively affected.

For example, aviation makes only hardly one percent of the global economy, but close to ten percent of the global oil demand. And it is very, very negatively affected. So we will see is significant implications on oil markets, oil demand growth, coal, gas and others and, Madam Chair, we plan to release our Annual Oil Market report in several weeks, next Monday, but we are going to release what we expect from the oil markets 2020 this Monday in Paris what are our expectations there.

These are, this Coronavirus, a major issue but it is, of course, a temporary issue. Looking at the fundamentals, we see the fundamentals of oil demand is still strong and global demand will continue to increase. And in terms of the United States, a few years ago I came here and I said, soon United States will be the top oil producer which is the case now, as the Ranking Member just mentioned. Now what we have seen at the end of last year, the United States became a net oil exporter and this will continue. The United States will import a lot—export a lot of oil and we expect these export levels in five years will reach at least one million barrels per day, a significant increase and major input to the global oil markets.

Having said that, why we celebrate this is it is important for the global oil markets, oil security. You should also note that the Middle East will still remain an important oil exporter. So it is the reason, I think, we have to look at the global markets and we should understand it. While the United States becomes the number one oil producer and a major oil exporter, the Middle East will be still important as an oil exporting region to the, especially to Asia and as such, developments in Middle East will be important.

I can mention it too, developments of crucial importance. One is the attack on Saudi Arabia facilities, the terrorist attack on Saudi Arabia facilities in the recent times, and the second, the discussions around the Hormuz Strait. I think both of these events tells us that the oil security still does matter, even in the period of oil abundance, and therefore the stocks that we have, oil stocks we have, the core mission of the IEA, oil security is very important. As such, the U.S. Strategic Petroleum Reserves of still critical importance for U.S. and for the global oil security.

Natural gas, again, very good news for United States. As again, Ranking Member Manchin said, records after records. 2018, only in 2018, the production increased about three TCF, which is the largest increase of any country in the history in terms of gas, oil, gas production growth. Gas production growth, three TCF, big increase in 2018 and 2019 another increase, ten percent. Now this is good for the United States, but good for others. I give you one example. In Europe, many, many importers of pipeline gas from a major gas exporter since they have a new option now, another option, they sit at the table and they renegotiated existing contracts with the pipeline gas exporting country and they brought the gas prices down equivalent to $8 billion. They benefited from the availability, the option of the U.S. LNG.

So this is very important. Even they didn't, some of them didn't, import one BCM of U.S. LNG. The fact that there is an alternative makes their hand stronger, and they have renegotiated their contracts and brought the prices down. And I can tell you that our

numbers show that in such a short period of time, in the last six months, the United States became the number one LNG importer nation for Europe. So this is a very important good news for Europeans and the rest of the world to what the United States provides.

In terms of renewables, also good news around the world and in the United States with solar and wind growing very strongly. In United States the share of solar and wind today combined, second largest compared to, for example, EU which is the region which puts a lot of efforts there. But when you look on a state level, 15 states in United States have higher solar and wind share than the EU, European Union, averages today.

Solar and wind are good but they have one significant challenge, what do we do if there is no sun? What do we do if there is no wind? And everybody wants 24/7 electricity. So integration of solar and wind is very important and securing the electricity supply is of crucial importance. Therefore, we also need, fixed electricity generation technology and to integrate the solar and wind in the best way to our electricity systems.

Here I have one concern, Madam Chair, which is the station in United States and in many advanced economies, station of nuclear power. The nuclear power in advanced economies are not getting, in my view, the attention and recognition they need to because they are providing baseload electricity and without emitting carbon dioxide emissions. And in advanced economies today, they provide about one-fourth of the electricity generation but if we do not change our policies, their contribution will decline very, very quickly. And but on the other side of the coin, we also see that the other countries, such as China, are building nuclear power plants one after another and our numbers show that in less than seven years of time, China will overtake the United States as the number one nuclear power capacity in the world. And therefore, it is very important to, in my view, to provide lifetime extensions to nuclear power plants as they are the cheapest source of clean electricity generation and also look at the options of new technologies such as in small modular reactors.

I want to finish by a couple of good news, if I may, Madam Chair. I am also the Chair of the Davos World Economic Forum on Energy Board. It is the 14th year I have attended in a row. I attended those meetings. I have never seen environmental issues, especially climate change, becoming such a dominant topic there and everybody was talking emissions are still increasing. But the International Energy Agency has found out that, in fact, 2019 emissions did not increase. They remained flat. Good surprise for many of us and here when we look at which countries were leading the decline and which countries were leading the increase of their emissions, we have seen that the United States was the country which had the largest decline in emissions. So this is something that we all need to see as a positive development.

A concern, another concern like nuclear is energy efficiency. It is unfortunately the political commitments of the government's industry is not there as much as we would like to see and I am very happy that the, this Committee puts high priority on energy efficiency so we have thought that the energy efficiency is international political momentum and it is the reason we built the Glob-

al Commission for Urgent Action on Energy Efficiency bringing several political leaders around the world, business leaders and thought leaders. And I am very happy that, once again, Chairman Murkowski is an honorary member of this effort.

Now, United States, when I say, when I think of United States and energy since years and years, I would associate the United States and energy with one word, innovation. Innovation is very important and you have groundbreaking work of several national laboratories and there are some, several, in fact, good moves and I want to highlight two of them and finish here. One of them is the Energy Storage Grand Challenge. The storage is extremely important especially with the renewables, and I would like to commend Secretary Brouillette here for the announcement of the energy storage grant, Grand Challenge Comprehensive Program, to accelerate the development for the next generation of energy storage.

Finally, about coal, in fact many people think that we are at the end of a coal era and the more we talk on the coal, send tweets left and right, that coal is disappearing. It is, in fact, completely wrong, Madam Chair. Between 2000 and 2018 global coal consumption increased about 65 percent, is a big increase 65 percent. And this reminds me that if I have to, there are many technologies at the IEA, we look at all the technologies. In fact, if I have to pick out one technology form which is the most critical technology if I had a magic touch to make this technology mature and have a big market share, this is carbon capture, utilization and storage. I couldn't think of any other technology which could be so crucial, you know, and enhanced energy security, make the energy affordable for the citizens but at the same time they use the greenhouse gas emissions.

So therefore, the U.S. efforts on the 45Q is an example for here and we expect the United States to be leading, hopefully, with other countries around the world such as Norway, such as U.K., Netherlands and others will lead the force in the carbon capture, utilization and storage. And I will expect in 2020 more and more announcements will be made in terms of new projects.

So, Madam Chair, I wanted to thank you once again for inviting me here. We at the IEA, we believe that the problems are so huge in terms of energy and environment and climate change that we need all fuels, all technologies to be on board and I, as much as I read, your energy bill is very much in line with to get all fuels, all technologies, including innovation at the heart of it. And I wanted to congratulate you, together with your Ranking Member, for this bipartisan bill, Madam Chair, and I thank you very much for your attention.

[The prepared statement of Dr. Birol follows:]

Written testimony
Hearing of the U.S. Senate Energy and Natural Resources Committee
Prospects for global energy markets, including the role of the United States

Dr Fatih Birol
Executive Director
International Energy Agency

5 March 2020

Chairman Murkowski, Ranking Member Manchin and distinguished Members of the Committee, thank you for the opportunity to appear before you today and to present the International Energy Agency's view on global energy trends.

It has been my privilege to serve as the Executive Director of the International Energy Agency (IEA) for over four years. And I am very pleased to share with you our latest views on the prospects for global energy markets, and in particular on the role of the United States.

A brief overview of the IEA

First, I would like to give you a short introduction to the IEA. Since the founding of the IEA almost 45 years ago, the United States has been a crucial pillar for the Agency. US leadership and support has come from across government, including the White House, the Department of State, the Department of Energy and your National Labs. I would like to particularly express my great appreciation for the strong partnership with Secretary Brouillette as well as his predecessor, Secretary Perry. But US engagement with the IEA is by no means limited to the Executive Branch; we are also very much honored by the support from this Committee and from the Congress more broadly. I have been privileged to appear before this Committee each of the past four years and have benefitted from Committee Members' insights, interactions and guidance. Let me thank Chairman Murkowski and Ranking Member Manchin, in particular.

The IEA was founded by United States and 16 other countries in the wake of the 1974 oil crisis to promote energy security, co-operation and stable markets. Since that time, our Agency has evolved, expanding to become the world's leading authority on global energy issues, providing data, analysis and advice to governments and industry on all fuels and all technologies.

Today, the IEA has 30 Member countries. Since the start of 2016, we have welcomed eight IEA Association countries: Brazil, China, India, Indonesia, Morocco, Singapore, South Africa and Thailand. This broader IEA family reflects the global nature of the energy system, accounting for almost 75% of the world's energy consumption compared with less than 40% in 2015.

The coronavirus and global energy markets

Before I begin describing the major trends that are shaping the global energy landscape, I would first like to briefly address the current turmoil resulting from the impact of the novel coronavirus (Covid-19). As we all know, Covid-19 is a major global public health emergency that has brought tragedy to many communities around the world. Its impact is fast evolving and still playing out across the globe.

Any specific short-term forecasts I give you today could be out of date by tomorrow. But it is already clear that Covid-19 is negatively affecting global economic activity. Its impact on oil markets is disproportionately strong because it is stopping huge amounts of people and goods from moving around by car, truck, bus, plane and many other forms of transportation. The IEA is monitoring the situation extremely closely and will provide updates to our member governments as often as needed.

Key global trends

While keeping the unfolding impact of Covid-19 in the back of our minds, I would like to start my main presentation by giving you a broad outline of what the global energy system looks like in 2020. It is an energy world marked by a series of deep disparities. There is the gap between the promise of energy for all and the fact that almost one billion people still do not have access to electricity, mostly in Africa. The gap between the latest scientific evidence highlighting the need for ever-more-rapid cuts in global greenhouse gas emissions and the data showing us that energy-related emissions remain at historic highs. And the gap between expectations of fast, renewables-driven energy transitions and the reality of today's energy systems in which reliance on fossil fuels remains stubbornly high.

As ever, governments' decisions remain critical for the future of energy systems. This is evident in the divergences between the scenarios produced by the IEA that map out different routes the world could follow in the coming decades, depending on the policies, investments, technologies and other choices that decision makers pursue. The scenarios do not provide a forecast of what will happen. Instead, they explore different possible futures to help inform policy and investment decisions today.

The United States remains a cornerstone of global energy security

A fast-moving energy sector highlights the importance of a broad and dynamic approach to energy security. The attacks in Saudi Arabia in September 2019 underlined that traditional energy security risks, centered on **the global supply of oil**, have not gone away. Meanwhile, new or evolving hazards – from cybersecurity to extreme weather – require constant vigilance from governments.

In the IEA's Stated Policies Scenario, which reflects the impact of existing policy frameworks and today's announced policy intentions, shale output from the United States stays higher for longer than previously projected, reshaping global markets, trade flows and security. Annual US oil and gas production growth slows from the breakneck pace seen in recent years, but updated official estimates of underlying resources mean that the United States still accounts for 85% of the increase in global oil production to 2030 and for 30% of the increase in gas. This strengthens its position as the world's largest producer of both fuels. By 2025, total US shale output (oil and gas) overtakes total oil and gas production from Russia.

It is not just the growing volumes of US shale oil that make it a unique contribution to global markets. After a decades-long oil industry shift towards larger projects with longer lead times, US shale offered new supply from projects with short lead times that could be quickly scaled up or down, providing much needed flexibility. Without the response from the US shale industry, the recent supply reductions from Libya, Venezuela and Iran would have delivered painful shocks to the world economy.

Higher US output pushes down the share of OPEC countries and Russia in total oil production. In the Stated Policies Scenario, this share drops to 47% in 2030, from 55% in the mid-2000s, implying that efforts to manage conditions in the oil market could face strong headwinds. Pressures on the

hydrocarbon revenues of some of the world's major producers also underline the importance of their efforts to diversify their economies.

Whatever pathway the global energy system follows, the world is still projected to rely heavily on oil exports from the Middle East for years to come. The region remains by far the largest net exporter of oil to world markets, as well as an important exporter of LNG. This means that one of the world's busiest trade routes, the Strait of Hormuz, retains its position as a crucial artery for the global energy trade, especially for Asian countries such as China, India, Japan and Korea that rely heavily on imported fuel. In the Stated Policies Scenario, 80% of international oil trade ends up in Asia in 2040, propelled in large part by a doubling of India's import needs.

These trends underscore why IEA member countries maintain strategic oil stocks that can be collectively pledged to markets when a disruption occurs. The United States, together with Japan, Korea and Europe are the central pillars of this system. US strategic stocks have proved themselves useful not only during cases of global oil disruptions but also during domestic disruptions, such as during severe impacts from hurricanes, most recently in 2017.

The importance of oil supply security persists even under the strong decarbonization policies included in the IEA's Sustainable Development Scenario – a pathway that indicates what needs to be done differently to fully achieve climate and other sustainable energy goals. Investment in upstream projects is still needed even in rapid transitions, since production from existing fields declines at a rate of roughly 8% per year in the absence of any investment, larger than any plausible fall in global demand. Projects that are low-cost and that have tight control of emissions would naturally be favored in such a scenario. However, the risks of geopolitical disruption may also be heightened in a world where major producers have to cope with significant reductions in hydrocarbon revenues.

Our recent in-depth review of US energy policies, which I presented alongside Secretary Perry here in Washington last September, noted the continued priority the United States places on energy security. The United States remains a cornerstone of global energy security and will play a critical role in any future IEA oil collective responses. In that context, as the shale revolution turns the United States into a net oil exporter, continued careful consideration is required when examining proposals to modernize and sell down the US Strategic Petroleum Reserve.

The US shale revolution has also significantly contributed to global **natural gas security**. Soaring shale gas production in the United States has transformed the global LNG market by diversifying supply and increasing flexibility. This has helped accelerate fuel switching from coal to gas in electricity generation worldwide, which in turn has reduced global carbon dioxide emissions. In Europe in particular, growing imports of LNG from the United States have driven down gas prices, helping European countries cut the amount they pay for gas from Russia by USD 8 billion a year, according to IEA analysis.

The growing importance of electricity security in the United States and beyond

Cost reductions in renewables and advances in digital technologies are opening huge opportunities for energy transitions while creating new energy security challenges. Wind and solar PV provide more than half of the additional **electricity generation** worldwide to 2040 in the Stated Policies Scenario and almost all the growth in the Sustainable Development Scenario. Policy makers and regulators will have to move fast to keep up with the pace of technological change and the rising need for flexible

operation of power systems. Issues such as the market design for storage, the interface between electric vehicles and the grid, and data privacy all have the potential to expose consumers to new risks.

The US power sector is experiencing a significant transition. Renewable electricity has seen rapid growth, driven by reduced costs and policy support. State-level Renewable Portfolio Standards and federal tax credits have helped lower the costs of wind and solar generation and increase the share of renewables in the electricity mix. Today, 15 US states already have a higher share of wind and solar generation than the European average.

As the share of variable renewables such as wind and solar PV increases, the work of smoothly and cost-effectively integrating them into the power system becomes increasingly critical. The United States has shown itself to be a global leader in innovative regulatory approaches for digitalized and flexible electricity market design. Grid operators are incorporating more flexibility resources such as storage, demand response and power market integration in order to safely accommodate larger shares of variable renewables. Further integration of these sources can be fostered by pursuing market regulations that leverage the geographic diversity of resources by expanding transmission capacity. Nevertheless, flexible power generation from gas turbines are set to remain essential for electricity security for decades to come.

The shale gas boom has made natural gas-fired generators more cost-competitive than coal power plants. Natural gas-fired electricity production increased by over 60% in 10 years, and now exceeds coal's share in the power mix. In this context, coordination between the electricity and the natural gas systems takes on special importance when dealing with gas supply disruptions and electricity blackouts as well. A key challenge is to resolve infrastructure bottlenecks that limit the ability of increased shale gas supply to offset the loss of power system flexibility resulting from the retirement of coal-fired and nuclear power plants. These bottlenecks are a particular concern for the Northeastern United States.

At the same time that renewable power is expanding in the United States, the other key source of low-carbon electricity, nuclear power, is facing growing economic pressure, prompting several plants to prematurely shut down. The IEA explored the consequences of this trend for energy transitions and energy security in a major report last May, *Nuclear Power in a Clean Energy System*. Looking ahead, the value of nuclear power as a stable, low-carbon generation source for overall power system resilience should be considered more closely.

It is also vitally important for the United States and other countries around the world to preserve and improve the functioning of their hydropower plants, which remain the world's largest source of renewable electricity generation. Hydropower will play a critical role in providing flexibility to wind and solar PV. The United States is at the forefront of using modern digital tools to exploit hydropower's flexibility potential. I am happy to announce that the next IEA Renewables Market Report, due in October, will have a special focus on hydropower. And I wish to thank the Department of Energy and National Labs for their excellent collaboration with us in this area.

The recent IEA review of US energy policies highlighted the country's continued focus on the protection of its energy infrastructure. It applauded steps taken by the government to update its security frameworks, including by introducing processes to address new trends such as cyber threats. It remains important to conduct regular and comprehensive assessments of risks and vulnerabilities

to foster preparedness and maintain reliability and resilience in the face of new challenges, such as extreme weather events.

I am pleased to say that the IEA will be publishing a major study on electricity security later this year that will help policy makers better manage the integration of variable renewables, guard against new cybersecurity threats and develop resilience to extreme weather events.

The United States is leading the world in reducing emissions

The focus of my presentation today has been on energy security – and one vital aspect of achieving a secure and sustainable energy future is the need to reduce global **greenhouse gas emissions** to mitigate climate change. Doing so is essential to ensure the security of communities, businesses and the energy infrastructure that underpins human economic activity and well-being.

The United States is a world leader in reducing emissions. Last month, the IEA released new data showing that global energy-related carbon dioxide emissions stopped growing in 2019 even as the world economy expanded by 2.9%. This welcome development was primarily due to declining emissions from electricity generation in advanced economies, thanks to the expanding role of renewable sources, fuel switching from coal to natural gas, and higher nuclear power generation.

The United States recorded the largest emissions decline on a country basis, with a fall of 140 million tonnes, or 2.9%. US emissions are now down by almost 1 gigatonne from their peak in 2000 – more than any other country over that period. The powerful combination of technology and supportive policies can continue to strengthen this trend of emissions increasingly decoupling from economic growth, but issues such as the early retirements of nuclear power plants risk undermining progress in other areas. And although the US emissions reductions over the past two decades are impressive and commendable, the country remains the world's second largest emitter after China.

One area of particular concern for global efforts to reduce emissions is the faltering momentum behind **energy efficiency** improvements. This lack of momentum comes against a backdrop of rising needs for heating, cooling, lighting, mobility and other energy services. Improvements in the energy intensity of the global economy (the amount of energy used per unit of economic activity) are slowing: the 1.2% improvement in 2018 was the weakest since 2010 and far below the 3% level that IEA analysis shows is achievable with technologies that are already available today. This worrying slowdown reflects a relative lack of new energy efficiency policies and a lack of efforts to tighten existing measures. Reversing this trend can bring huge economic, social and environmental benefits. Innovative approaches include the use of digital tools to make efficiency easier and more attractive, and to shift electricity demand to cheaper and less emissions-intensive hours of the day.

I am aware of the high priority this Committee gives to energy efficiency, and I commend its deliberations on the subject, including the many strong proposals put forward as legislation. The IEA is devoting considerable efforts to advancing energy efficiency globally. The potential for efficiency improvements to help the world meet its sustainable energy goals is vast, so we have brought together thought leaders from around the globe through the Global Commission for Urgent Action on Energy Efficiency. This is a very important process for identifying the key actions governments can take to make better progress on energy efficiency – and I would like to thank Chairman Murkowski for her invaluable leadership in the Commission's work.

The United States is a pioneer in new energy technologies

Ten years ago, the idea that the United States could become a net exporter of both oil and gas was almost unthinkable. Yet the shale revolution – and over $1 trillion in upstream and midstream investment – is making this a reality. The foundations date back to a publicly funded **research and development** effort that began in the 1970s. This was followed by tax credits, market reforms and partnerships that provided a platform for private initiative, innovation, investment and rapid reductions in cost.

Today, solar PV, wind and some other renewable technologies – mostly in the power sector – are becoming mainstream worldwide. This is also the result of turning initial policy and financial support into large-scale deployment. The United States – the world's largest government investor in energy innovation by a good distance – has played an important role. The progress that has brought down the costs of renewables has been aided by the groundbreaking work of US National Labs.

As I mentioned earlier, the next frontier for expanding renewables like wind and solar PV is to ensure they are reliably and cost-effectively integrated into power systems alongside sufficient flexibility resources such as hydropower, natural gas, demand-side response and storage. In this context, I would like to commend Secretary Brouillette's announcement in January of the Energy Storage Grand Challenge, a comprehensive program that aims to accelerate the development, commercialization and utilization of next-generation energy storage technologies.

The United States has also driven innovation in technologies that can help mitigate climate change by capturing carbon emissions and then storing or using them. Almost 70% of all carbon dioxide captured from carbon capture, utilisation and storage (CCUS) facilities globally happens here in the United States, which has the most attractive investment environment for **carbon capture** of any country in the world. This is largely due to the expanded 45Q tax credits and other complementary policies, such as the Californian Low Carbon Fuel Standard, which are providing a strong incentive for carbon capture investment. A significant number of project announcements have come in the past year, including plans to develop large-scale storage facilities, to expand carbon capture across industrial applications and to scale up new technologies such as direct air capture

We anticipate more investment activity in 2020 following the release of initial IRS guidance last month and with further guidance expected soon. This will cement the leadership of the United States for this critical technology. Research efforts supported by the Department of Energy and US National Labs will also continue to bear fruit in carbon capture – as well as other key areas for energy transitions such as advanced nuclear technologies and system integration of renewables.

Transforming energy systems across the globe will require progress across a much wider range of technologies, including efficiency, CCUS, hydrogen and nuclear among others. It will require action across all sectors, not just electricity. It will also require assembling a broad range of skills, resources and stakeholders. For example, scaling up technologies such as CCUS and hydrogen and bringing down their costs will rely on large-scale engineering and project management capabilities – qualities that are a good match to those of today's oil and gas companies.

The IEA looks forward to working with the United States and all other IEA member countries to help ensure that the transformation of energy systems results in benefits rather than burdens for their

citizens and economies. It also committed to assisting them in spreading energy services, with all the advantages they bring for human well-being, to communities around the world that still live without access to energy, most notably in Africa.

With its boundless human ingenuity, rich resources and track record of successful innovation and commercialization of new technologies, the United States is extremely well placed to continue to lead the world in the development and deployment of energy technologies that can help ensure a secure, affordable and sustainable supply of energy for decades to come.

Chairman Murkowski, Ranking Member Manchin and distinguished Members of the Committee, thank you again for the opportunity to appear before you today. And thank you above all for your continued strong partnership and support for the International Energy Agency.

The CHAIRMAN. Thank you, Dr. Birol. I know that Senator Hoeven needs to run, so I am going to turn to him first. Thank you.

Senator HOEVEN. Thank you, Madam Chair and Ranking Member. I appreciate it very much. Dr. Birol, thank you for being here. You mentioned the importance of baseload power and you mentioned the important role that coal plays in providing baseload power both here in the United States and around the globe and the work that is being done in carbon capture and sequestration (CCS). I would invite you to come to North Dakota, because we are very actively working on carbon capture and sequestration. We already do it and we are working to do more of it and get it to a commercially and economically viable point and believe, as you said, then that is the technology that will be adopted not only around the country but around the globe.

You mentioned, actually, the increasing use of baseload coal around the world and, in fact, I think Japan has plans to build 22 coal-fired electric plants. So my question to you is, what is it that Japan sees that we don't as we are seeing coal plants retired in this country and not providing fair compensation for capacity value in order to keep those plants so that we have that baseload power while we are developing this carbon capture technology?

Dr. BIROL. Thank you very much, Senator Hoeven. I think in the United States the main issue is the economics of it. The natural gas prices are very, very low in the United States and the renewables are also getting attention. But having said that, again, in North Dakota or elsewhere your efforts for pushing CCUS is extremely important for today and also maybe more important for tomorrow, and this will make a very good marriage between the environmental concerns and energy security. So it is, and I said, if I have to pick out one technology out of perhaps 120 technologies we look at at the IEA, this will be the most important technology.

And I wanted to congratulate you as the Senator from North Dakota for recognizing this very important technology, sir.

Senator HOEVEN. Thank you, Doctor, I appreciate it very much. Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator Hoeven. Sorry to make you a few minutes late there, but I am glad you had an opportunity for the question.

I want to acknowledge another individual who has been helpful with us as we have worked on so many of these issues. We have the Assistant Secretary for International Affairs, Ted Garrish, and some of his team with us here this morning. I know he is listening with interest, but in working on many of these issues as they relate to our global partners, it is good to have you with us this morning, Ted.

I will turn to Senator Manchin now.

Senator MANCHIN. Doctor, thank you.

A couple things I just want to go over because you have hit so many important things, and we will have time to talk a little bit and I really appreciate it. Energy efficiency really bothers me. We know, we all know, that is a low-hanging fruit. We can do more to change the greenhouse gas emissions just by energy efficiency, cheaper, quicker, faster than anything else we can do. But you also pointed out in 2018 global energy efficiency improved by only 1.2

percent. It is the slowest rate since 2010, barely half of the average rate from 2010 to 2017 and energy efficient improvements have also stalled around $240 billion globally with little or no growth from 2017 to 2018.

These numbers fall far short of what you all have anticipated. Why do you see this diminishing investment and improvements in energy efficiency, and what policies could we do or does the world need to do or maybe we could lead in changing that?

Dr. BIROL. Thank you very much, Senator Manchin. Now we are seeing that the less and less governments are interested to put energy efficiency policies or courts or standards. Let me give you one example, India, very important country. Economy is booming, 1.3 billion people and one of the major drivers of energy demand growth. Do you know what is the main driver of electricity demand growth in India? There is one single very important driver which is the air conditioners by far. It is 50 degrees in the summer and when the income level of the citizens go up, one of the first things they do is to buy an air conditioner. In United States today about 90 percent of the households have air conditioner. In India, it is less than five percent, and with the increasing economy levels they buy air conditioner. There's no problem here.

The problem is the following: For every air conditioner in India in order to provide the same comfort like in United States, they need to use three times more electricity because of lack of energy efficiency standards. Three times. They provide the same comforts, but with two different air conditioner boxes because we do have the right standards for manufacturing those air conditioners. It is the reason International Energy Agency is working hand-in-hand with the Indian government to put the right efficiency standards so that the air conditioner boxes are manufactured that way. But India is not the exception. Many countries it is like that. The policies are not, unfortunately, enacted.

Now what also doesn't help?

Senator MANCHIN. Is it because there are no incentives?

Dr. BIROL. Exactly, I was about to come to that.

Senator MANCHIN. No incentives.

Dr. BIROL. There is no financial incentive. There is no financial——

Senator MANCHIN. There are no penalties.

Dr. BIROL. Exactly.

And what is happening is that, in fact, in many of those countries, electricity prices are subsidized, very, very cheap. They don't need to feel to save electricity and this is the reason the prices need to be right in order to give the right signal.

Senator MANCHIN. Is the government listening to you at all?

Dr. BIROL. Many governments don't do it and some governments are reforming the price structures but some still don't and some of them even heavily subsidizing the energy prices.

Senator MANCHIN. Doctor, if I could, given our time, I am going to stay here for a while and ask you some more questions, but real quickly, the Coronavirus, is it affecting world markets? Do you see the effect of the Coronavirus on world markets right now, and do you see it getting better if we find vaccines or basically the con-

cerns that people have are they going to be worsening before it gets better?

Dr. BIROL. So, Mr. Senator, I am—I don't have much medical information about this.

Senator MANCHIN. I am not saying that. I am just saying what are you seeing in market moves right now?

Dr. BIROL. The market is going to definitely be affected negatively, especially oil market, but not only coal and gas markets as well and——

Senator MANCHIN. All shipping products, all shipping?

Dr. BIROL. We are revising down our oil numbers. I am going to announce it Monday morning in Paris at the press conference, but I am afraid the impacts are already severe because, mainly because, the transportation sector is heavily affected.

Senator MANCHIN. I was afraid of that. Under China's One Belt One Road, they have taken steps to lock up most all the minerals, critical minerals, that it takes for our EVs, electric vehicles. Can you explain to me what your concerns would be? Our concerns, what we see, is basically that a lot of these raw materials coming from very poor countries, China taking advantage of a lot of people and then, kind of, enslaving a lot of people to produce these minerals. There has to be some conscious sourcing going on somewhere because here we are wanting to expand and that is great, but we are expanding at a cost to someone in the world. Is there a balance to be had or how do we control this?

Dr. BIROL. It's a very, in my view, it's a very valid concern, Senator. I can tell you that for years and years when we talk about energy security, we talked of oil security and geopolitical tensions. Now, in addition to that, we are seeing that electric cars planted in the markets, the critical materials of crucial importance and as it was the case in the oil markets, many, many years, it's not like that. The critical materials are concentrated on a very few number of countries so therefore, when we talk about the electric vehicles we shouldn't forget where the material is coming from and it is not unfortunate, as it happens so it is not diversified, the right dose of critical materials come, but more concentrated. So I think it is important to keep an eye on that.

Senator MANCHIN. Thank you, Doctor.

The CHAIRMAN. Thank you, Dr. Birol.

I know you have indicated you don't have any medical expert insight here, and I will just ask one final question about the impact of the Coronavirus on the energy markets and just what that means globally. You had said that the impact is temporary. If we are in a situation where come summer we are still dealing with outbreaks globally, how do you account for this disruption beyond more than just a temporary view? You are going to be releasing your report on Monday. We will be anxious to look at that. But I am assuming that that will be a revised assessment or a revised review based on what we have seen in just these past couple months. Would you be looking to, again, revise or update if the situation is still very much on edge in just a few months this summer?

Dr. BIROL. Definitely so, Madam Chair. What we are going to do on Monday is we will have a base case, how do things look like

now, but we will, exactly in line with what you have just said, we will have also a worse case because we may well see that this station may go global beyond China and this may well affect the energy markets, especially the oil markets substantially.

Let's not forget that China, last year, was responsible for more than 80 percent of the global oil demand growth and China is now at the epicenter of this issue and China is, if we think about this, China is the number one trade partner of more than 100 countries around the world. There will definitely be several waves coming here. It will be a big challenge for all of us, for the entire economy, but disproportionate for the energy sector and with the energy sector, oil markets.

The CHAIRMAN. Okay, we will wait until Monday.

Let me ask what IEA is working on right now with regards to different ways that the oil and gas industry can reduce its environmental footprint? In my home state we are actually viewed as cleaner producers, if you will. We do not flare our gas. We reinject it into the fields.

Because of the challenges of Arctic development, the footprint is a small footprint, and we have worked with extremely high standards as they relate to emissions and just overall impact. But setting aside the carbon dioxide emissions, I hate to use the term low-hanging fruit because I think it is overused, but what more can we be doing within this sector to address the issues of climate change, but again, just reducing that overall environmental impact within the oil and gas sector?

Dr. BIROL. Thank you very much, Madam Chair.

First of all, I wanted to say that the, we will need oil and gas several years to come. Some people confuse it, but energy is a good thing. Emissions are a bad thing.

The CHAIRMAN. Good. Repeat that again.

Dr. BIROL. We need energy so this is very important. So while we need oil and gas several years to come, we should also recognize that there is a clean energy transition and the clean energy transitions are important and no oil and gas company will be unaffected from the clean energy transitions. So what they should do, they can do at least two things. One, low-hanging fruit here, in my view, is the following. Today, 15 percent of the global emissions come from the own operations of those companies. They can reduce these emissions easily. And when I say, without those emissions, the main—is, maintain emissions. Maintain emissions can be at low cost or at no cost can be substantially reduced. So this is the big homework for those companies, and for me it's a litmus test—how serious they are to this issue. This is one.

Second, those companies, oil and gas companies, have a lot of big engineering skills. They have run major large-scale projects. They may well be also drivers of technologies. They are not mature today yet, such as the, again, carbon capture, utilization and storage. This can well be an important asset protection strategy for those companies and with their engineering skills, project management experiences and in many cases, deep pockets, they can be well in the side of accelerating some technologies which need to mature as soon as possible such as carbon capture and storage, hydrogen, among others, Madam.

The CHAIRMAN. I thank you for that. When we think about the issue of flaring and the fact that we are a decade into this shale gale that we still see the amount of flaring that we do.

Senator Cortez Masto, you are next on the list.

Senator CORTEZ MASTO. Thank you, thank you, Madam Chair. Welcome, it is great to see you again, Dr. Birol.

You said in your testimony that you anticipate oil markets to be disproportionately affected by the spread of the Coronavirus. I know, just yesterday, I saw a report in IHS Markit that said the Coronavirus has caused global oil demand to drop 3.8 million barrels per day below the same period last year resulting in the largest recorded drop in demand within a financial quarter.

And so, my question to you is, how are the IEA member countries preparing for the spread of the Coronavirus and its impact on the energy sector and where can the U.S. Federal Government be helpful in providing support?

Dr. BIROL. Thank you very much.

We are going to announce our results of our annual expectations on Monday, the impact of Coronavirus on the oil markets as well as coal, gas markets and other energy sources. But why I said it has disproportionately affected LNG markets from Coronavirus is the following: There are two reasons. One, the economies affected once, but within the economy, you look at the sectors of the economy, the biggest hit is on the aviation sector. It's very bad, both domestic and international flights. Aviation makes up less than one percent of the global GDP but close to ten percent of global oil consumption, and it is really going down substantially.

Senator CORTEZ MASTO. Dr. Birol, and excuse me, I just have five minutes to ask questions. No, I appreciate that. I heard that in your opening remarks.

Dr. BIROL. Yeah.

Senator CORTEZ MASTO. I guess my question is once the report comes out, and I understand Monday——

Dr. BIROL. Yes.

Senator CORTEZ MASTO. You are looking to put the global impacts——

Dr. BIROL. Yes.

Senator CORTEZ MASTO. But knowing the impacts, what is the plan after that? Are you going to be anticipating with the other member countries then, a plan to address those impacts? That is my question. And do you need help or assistance from us at a federal level here?

Dr. BIROL. Definitely. We will be working with the United States and other 29 member countries, how we can prepare ourselves if there are unexpected consequences. But today, the major impact will be on the oil prices will experience a downward pressure.

Senator CORTEZ MASTO. Right.

Dr. BIROL. And in the case of United States, if this downward pressure continues for a long time, it may have impact on the shale production. This would be a key challenge.

Senator CORTEZ MASTO. Let me add something else because I know that many solar panels that are used and utilized in the U.S. for installation are purchased from Southeast Asia companies that tend to source their key raw materials from China. In fact, roughly

90 percent of the silicon wafers used in the United States originate in China. So I would anticipate that the Coronavirus is going to have an impact on the supply chain for solar panels. Is that something that will be in your report as well and will you be talking at that level of detail?

Dr. BIROL. I will be talking about it as well, but I can tell you that as far as the solar panels, and you are completely right, a big chunk of the solar panels around the world is either directly manufactured in China or financed by the Chinese companies and other Southeast Asian countries. But currently there is oversupply of solar PV panels and if the station is getting under control in a short period of time, we will not see any problem because there is a surplus of solar panels in the world. But if it continues over one year, we may see some bottlenecks. But it is not as an immediate concern in my view as the impact on the oil markets.

Senator CORTEZ MASTO. Okay, thank you.

Let me touch on a separate subject, and I have just got about a minute here and we talked about this last time you came to visit with the Committee, thank you. In the World Energy Outlook report, how is the IEA continuing to factor in changes in water availability and the potential declining supply of water? I know the Chairwoman, this is always a concern of hers and she has legislation to address this, this nexus between water and energy. We have to make it. We have to constantly be talking about it. And I so appreciate the fact that I know the IEA considers this.

I am curious about your thoughts on this as we move forward, and how are you continuing to factor the relationship between the two?

Dr. BIROL. So water is very important in order to first of all generate electricity. Hydropower is one of the most important sources of electricity generation and as it happens this year, our renewable energy report is focusing on hydropower. In my view, when we talk about renewable energy, we talk a lot on solar and wind. But hydropower is not very much recognized but they made it very quietly, they make a very good service to the global electricity generation without emitting any emissions.

So they're a source of electricity generation, water, but at the same time in order to generate water you also need energy, in many cases, to desalination of the sea water is one of the areas of——

Senator CORTEZ MASTO. Or to generate energy you need water.

Dr. BIROL. Exactly.

Senator CORTEZ MASTO. I mean, there is a nexus between the two and in the West we have a declining supply of water and that, I think, is the concern around the world as well——

Dr. BIROL. And also——

Senator CORTEZ MASTO. ——in some countries.

Dr. BIROL. Exactly.

Also, I should tell you that the changing in the temperatures, the global temperatures, also affects the availability of water as well which in turn has implication for the energy security. But this nexus is getting closer and closer.

Senator CORTEZ MASTO. Okay, thank you.

Dr. BIROL. Thank you.

The CHAIRMAN. Thank you, Senator Cortez Masto.

Senator Heinrich.

Senator HEINRICH. Dr. Birol, you mentioned the importance of methane capture and I appreciate that because we have seen this Administration, we had methane capture rules under the previous Administration. They were rolled back by this Administration. And for those of us from oil and gas producing states, it meant that our states have had to step up and fill that gap, losing literally years' worth of time in the process which is, I find, very unfortunate. I think we should be leading the world in that technology and the implementation of it in the United States.

I do want to ask you about your historical predictive analysis when it comes to the growth of distributed renewables, particularly wind and solar, because it seems like the dynamic there has been consistent for a very long time. The IEA projections have, frankly, been very far off, but we can kind of look back at the data now and see why. Those projections have historically been linear and the growth has not been linear, and any mathematician can look at a line and tell you the difference between linear growth and exponential growth.

And then, when you flip that around and look at cost reductions, the same holds true. The predictions are linear. The cost reductions are exponential. Why should we take those predictions seriously when that structural flaw has existed for so long?

Dr. BIROL. I thank you very much. I will come to CCS in a minute, but talk about our projections. So we do not center, we do not make forecasts. What we do is that we make scenarios. We take some policy assumptions. With these policies you go there, picture, we paint to policymakers. And in fact, putting a mirror in front of them. If you don't like these policies, please change them. Solar is one of them. With the policies all enacted, solar growth is not as strong as it should be so therefore, what we are seeing is the——

Senator HEINRICH. But the fundamental nature of that growth is not reflected in those predictions. So I am not arguing over whether solar is going to grow by four percent or six percent next year. What I am saying is that for decades people have taken your projections seriously, but those projections are based on bad math in the sense that the fundamental shape of the curve is wrong. And whether or not those projections in any given year are right or wrong, people take them seriously and they have been, as a result, I think, misrepresenting the fundamental math and the potential for growth. Not the potential, the reality of that growth for multiple decades now and I think that that does a disservice to the conversation that we have around how is the energy sector changing.

Dr. BIROL. I think your notes need to cover, Mr. Senator, that for example, this year, talking about this year's World Energy Outlook, I will be happy to give you a copy. We are saying that the solar is the star of the electricity generation which shows exponential growth. So you may want to see and look at your notes again.

Why solar is the star, we say, why we say that solar has the exponential growth? Mainly because of the cost reductions. Only last

year 40 percent of all power plants installed in the world was solar as the IEA has already said before anybody else.

Second, our cost assumptions are very much in line with the assumptions of the industry, assumptions of the renewable energy organizations. They are just the same so there is no difference, so therefore, you may want to look at those notes.

Senator HEINRICH. I very much look forward to looking at those——

Dr. BIROL. Thank you very much.

Senator HEINRICH. ——because it has taken us a few decades to get there.

Dr. BIROL. Thank you. If I may address CCS? Pardon.

Senator HEINRICH. Yes, I do want to ask you about CCS. You focus a great deal on CCS. You focus a great deal on nuclear. Both of those, I agree, could be incredibly important technologies out to the 2050 horizon in terms of decarbonizing our energy sector. However, the challenge we have there is the cost competitiveness issue. In the United States nuclear is shutting down because it is simply not cost competitive in the market. I think that is a real problem from a carbon balance point of view. CCS, I am not aware of any CCS technology that is remotely economically viable. How do we change that?

Dr. BIROL. So it is in fact very much in line with your first question, Senator. Solar, I followed the solar since almost three decades. When the solar has started it enjoyed a significant amount of government support. As it is out of that government support, we scale up the solar use——

Senator HEINRICH. But the solar is different because it is—you can break it down into very small distributed pieces.

Dr. BIROL. Exactly.

Senator HEINRICH. And when you subsidize very large projects, a nuclear power plant for example, you don't see those same reductions in cost. So when you have something that is very complicated and very large-scale like, for example, carbon capture and sequestration, you can subsidize it all day long, you don't see the reductions in cost because it is not a scalable technology.

Dr. BIROL. I would slightly disagree on the carbon capture and storage but let me first talk about the cost you mentioned. Today, in the United States, for example, lifetime extensions of the existing nuclear power plants is the cheapest source of electricity generation, the cheapest, less than $50. So, therefore, it is, but existing ones. I'm not talking about building new ones, the existing ones. So it is better than even just other renewable energy sources.

Senator HEINRICH. We all agree that we should keep those on as long as they can be done safely.

Dr. BIROL. Thank you, thank you very much. You all agree but——

Senator HEINRICH. However——

Dr. BIROL. Yes.

Senator HEINRICH. That doesn't change the fact that we can't build a new one for a cost competitive environment.

Dr. BIROL. You are completely right. You are completely right, but I think it is important to value the service that the nuclear power plants are providing in terms of electricity security and in

reducing the emissions. How the United States does it, how other countries do it is up to them, but it should be valued this or that way.

Another point on the nuclear power. There are new technologies which are smaller, which are more flexible, such as small modular reactors and I know that the United States, like many other countries around the world are keen to give a push to small modular reactors because, Mr. Senator, I'm afraid we do not have the luxury to pick up, solve the problem of the world, climate change, only with solar. We need solar. We need wind. We need, in my view, nuclear power, energy efficiency and carbon capture and storage.

You are completely right. Carbon, to scale up carbon capture and storage is not an easy task. But today, let's not forget 80 percent, 80 percent of global energy comes from fossil fuels. That does not change from one day to another, 80 percent. And this is despite the exponential growth of solar.

Senator HEINRICH. I look forward to coming back to this, because I am way over my time. Eighty percent of transportation in 1900 relied on the horse and 25 years later, it was completely, completely different. Changes over time that are not linear can happen very quickly.

Dr. BIROL. But, if I may, today 80 percent, Mr. Senator, it was 80 percent 35 years ago the share of fossil fuels in the total energy mix. It didn't change in the last 30 years and we all, I believe, we need all the technologies at our disposal in addition to solar, wind, energy efficiency, CCUS and nuclear. And if not the United States, who could lead the world in terms of innovation and energy technologies I would say.

The CHAIRMAN. Therein lies the reason for our American Energy Innovation Act.

Thank you, Senator Heinrich.

Dr. Birol, I wanted to ask about some of our strategic energy partners globally. I had a Congressional Staff Delegation conduct oversight on the nation's strategic energy partnerships with key U.S. allies, including Australia. There is going to be a report coming out relatively soon, but it has already been reported that the U.S. and Australia have had talks to discuss the possibility of Australia leasing space and storing oil in the Strategic Petroleum Reserve.

So just your thoughts on this. Do you share a concern that an IEA emergency response truly has to be a global response and that the IEA members should share in that burden and just speaking more generally to the questions that should be asked when others are asking to store oil within the SPR?

Dr. BIROL. Thank you very much, Madam Chair.

Nowadays in the oil markets we are seeing an abundance of oil. This is very good. And if you look at the last one year, despite many geopolitical tensions such as the sanctions of Iran meant Iran oil exports went down basically to very, very low levels. Venezuela more or less disappeared in terms of contribution to oil markets. There was an attack on the Saudi Arabia. There was the Iranian general who was killed. There's a civil war in Libya. Despite all of these things, oil prices remained more or less the same. There was no huge increase in the oil prices. This mainly is a re-

sult of the U.S. and other countries bringing a lot of oil to the markets.

So we are in an abundance period. But there may be bad rainy days in the oil markets. The, as I mentioned, Middle East still remains a very important part of the world and one country, especially one country there is a major concern for me and the developments there which is Iraq. Iraq is today the second largest producer of OPEC, five million barrels per day and the tensions in Iraq are forming.

But I know that there are also possibilities of technical and physical supply disruptions if not today, if not tomorrow, maybe the day after tomorrow. So in my view, we still need an oil security safety network around the world and stocks are critical here.

To be a member of the IEA currently one of the major conditions is to have stocks of a minimum of 90 days. And not—most of the IEA member countries are fulfilling, overwhelming majority of the IEA member countries are fulfilling that requirement. From time to time some countries are temporarily not able to fulfill that requirement but I know that those countries are making huge efforts to get them working with other countries such as United States in order to take steps to fulfill that requirement. For me, as head of the IEA, I would like to see all of the member countries fulfilling their requirements without if and how.

The CHAIRMAN. Well, as you know, we are in the process now of modernizing our Strategic Petroleum Reserve. The Department of Energy reported that the life extension program is about two years behind the original projected schedule. So construction has not even commenced on this, as I understand it. I guess the situation with us right now is we are exporting crude. We still need the Strategic Petroleum Reserve. As you have indicated, the other IEA countries are seeking to fulfill their commitments, but is there anybody else, any of the other countries that have anything comparable to our Strategic Petroleum Reserve?

Dr. BIROL. You have huge reserves——

The CHAIRMAN. Right.

Dr. BIROL. ——definitely, but also other countries such as Japan, for example, or many European countries are keeping reserves higher than their 90 days of requirements, Madam Chair.

The CHAIRMAN. So they are in a position where they could be more, I guess, nimble——

Dr. BIROL. Yes.

The CHAIRMAN. ——in a release, if it was necessary.

Dr. BIROL. But I hope to see the U.S. leadership here also in terms of the keeping the required level of strategic reserves.

The CHAIRMAN. We agree.

Senator Cortez Masto, would you have follow-on questions?

Senator CORTEZ MASTO. I do. I would love to ask one final question because I think later in your testimony you talked about transitions to renewables and advanced technologies can open the door to new energy security challenges. And my question is revolving around cybersecurity. Can you address that? What should we be doing and what are your concerns when it comes to the threats, the cybersecurity threats to the energy sector?

Dr. BIROL. It is an extremely important issue, Madam Senator. We use electricity more and more in our energy systems and the entire economy, social life, is being electrified. So, therefore, the vulnerability of our societies to electricity cuts today is much more serious than compared to 10, 15 years ago. And with the renewables are growing, we are seeing the grids, electricity grids are growing and getting longer and longer. Therefore, the surface of possible attacks our vulnerability is growing and this means, in my view, electricity security includes the cybersecurity because we have seen that where all of the some, perhaps, low level of cyberattacks in some countries around the world with that, major impact. But this doesn't mean that this is something we have to ignore.

The International Energy Agency was founded 45 years ago as an oil security organization by, led by Mr. Henry Kissinger at that time and other leaders around the world. But as much as oil security today, electricity security is becoming a key issue within the electricity sector, cybersecurity is becoming a critical issue. It's a juncture of the energy and, perhaps, beyond energy concentrations but as energy organizations, as a global energy authority, we believe that electricity security is a key issue that the governments need to take note of. And we know that there are some corners around the world which may well use the cyberattacks in order to paralyze the electricity systems; therefore, the social economic life of our member countries.

Senator CORTEZ MASTO. Thank you.

The CHAIRMAN. Thank you, Senator.

Senator King.

Senator KING. Thank you. I apologize for being late. We need new technology to schedule hearings around here. We could use artificial intelligence which would help.

I know that the focus of your testimony has been a lot on what is happening in the United States, but I am very interested in what is happening in other places. We are doing a lot of work in renewables, as you know. It is growing very fast, wind, solar. We are doing a lot of work on storage. What is happening in the rest of the world because if we are talking about a carbon-free future, we can do everything possible here, but if it is not happening in other places, it is not going to matter. So give me a quick thumbnail of, for example, progress in renewables in other parts of the world, Europe, but also India and China.

Dr. BIROL. Europe, China, India, everywhere, renewables are growing very strong. When I say renewables, mainly solar and wind basically. Europe is definitely a leader here, solar and wind, by providing policy and financial support but China is also playing a key role in terms of solar, both in terms of deploying at home, but also as a manufacturer of solar panels, wind as well. India is making huge efforts on their modest plan which is they have put a program of a target of 175 gigawatts of renewable growth which many people thought far too ambitious for India, but they are able to reach that target and they are putting new targets.

Why is this happening? For two reasons, in Europe is mainly driven to address the climate change challenge. In China and India, it is because of the decline in costs but also to address the

air pollution challenge in the cities. So it is not the climate change per se——

Senator KING. It is the immediate—it is the Los Angeles smog 30 years later.

Dr. BIROL. Exactly. It is a driver but even that growth coming from U.S. but also from Europe, China, India, they themselves are not big enough to change the global CO_2 emissions strides and make them decline.

Senator KING. Because you testified just a few moments ago about the increasing electrification everywhere.

Dr. BIROL. Yes.

Senator KING. So we are gaining in renewables, but the production is going up.

Dr. BIROL. Exactly. The electricity generation growth is so strong that the growth from, strong growth from renewables, it is not enough to fill the entire gap. You still see other fuels to be part of it such as coal, such as and natural gas. They are also growing.

Senator KING. Well, it occurs to me that there are two areas that involve a tremendous amount of R&D. One is storage and the other is potentially a, sort of, rebirth of nuclear power. Is there anything going on in terms of international cooperation, a kind of air bus of the globe for these kind of technologies instead of everybody trying to get to storage? It would be a huge win for the whole world if we could get grid-scale storage and we are putting a lot of money into it here, but maybe there would be some advantages in a coalition working on this problem?

Dr. BIROL. I think the International Energy Agency is trying to put all the interested parties together to push the storage. And the United States is an exemplary country here, especially just in, generally, the Department of Energy started a new major program as well as many European countries and Japan. But the cost of storage is still not yet there for the commercially viable. We need to——

Senator KING. I understand that. This is an R&D challenge.

Dr. BIROL. An R&D challenge. We need to bring the cost down and this will cause future amounts of R&D, and we have seen in the past R&D investments pay back. If you think of the shale.

Senator KING. Well, that is the best example.

Dr. BIROL. Exactly.

Senator KING. And by the way there was a lot of federal money that went into that R&D.

Dr. BIROL. Yes.

Senator KING. That is why cutting research and development in our energy department is a bad idea, but that is not your problem.

Dr. BIROL. Yes.

Senator KING. But it strikes me that we are advancing, I am worried that we are advancing backward.

Dr. BIROL. Yes.

Senator KING. That we are making huge progress in renewables but the growth in energy demand and particularly in countries like China and India is still going to swamp the, we are still going to be building carbon plants into the foreseeable future.

Dr. BIROL. It is, it is. I can give you one example putting it outside of the U.S., the context. In Europe, maybe you have heard or

read, there is a European Green Deal. It's a major project in Europe. In 2050 they want to bring the emissions to zero. And it is a huge, about a $1 billion project the new commission has started. But Europe is today responsible for only nine percent of global emissions, 91 percent comes from somewhere else.

Senator KING. Right.

Dr. BIROL. Even, forget the bringing the emissions in 2050 to zero, even if you bring the emissions tomorrow to zero in Europe, global temperature trajectories will not change dramatically because one ton of CO_2 goes into the atmosphere——

Senator KING. And that is why when I go to home to Maine, I have got to tell people in Maine that we are not only doing our part but that other people are as well because otherwise people say why should I bother if we are doubling, if we are building a coal plant every month in China.

Dr. BIROL. Exactly. So one ton of CO_2 going to atmosphere from Jakarta or from Paris or from Detroit, it has the same effect on everybody.

Senator KING. All the same.

Dr. BIROL. So, therefore, it is very important to have a global view here. But of course, what Europe is doing is of exemplary nature, being a model, being a source of inspiration but we need a global approach here otherwise those efforts will not bring the results that we would like to see.

Senator KING. Well, thank you very much for your testimony. I appreciate it.

Thank you, Madam Chair.

The CHAIRMAN. Thank you.

Speaking to how we can be working together globally. As we have discussed, I launched last year the Strategic Energy Initiative. This focuses on infrastructure that we need in order to connect American commodities with technologies in global markets. We have incorporated much of this in the work that we have done with advanced nuclear, the critical minerals.

More broadly, how important do you think the role of export credit agencies and development finance institutions are with regards to energy investment? We have our partners to use the Export-Import Bank, the Development Finance Corporation to support strategic energy infrastructure projects around the world, whether it is in Asia or in Africa. Can you speak to the role of these credit agencies as opportunities? Again, you can share the technologies but how you actually get them out there on the ground is yet another matter.

Dr. BIROL. Thank you very much, Madam Chair.

This is, for me, a very key issue, the financing. Where the financing will come and under which conditions and which technologies to be pushed. As I said before, we are an organization of all fuels, all technologies and many countries around the world, in Africa, for example and in Asia, Latin America, need to have access to financing and having these credit agencies, export/import agencies providing incentive, providing support for those countries under sustainable, right conditions will be of critical importance. So I would very much like to support that, Madam Chair.

The CHAIRMAN. Well, that is something that we are trying to work on here.

Senator Manchin had mentioned just very briefly the topic of minerals and mineral security. This is a key part of our energy bill. When we think about security, when we think about supply chain security and what we need to do to ensure that we have those minerals building out whatever, whether it is the smart grid technologies and the instrumentation or whether it is the blades on the wind turbines. Does IEA keep an eye on minerals markets, especially those that are viewed as critical for energy generation and transmission and storage? Do you monitor that and are you seeing any trends that are sending off any alarm bells?

Dr. BIROL. We are following it closely and what we are seeing is that the clean energy, some of the drivers of clean energy transitions around the world need those critical materials. While we are happy to see clean energy transitions growing strong around the world, we are concerned that in some cases, those critical minerals are concentrated only on a few number of countries which is not good news for the energy security.

So, therefore, it is important to look at the entire supply chain and to note that not only the positive impact of clean energy transitions need to be considered but also where the source of these critical materials are and which countries, outside of the host country are interested to work closely with the host countries there and what their plans and strategies are.

The CHAIRMAN. Okay. Well, it is good to know that you are following that as we are.

Last question from me is the issue of hydraulic fracturing and horizontal drilling. When you talk about the shale revolution, when we talk about all the advances that have been made in this country just in the past decade here, we recognize that so much of this has come about because of the technology as it relates to hydraulic fracturing. There is a lot of discussion right now in the political world about banning fracking.

How would your testimony look today if these techniques were banned in the United States? What would that mean for us?

Dr. BIROL. So I follow this hot political discussion in the United States. We always, Madam Chair, give our view in a factual manner, in an expert manner.

The CHAIRMAN. Not in a political manner, I know.

Dr. BIROL. Exactly. We don't have political bias here and there. We look at the numbers.

Today, I talked about three things. One is the abundance of oil and gas around the world and despite this geopolitical tensions in the Middle East, we didn't see oil prices skyrocketing. Second, I told you that the many European consumers benefited from cheaper natural gas as they were able to renegotiate existing gas contracts with the gas pipeline exporters. Therefore, good news for the consumers, their cheaper energy prices. And third, we are seeing that the natural gas in many parts of the world, including the United States, by replacing the coal plants, brought the CO_2 emissions down. And they're all in my testimony. If the shale revolution didn't take place, I wouldn't be able to put these things in my testimony, Madam Chair.

The CHAIRMAN. I appreciate it.

Senator Manchin.

Senator MANCHIN. Yes, I would love to.

If we could recap a few things, because as you know, we are right in the middle of an energy bill, an energy bill that is basically 53 bills we put together and we tried to hit every topic, Doctor. We have hit energy efficiency. We have hit renewable energy. We have hit energy storage. We have hit carbon capture, utilization and storage. We have hit nuclear, industrial technologies, vehicles, Department of Energy, mineral security, cyber and grid security. We have tried to take everything that you told us last year and bring it together.

So like you said, right now in America, in the United States of America, power generation, the emissions that we have from greenhouse gases from power are 27.5 percent of our emissions. Transportation is 29 percent, higher than generation. People in my home state and everywhere else believe that coal-fired power plants are causing all of our emissions. Then we have 22 percent from industry. Then also, we have 11.5 percent from commercial and residential. So that is the building that we are in and all of this and that.

You have told me the things that are alarming. First of all there are more coal-fired plants in the world being built. There is more demand because electricity has a higher demand and developing. We have to do something. You have less amount of investments into energy efficiency which is the cheapest, quickest way to make an impact.

So the world is moving in a direction. We are moving in one direction. How do we bring this together? We can't just say do it because we did it. They are going to say, yes, you are on your third generation of power plants. We are developing for the first generation. We don't care about the cost right now.

And you are talking about India. India basically is saying that well, we are going to subsidize the cost. People are getting it for the first time and the first thing they buy is an air conditioner which is three times more inefficient as a United States' air conditioner.

All these things are happening and we are trying to set an example and we want to keep our economy strong, but we want to be a leader and I think we have been. We have reduced emissions more than any other nation and we can continue, but we haven't had anybody following suit. What do we do? How do you do it from the IEA? You come here with the facts and figures. You are not coming here with a political agenda.

We are trying to thread the needle now to take the facts that you are giving us to fix things. We want renewables. We want EVs. We want all these things but we want them in a manner that we can continue to have an economy and also be able to lead the world in that direction, but we are not doing a very good job of leading because nobody is following right now. The sign of a leader is anybody behind you following you.

Dr. BIROL. I think the U.S. is doing a good job in many areas as you have rightly mentioned, Senator, but as I said, emissions, they don't have a passport. They travel around the world. If it comes from Jakarta or—it is same for everybody.

Senator MANCHIN. Right.

Dr. BIROL. And one thing I should say, not only emissions but the time. For example, even though United States has a lot of oil, in my view, what happens in Middle East still is important for the United States for the oil security in the United States. Another thing, we have just seen what happened in China affecting all of us through different channels. So no country is an energy island. They are all affecting——

Senator MANCHIN. But what gets me is they keep—we keep hearing all the time——

Dr. BIROL. Yeah.

Senator MANCHIN. ——that we are behind China in developing renewables. China is ahead of the United States in developing renewables or bringing them to market. But yet, China still has and is projected to have more emissions of greenhouse gases for the next 30 years than any other nation on earth.

Dr. BIROL. This is, you are right, Senator. China is number one. United States is number two in terms of global emissions, but again, China being number one, U.S. is number two, other countries, number three, it doesn't—it will affect all of us. This is the issue definitely.

Senator MANCHIN. Well——

Dr. BIROL. What we believe as the IEA, first of all energy sector is at the heart of this problem because 80 percent of the emissions causing climate change come from the energy sector, but at the same time we need energy as I was saying in the beginning, energy is a good thing. Emissions is a bad thing. So therefore we believe we can solve this problem only if we can build a grant coalition, as we say in the IEA, bringing governments, industry, investors, the utilities together, everybody who is seriously interested to address this problem. Without bringing everybody together our chances to solve this problem is very, very limited, if any.

Senator MANCHIN. Let me ask this question. Are you seeing anywhere in the world that has more efficient coal-fired burning power plants that we should be adopting? If it is going to be used around the world, shouldn't they adopt the cleanest version of it? Do you see any version of wind and solar that is more efficient and more cost-effective that is being developed somewhere else in the world? Are there any examples of something that is at a higher level that if we could attain or are they looking to the United States for research and development and the innovation coming from our country that would help this?

Dr. BIROL. I think innovation coming from this country, in a few areas, would be extremely important for the rest of the world——

Senator MANCHIN. Let me tell you about the bill we have then.

Dr. BIROL. Yes.

Senator MANCHIN. Energy efficiency, we put $3.1 billion in this piece of legislation. Carbon capture, utilization is $5.4 billion. Nuclear $1.4 because our nuclear is going this way when it should be going that way.

Dr. BIROL. Exactly.

Senator MANCHIN. Okay.

And then we put $3.8 for cyber and grid security. We also put $3.1 billion for renewables. This bill we have looks at every part of the energy sector.

Dr. BIROL. I cannot agree with you more. Only one thing I can tell you that among all these technologies, they are all extremely important, they all need to be pushed but if I have to just the right to tell you, one of them stronger than the others. It is carbon capture, utilization and storage. It is extremely important.

Senator MANCHIN. Because they are going to continue to use fossil.

Dr. BIROL. Exactly. It didn't change the share of fossil fuels in the global energy mix didn't change since three decades, 30 years, 80 percent. It will go down, but it will go 75, it's still there so how to marry——

Senator MANCHIN. It is not going to be eliminated.

Dr. BIROL. Exactly. How, exactly, how to marry this international climate goals and with the availability of fossil fuels is the way is carbon capture. One of the ways is carbon capture and storage.

Senator MANCHIN. And no matter what we do in renewables, it is not going to overtake the amount of fossil that the world is going to use.

Dr. BIROL. On the renewables we use mainly in electricity generation. As you mentioned, a lot of emissions come from industry sector, iron and steel, cement and others.

Senator MANCHIN. Yes.

Dr. BIROL. CCUS can be a very good solution to that one as well, but your bill is, I mean, this is—International Energy Agency is not able to vote——

Senator MANCHIN. We might need you to come to our caucus.

Dr. BIROL. Yes, definitely. But it is an excellent one as far as I read. I don't know details but——

Senator MANCHIN. Well, we will give you a breakdown on the whole of things. Anything you think we can——

Dr. BIROL. Thank you very much. Thank you very much, Mr. Senator. Thank you.

Senator MANCHIN. Okay.

The CHAIRMAN. Senator Cortez Masto.

Senator King.

Dr. BIROL. Thank you very much. Thank you.

Senator MANCHIN. Thank you.

The CHAIRMAN. I just want to close here. As Senator Manchin has outlined, we have incorporated so much that we have learned from you and tried to create what we think is a very robust bill hitting all of these very significant areas within the energy sector.

Last year we were reminded that the three areas of importance were advanced nuclear storage as well as CCUS, and you have kind of summed up what we need to do for the year going forward. I was going to ask the question, if we were starting our energy bill all over today, which we are not going to do because we need to get this one done after 12 years, but what would be your advice for that next bill going forward?

I think you have already shared it with me. You said, in one word, it needs to be about innovation, that the storage challenge, if you will, is absolutely key and have, again, reinforced the ration-

ale behind carbon capture, utilization and storage. And so, I take your guidance there very seriously, knowing that this is where we have been headed, but knowing that you think that we are on the right track with the focus on innovation right now.

Sometimes I like to distill things in just bumper stickers and some time ago I had a bumper sticker made up that was just "Energy is Good" and that was the bumper sticker. I still have it. It is still applicable. I only had one made so it is not on my car. But now I am thinking that I need to have that bumper sticker remade so it is, Energy equals good. Emissions equal bad. That we can distill because I think sometimes people get confused and think that somehow or other energy is bad because energy is necessarily emissions. It doesn't have to be that way, and we are working in that direction.

Energy is good. Energy is what allows us to be the great nation that we are, a leader in competitiveness, a leader in our commercial economy, a leader in healthcare, a leader in all of this. It is because we have accessible, affordable, clean diverse sources of energy. And it is good. So let's work on the bad part of it which are the emissions. You have given us clear guidance with that.

But again, Dr. Birol, I so thank you for your focus, your leadership in these areas and your willingness to give of your time to share with the Committee here today.

Dr. BIROL. Thank you very much.

The CHAIRMAN. With that, the Committee stands adjourned.

[Whereupon, at 11:07 a.m. the hearing was adjourned.]

APPENDIX MATERIAL SUBMITTED

U.S. Senate Committee on Energy and Natural Resources
March 5, 2020 Hearing: ***The Latest Developments and Longer-Term Prospects for Global Energy Markets, with a Special Focus on the United States, from the Perspective of the International Energy Agency***
Questions for the Record Submitted to Dr. Fatih Birol

Questions from Ranking Member Joe Manchin III

Question 1: You have previously spoken to the Committee about the importance of safeguarding the existing nuclear fleet while also accelerating innovation in nuclear technologies. I have also been interested in the export of U.S. civil nuclear technology, but since the U.S. does not have state owned and operated civil nuclear programs, it has not been as competitive as other countries that are able to fully finance foreign countries' civil nuclear programs. Can you speak to Chinese and Russian efforts to use civil nuclear as a geopolitical tool?

Of the 51 nuclear power plants currently under construction worldwide, 29 are being built in countries using their own designs: China, Russia, the Republic of Korea, India, the U.S and Argentina which is building a small modular reactor.

Of the 22 that rely on imported technology – over half are of Russian design being supplied to seven different countries. A Korean company is supplying four units to the UAE, three EPR units are under construction outside France, and China is responsible for two units under construction in Pakistan as well as being a partner in the UK projects.

In the IEA's Nuclear Power in a Clean Energy System, we stated that strong government intervention would be needed to finance new nuclear power plants using the existing technology in Europe or North America, because of the policy, technology and project management risks as well as market and financing barriers. Certainly the favorable financing terms that Russian or Chinese state-owned companies have offered is a factor in their success in the exporting the technology.

Question 2: With regards to developing civil nuclear programs, do you see a preference by countries to work with the U.S. instead of with countries that look to use energy as political leverage, and if so, should the U.S. increase our foreign financing capabilities to support civil nuclear programs?

There is certainly interest in US nuclear power know-how, with the world's largest power reactor fleet and its leadership position in nuclear innovation, particularly with the developments in small modular reactors. The US NRC is also a leading nuclear safety regulator – a license to operate a certain design in the US increases its acceptance elsewhere. That said, new US nuclear technologies will have to compete with others who are willing to offer competitive financial terms that lowers risks for the investing utility. That speaks to continuing role for government support for US nuclear exports.

Question 3: The IEA recently launched a methane tracker that provides attention to the issue of venting and flaring of methane, which is very much needed given the comparative impact of methane to carbon dioxide. What mechanisms (technologies, policies, regulations, etc.) have you seen as most effective in addressing methane emissions, and do you have any thoughts on how the government could collaborate better with industry to mitigate these emissions?

The new IEA methane tracker aims to raise global awareness of the benefits and cost-effectiveness of actions on methane abatement. In terms of technologies, one of the most-recent and promising advancements in understanding and tackling methane emissions is the use of satellites and other aerial measurement methods

such as drones or planes. It is often the case that once a leak has been found, it can be fixed relatively quickly and a key advantage of these technologies is that they can provide a quick and comprehensive view across a large area to help locate emitting sources expeditiously.

A combination of actions from different actors will be needed to bring down methane emissions from oil and gas operations quickly and permanently. Quantitative targets set by leading companies are a welcome first step, and third-party verification and transparency on data and methods are also essential for credible reporting. But there are limits to what can be achieved by voluntary action because the pool of those willing to take such action is limited, and because the actions themselves may fall short of what is desirable from a public policy perspective. Policies and regulations will therefore be needed. These should encourage data gathering and reporting to improve understanding of the issue, to measure progress against goals, and to develop and refine objectives and targets.