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P R O C E E D I N G S

MR. EBINGER: Good morning, ladies and gentlemen. I'm Charlie Ebinger, senior fellow in the Energy, Security, and Climate Change Initiative here at Brookings. And on behalf of Bruce Jones, our vice president for Foreign Policy, who was hoping to be here today and to moderate the session, regretfully has a young child who is sick, so Bruce cannot be here, and he sends his sincerest apologies.

But we will move forward, and we are delighted today to have Heymi Bahar and Allison Archambault as a discussant of the IEA's new report on renewable energy.

I think we all know that since COP21 ended, countries around the world have committed to their most ambitious renewable targets to date. New policies in countries, including the U.S., China, and Mexico to support renewable energy development have bolstered rapid growth in wind, solar, and hydro. At the same time, rising electricity demand is outpacing renewable energy growth, particularly in critical markets such as China, India, and Southeast Asia, and low global fossil fuel prices have further challenged the ability for renewables in some markets to compete on cost. The global community's ability to increase energy access while keeping temperatures below two degrees Centigrade hinges upon clean energy growth relative to GHG-emitting sources, such as coal. And understanding the global market dynamics in renewable energy is fundamental for the promotion of effective policies and regulations to support that growth.

To address these and other issues, we are pleased to host the U.S. launch of the IEA's medium-term renewable energy report, which is truly a remarkable document. In the study, for those of you who haven't seen some of the early press

reports coming out of Singapore and have been covered extensively in the Financial Times, the IEA has upped its five-year renewables forecast by 13 percent and is projecting record growth in renewable energy. Their findings include the fact that half a million solar panels were installed every day around the world in 2015. Two wind turbines were built every hour in China last year. Worldwide, solar and wind power overtook coal to become the largest source of cumulative installed power capacity and the IEA projects that global renewable energy capacity will increase a remarkable 42 percent between last year 2015 and as early as 2021, providing more than 60 percent of the global increase in electricity output over the next five years.

Today we are extremely excited to welcome IEA's Heymi Bahar, project manager in the Renewable Energy division to present key findings of the study, and I am particularly gratified to host this event for two reasons. My first job in the U.S. Government in 1975 at a very junior staff level was to help set up the IEA, a very difficult job at 25 to have to go to Paris about every three weeks. And also because Heymi was my former student at Johns Hopkins, and it's always a pleasure to see one's students go on to surpass their professors.

Before IEA, Heymi worked as a trade policy analyst at the OECD, where he analyzed domestic incentive measures for renewable energy sources and their possible trade implications. His experience also includes work on cross-border trade and electricity and the development of renewables-based electric power.

Following Heymi's presentation, we will be joined by Allison Archambault, who I will introduce properly at that time, but in the interim, Heymi, the floor is yours.

MR. BAHAR: Thank you, Professor Ebinger. Good morning, everyone.

Thanks for joining this event. It's a pleasure to be back at Brookings. We presented this report last year as well, and since last year, many things have changed, and I will basically explain what things have changed over the last past year, especially around COP21.

One year ago, our new executive director launched IEA's new vision, which was based on three pillars. The first one was opening the doors of the IEA to emerging economies, which is happening, and we took an important step last week as Singapore joined as an associate member. Strengthening energy security and broadening it. We are working more than oil on added security issues. We are working on gas security, electricity security. And third, we are trying to become an international hub for clean energy and energy efficiency. And renewables, our work on renewables covers all these aspects which I will explain during my presentation how IEA's three pillar strategy is basically strengthened by renewables.

I'm trying to get this going.

Okay. So I'd like to start with the context. As Professor Ebinger mentioned, there has been a record year over the last two years, 2014 and 2015, but 2015 was full of records. It's not only one record that renewable capacity was 153 gigawatts. I will give you five records that that happened. First of all, 150 gigawatts of renewable energy was installed. Secondly, it was a record level of wind installations, which is around 63 gigawatts. Record level of solar PV installations which is about 49 gigawatts. For the first time, renewables represented more than half of net capacity editions in 2015, which is an important development, which means that less fossil fuel capacity was built than renewables. And for the first time, renewables surpassed total installed coal generation, coal capacity globally. Obviously, coal still remains the largest

source of generation with 39-40 percent, but renewables instead of -- in terms of the install capacity, it surpassed coal.

It took around eight years to ratify Kyoto Agreement and the historic Paris Agreement is ratified in less than a year and four days. And so this has been an important achievement for the world, and one of the reasons why we see renewables going faster is what happened not after COP21 but in the preparation of COP21 and after COP21. But it definitely gives an important momentum to renewables.

Third, climate change mitigation and adaptation is not the only reason why renewables are growing. There are two other important reasons where many countries have started to realize the other benefits, such as local pollution and energy security.

Our energy measurement investment report, which is published in September, looked at all energy investments in 2015 show that there is a significant shift towards renewables in terms of energy investment. Renewable power generation represents about 17 percent of all investment in 2017. The total was about $1.8 trillion.

However, this is not enough, obviously, which I will show during my presentation at the end that we need more if you want to be in line with our goals that I set over the last 10 years and especially in the Paris Agreement, climate goals.

Last year, when we presented this report here at Brookings, we showed the bar, which is what you are seeing on the screen. We projected about 700 gigawatts of renewable electricity coming online over the medium term. It was between 2014 and 2020. This year, we project a 13 percent increase. Why? Everyone is asking why now IEA projects 13 percent? So let me be clear on this because renewables still are sheltered by policies all around the world. Most of the renewable capacity that came

online over the past and that will come online in the future will be supported by some kind of policy. This doesn't mean that these are high economic incentives, but these are policies and market frameworks that give incentives to renewables along with cost reductions.

So why did we increase our forecast? Three countries represent most of our increase. First, the United States, which is about 40 percent of increase of our forecast which will come from the United States. The reason is clear. Last year PTC and ITC was expiring. This year there was an unexpected multiyear extension of PTC and ITC on top of a construction clause which gives a little bit more time for renewables to build up. That's the first thing.

The second thing, China proposed higher indicative targets for solar PV and wind, which was a very important development in its 2013 five-year plan. That is the second reason.

And the third reason, but not the least, is India. India has seen an important decrease in solar PV cost reduction in terms of the auctions, and we saw better implementation of federal policies at the state level in India and several financial incentives that are coming through which made us improve the forecast.

The fourth one is Mexico. Mexico, the energy reform in Mexico and the competitive auctions gave us a little bit of more visibility in terms of the renewable energy deployment to Mexico, which will take up an important market in the coming five years.

For the first time with this extension in the U.S., U.S. capacity growth will surpass the European Union, which is the first time in history that will happen. I will show later in my presentation what's going on in Europe and you will be able to understand why Europe is falling behind. But for the first time the United States surpasses the EU;

that's one of the main messages of our forecast, with policy improvement.

Let's put this into a little bit more of an energy perspective. So electricity generation growth, as Professor Ebinger said, will continue to grow over the immediate term. This graph shows everything in index terms because we would like to see where the growth is coming. And in terms of index electricity generation, we will see charge activity which will mostly come from Southeast Asia, China, India, and partly in Africa. OECD countries, overall electricity demand will be stagnant. We don't expect more than 0.5, 0.8 percent annual growth in OECD markets. But most of the growth will come from Asia.

When we look at coal and gas, we expect the coal generation growth rates to decline over the medium term. It has already declined significantly in 2015 due to China's less demand, electricity demand, where the coal generation decreased by about 7 percent. In China's scale, this is incredible, and this is where you see the growth rates decreasing, and we expect a slower growth rate of coal generation going forward. Gas will continue to grow as gas costs are going down with an oversupply situation, and it will continue to grow in many parts of the world.

However, the biggest news is not gas, coal, or electricity demand; the biggest news I the green line, which is renewables are way -- growing much faster and surpassing any growth rates ever seen globally. So as a result of this significant growth, we will see a share of renewables increasing from 23 percent in 2015 to 28 percent in 2021. This means that we will see a transformation in the energy sector which requires certain modifications. Not maybe immediately over the medium term, but thereafter. I'll make remarks on this in my conclusion slide.

This growth will come, but in terms of the carbonization level, at the IEA

we see a two-speed world. Some countries will decarbonize faster than the others obviously. Asian countries, such as China, India, Southeast Asian countries, we see that electricity growth rate will be way higher than the renewable generation growth rate. This shows you in the future, in the incremental period, what electricity generation or demand versus the renewable generation will look like.

In China -- this is an important development. This is the largest market globally. However, the renewable generation growth will only represent about 50 percent of the demand needs, which means that the rest will still come from fossil fuels. For India, it is about 30 percent, or 27 percent, to be more specific. For Southeast Asia, it's even less. And most of this additional demand needs will be met by fossil fuels, and unfortunately, from coal in these countries, leading to a slower decarbonization. It's a great success what they achieve in terms of renewables, but if we put this into the context, it's a slower decarbonization compared to the right side of the chart, which shows the European Union, the United States, and Japan, where renewable generation growth will surpass demand needs of these countries over the medium term.

In the EU, it will be three times more than the demand needs. In the United States, almost double. And in Japan, more than 10 times than what Japan needs in terms of the money. What does this mean? It means that some commercial generation will go out. This means that the decarbonization will be faster in these countries.

One of the important drivers is also obviously cost reductions. So if we look at commissioned projects in 2016, mostly in 2015, and we try to understand the weighted average generation cost of more important, most important renewables, these are onshore, offshore wind and solar PV tilted scale.

The largest cost reductions were achieved over the past. Everyone knows this story. Solar PV, two-thirds reduction over the last five years. It was an amazing success and it will continue. We expect another 25 percent over the medium term, which will be an incredible achievement. But it's important to understand where this cost reduction will come from. Obviously, module prices will continue to decline, but module prices only represent about 30-35 percent of the overall system costs. The rest is coming from balance of system costs, which are different than modules. Most of the cost reductions will actually come from the balance of system costs, but one of the reasons why we have so many cost differentials between countries -- let me give you one example. The weighted average solar PV installation system costs in the United States in 2015 calculated by Irena, was about $2,300 for a one kilowatt system. In China, it was 1,100. So we are talking about similar module prices but significantly different balance of system costs. And this shows that there is much improvement in conversions of these costs.

In other stories of onshore wind, there has been a great success. And over the medium term, we expect a further 10 percent decline in generation -- 10 to 15 percent decline in generation cost over the medium term. Why? Because the turbines are getting more efficient. They will produce more energy at given sites, and this will result in lower cost reductions.

But the most dramatic cost reductions, which is not happening right now in the U.S. but it's a European story, will come from offshore wind. We expect about 40-45 percent cost reduction over the medium term on the offshore wind. It is truly becoming an industry and it's truly becoming a new success story in Europe. And this is slowly coming to the United States but it will be much slower than we expect.

This is only one part of the story. These cost reductions were mostly achieved by the financial support that is given to renewables. But we also see a new policy trend globally that is moving from government-set tariffs to policy-driven or government-backed competitive options. Over the last five years, most of the renewable policies were based on the government official setting up the price that they want to pay -- additional price or surplus, however you want to call it -- to pay for renewables. However, over the last two years, as the chart shows, we saw an incredible decrease in these tenders for renewables which are combined with long-term contracts which gives an incredible visibility to renewable developers and which resulted in significantly and record-low generation cost, as low as $30. Actually, lower than $30, about $29, of solar PV for a 15-17 year contract in Chile lately. We saw in Morocco about $29, a wind project, which is a large-scale wind project.

However, one caveat on this. These projects are just announced. They will come online in the coming two or three years, and then we do not know exactly which ones will come online, when they will come online, and if the costs that they submitted will be the same as is reported here. But we are following these projects one by one in order to understand if they will come online and how they will come online and what are the processes in between.

And another important point, these tenders also brought a new phenomenon, which is the perception of risk towards renewables. So renewable investments have been seen a little bit of risk investments. They were variable in terms of the generation, how they will cope with the new electricity markets, and so on and so forth. So with new supply chains coming in a competitive way, with developers, with the supply chain providers coming together to bid on these tenders created a new perception

of renewables, which is also recognized by the banks, which has resulted in lower cost of financing, which is the most important development that we see continuing over the medium term because financing cost basically is the most important thing for renewables as they are capital intensive.

I want to go back to the deployment story of renewables. This blue line you see on the screen is hydropower additions globally over the last two decades. So hydropower provided and still provides a significant part of the renewable generation globally. When I say hydropower, we include commercial hydropower into our renewable projections, so we count that as renewables. Some organizations don't, but it's in our projections. And you see that it has been contributing significantly to the growth of renewables. However, this picture will change over the medium term. We do not expect hydropower additions to grow; actually, it will stop declining starting from -- it already started declining in 2013 with peak additions in China. And we expect this trend to go down mostly because of China, because the economic and social reasons, the large-scale hydropower plants are not fully acceptable anymore even in the Chinese context. And then there are more social and environmental issues that are taken into account which will see a slower growth going forward. In other countries, hydropower additions will grow but when you take China into account and its size, we see this growth going down.

On the other hand, you have solar PV and wind additions which have been growing over the medium term and over the past which will grow, but the problem is that there is a perception that they kept growing over the past. Actually, the way to the growth was not as simple as everyone thought. It has been boom and bust cycles due to policy reductions or policy improvements or policy changes, and we expect this trend to

continue.

Just to give you a few examples, some of these boom and bust cycles, in 2009 and 2012, we saw a wind boom cycle in the U.S. because of the PTC. In Europe, we saw in 2011, in solar PV, incredibly generous incentives that are given and then there was boom and then a bust, which I will show in my European slide in a few minutes. We saw a boom in China in 2015. We will see another boom in China on solar PV in 2016, and we will see a bust in Japan in 2018 because of the high incentives which are taken away.

For other renewables, the growth will be more or less stable. There are particular challenges for other renewables, such as for geothermal, predevelopment risks, and finding financing is challenging. For bio energy, supply chain restrictions and high cost compared to fossil fuel prices. Also, for ocean and solar thermal electricity, there are technological challenges that still exist and it will affect their growth.

One of the more difficult things that we are trying to predict are these policy boom and bust cycles, which is extremely difficult to predict, but it has been happening over the past years and it will continue to happen because, as I said, renewables will be supported by the policies and will be affected by the policies. Whatever we suggest all the time to government is the smoother and expected changes in policy so that the investment is not affected or doesn't die basically as happened in Spain, for instance, and a few other European countries.

China remains the undisputable leader of all renewable energy markets. Although coal will continue to provide the majority of electricity needs, we have to face that China represents and will continue to represent the largest renewable energy market globally. For the large three technologies, it represents about 38-40 percent of the global

market, global growth market going forward.

However, we need to note something important about China. It is the challenges. Yes, the growth is strong. It's supported by feed-in tariffs. It's supported by, in some cases, generous feed-in tariffs. But there are risks in China as well, which we highlighted in our report.

And the first one is grid integration. China curtailed about 15 percent of wind generation in 2015; about 12-13 percent of solar PV generation again in 2015. When you put those curtailments together, it's three times Washington, D.C. consumption in one year. It's about the same as Connecticut. So we are talking about an incredible amount of generation that is thrown into the garbage.

And this also has an impact in terms of the connection of renewables, and it will continue to be a major impact. But this is not the one story. China now is facing a new economic dilemma, which is that power demand is not growing as fast as before. China is still building renewables, coal, nuclear and gas at a fast scale, but the demand is not growing as fast. What you will see is a new phenomenon of overcapacity, that is the trigger of curtailments because coal power plants are running in certain levels and they are providing also heat needs of China, heat requirement needs of China, which they cannot just cut like this. So that's why when coal is running in certain states, when demand is low, you curtail renewables. And this challenge will continue to become an important issue and affect renewable deployment. China is putting right policies to deal with those but it will take some time to take care of all these issues.

Another issue in China -- I will say challenge -- is the cost of renewables. Chinese (inaudible) administration produced a paper saying that they are not any more willing to give that much feed-in tariffs to renewables, and then there's a new policy

transition that will come through. This is not included in our forecast because it is not clear right now, but we will see China transitioning for feed-in tariff, probably a more competitive policy scheme in about 2018 or 2019.

I'd like to go back to the U.S., which is the second largest growth market. The black line I showed here last year. This was our forecast last year. These are the annual additions in the U.S., and the other columns are our forecast this year. So it's 60 percent higher than before, and about 95 percent of additions will come from solar PV and wind as they are supported by PTC and ITC. The other technologies will fall a little bit behind as their extension was not multi-year.

And this multi-year extension gave an important visibility to investors, but the black box in the U.S. will be the distributed generation, which is very, very difficult to estimate. Currently, there are a lot of challenges between utilities and developers and solar PV deployers at the residential and commercial scale. This is not only a U.S. question by the way; it's all around the world this will happen about who is going to cover and how network costs going forward. We expect the majority still of the U.S. capacity, solar PV capacity to come from tilted scale projects as ITC extension gives an incredible visibility for these projects. And the challenges are less compared to distributive generation.

We expect slower growth in Europe. If you see these annual additions in the chart, you will see peaks in 2011 and the busts afterwards. This is a very clear picture of the European summary, which means high incentives, high growth, then no growth. Because the market is in an overcapacity situation in Europe and you will see that the additions peaked in Italy and Germany in 2011-2012; in the U.K., for exactly the same reason but a little bit later, in 2015, because U.K. gave an unbelievable investment

incentive to solar PV, then took it away last year. That's why you will see a decline. The only sustainable growth we expect from France because of a particular reason, because France introduced a new low with a clear schedule of competitive tenders for solar PV in 2017, 2018, 2019, which shows you a growing trend.

Quick word on India. We do not expect India to reach its solar PV target in 2022. This is at least for the current policies in place. So in 2009, most of the capacity was coming from hydropower, wind, and bio energy. Solar PV did not exist at all. In 2015, the growth came mostly from, again, hydropower and wind, with the accelerated depreciation investment scheme and a little bit of bio energy. But over the medium term, we expect still most of the growth to come from solar PV. It's about 50 percent. We see India more or less in line with its hydropower target in 2022, almost in line in its wind target in 2022, but not currently in line with our forecast, its target in 2022.

The reason is very simple. We are talking about significantly expanding capacity in a short period of time in a country where grid integration and financial health of utilities still remains an important challenge. That's why we expect significant growth, but not at the level that India wants to achieve in a short period of time.

What needs to be done, obviously, is the financial health of utilities needs to be strengthened. Grid integration issues and grid buildouts should be faster. And also, there is a policy disconnect sometimes between the federal policy goals and the implementation at the state level. And there have been some improvements on this but we still expect this to become slowly developing. India took all the right policies but the implementation of them in our opinion will take some time, which is affecting our forecast. Probably we will revise up our forecast for India next year because we will see improvements in the implementation of these policies.

Latin America is an important region. It has to be a hydropower story, but now a diversification requirement from hydro, especially after the drought that started in 2011-2012, drives a different kind of growth in Latin America. You have two types of countries in Latin America -- either they are dependent on hydropower or they are dependent on imported natural gas. Examples, Brazil and Chile. We expect non-hydro renewables, such as solar PV and wind to come into play over the medium term and to provide a majority or more than half -- slightly more than half of the renewable capacity additions over the medium term. This is important because this is where you see the great resource potential combined with right policies and lowest prices in the world. In this region, renewable generation costs are actually lower than fossil fuels in many parts of the country. Many, many parts in the countries. So it is important that renewables provide, and non-hydro renewables provide an affordable solution to generation needs going forward.

But one important caveat that especially implies to Brazil is the macroeconomic situation. We are less optimistic in Brazil this year compared to last year and over the region, and this is mainly due to the macroeconomic conditions and difficult financing situation in many parts in the region and demand is not growing and the generation needs are questioned.

One last region, Middle East and Africa. So this region holds the great potential, greatest potential and lowest cost as well. And we expect that additions in 2015, 2021, will be three times more than the additions that we saw in Middle East and Africa over the last six years. However, it underperforms of its potential. Most of the capacity expansion will come from either EPC contracts that are launched by the governments, or competitive tenders. But the main issue in this region is the

implementation of these announcements and then how policymakers will follow up to make these projects happen, because you have many challenges, such as regulatory challenges and licensing challenges in many of these countries. You have high financing rates and not all the time international financing coming through. You have market access problems, and you also have sometimes fossil fuel subsidies which affect competitiveness of renewables in these regions.

That's why we also created an accelerate case, which is actually the largest accelerated case, which is 60 percent more, because the majority of these policies are announced. The projects are there but their implementation has been slow. Still, hydropower is expected to provide around -- is the largest technology, will remain as the largest technology. Especially in Africa, interconnection opportunities is huge, and some countries will continue to exploit that. But solar PV and wind will come into the picture as well.

So overall, when we put all these regional forecasts together, we see annual additions going forward in a stable way. Why? Because hydropower additions, which provide a significant capacity over the past, will not be there in the future, in the coming future. And then we will see solar PV -- two technologies will try to compensate for the growth.

Our forecast, this is the main case forecast, is in line with NDCs or INDCs, all INDCs, NDCs that are submitted for the COP21, this forecast that you see is in line with those generations on the electricity side. However, NDCs will only take us to 2.7 decrease/increase. So, and our goal, our long-term comment goal is about two degrees and well below two degrees, which new assessments will come (inaudible) 1.5 degrees going forward.

Our accelerated case, which are representative for Middle East and Africa, we actually have for all the regions, which can actually put renewables into a growing context going forward, but this requires three major challenges in many countries to be overcome. The first one is the financing challenges. In some countries, financing rates remain high, mostly developing countries. Second, grid integration challenges in many countries, including China, India, and also partly Europe. And also, there are still a lot of policy uncertainties in too many countries, or regulatory uncertainties. And we see that if those uncertainties is doubt over the coming 24 months or 12-24 months, the growth actually can pick up fast. And can be in line with the scenario that we want to go to.

However, electricity is only one story. It is the most fashionable and most talked about story of renewables. However, it's only one part of the story. As I said, the electricity generation, renewable generation or electricity demand will increase from 23 percent to 28 percent, but you have two big elephants in the room where their decarbonization is very, very slow. It's heat and transport. So their level of providing renewable share in these sectorial demand remains below 10 percent for renewable heat and it will be slightly more than 10 percent in 2021. And for biofuels and road transport, it is even less than 5 percent. This is only road transport. If you include all transport, it's less than 4 percent.

So these two sectors which are more difficult, I'll explain very, very shortly why they are more difficult and why the policies are not giving a lot of attention to them, but the issue requires certain attention if you want to go towards two degree scenarios.

On heat, so heat is not like you are producing electricity as a supply and

then you provide it to the customers. Heat has two major sectors, market segments, which are industry and buildings, which include consumer choice. Which means that you have an unbelievable number of technologies, fossil fuels, usually lower than -- their costs lower than renewable options. And you see a consumer behavior barrier, which is a noneconomic barrier in terms of the cost. For instance, your boiler, oil boiler or natural gas boiler is broken. You need a boiler. You don't have enough information to go for renewables. The supply chain is well-developed on the oil side and fossil fuel side. You don't even question what are the other options. You just go and get a new boiler because it's required. And at the industry level, there's also some levels of heat and pressure that renewables cannot provide. So we are talking about different market segments, different consumer options, which renewables cannot penetrate the market as fast. Because particularly, policies that are giving strong incentives to electricity are not giving it on the heat side. Many few countries are providing these policies. Most of the heat demand growth is expected to still come from bioenergy in 2021 on the (inaudible). This is modern bioenergy. We did not include traditional biomass as a renewable source. It's included in the demand but it's not in the renewable source. And we also looked at how much electricity, renewable electricity is used in heat, and we basically calculated that the brown bar, which is the only -- almost only most increased one.

The most dynamic technology remains solar thermal heat technology, which is also widely spread in the United States. Just one important note: we think that solar PV capacity is the largest in the world. Actually, solar thermal heat capacity is double than the current global solar PV capacity. So you have more homes that install solar terminal water heaters than the solar PV in the world globally. So we talk about the widespread technology but its contribution remains extremely limited despite its

expansion.

One last point on biofuels and I will go to my conclusion. We looked at the production of biofuels over the past six years, which is in the chart, U.S. ethanol story. Support of ethanol in the U.S. has created this incredible boom over the past years, which is almost hitting the blending wall at this point. But over the medium term, we see an important geographical shift in terms of where the growth will come from. U.S. growth will be extremely limited, which means that we see a flat ethanol consumption over the medium term. This small growth will come from biodiesel. Biodiesel will slightly continue to be produced because there is still support, but the overall ethanol hits the blending wall unless there is a change, significant change in the structure. And if the structural problems are solved in terms of the flex vehicles, fuel flex vehicles or infrastructure in terms of fueling, we expect the ethanol production to remain stable.

In the European Union, the production capacity, the mostly biodiesel production capacity, it's not operating at a higher scale. And it will be our forecast basically and only investments will come because of the 2020 targets, 2030 targets which are not clear at this point in the European Union. In Brazil, we will see a sustainable growth, but the important story here is that Asia will take the lead in terms of the growth. And this is mostly Thailand and India on ethanol, and Indonesia and Malaysia on biodiesel. The reason is very simple in this case; it's energy security. All these countries are dependent on oil, and the reason why, despite the low fossil fuel prices, they introduced new policies, increasing their mandates, due to energy security reasons.

And that's why the relationship between fossil fuel prices -- low fossil fuel prices and biofuels, they're a little bit more complex than thought. It affects future investment decisions in the United States for sure. This is a very important point that you

need the right signals to invest in additional biofuel capacity in the U.S., which is running at more than 90 percent capacity at this point already. That's why in order to increase the production, you need a new investment, and fossil fuel prices over the longer term will have an impact. But in the other countries, it's more of an added security issue. That's why they increased their policy support.

A few conclusions, which you already heard most of them. We revised up our forecast mainly due to the policy improvements in several markets and cost reductions and the drivers that involve improving air quality, especially in Asia. The impact of low fossil fuel prices, whereas by sector, I mean, heat is even more complicated than biofuels in this case, but what we observed in our data, the sales of renewable boilers, renewable energy boilers in households decreases in Europe, in major countries in Europe, in the U.K. and Germany, with the increasing fossil fuel prices -- with the increasing fossil fuel. So you have a positive correlation. Oil boilers increase when the fossil fuel prices are low and we see a very fast consumer reaction to this. In 2015, we observed this in the U.K. and Germany data clearly, especially in market segments where renewables are directly competing with renewable options.

Overall, the only two technologies in the whole forecast, which is in line with 2DS scenario that we have is onshore wind and solar PV. The rest is still falling behind. If you want to decarbonize, it's really important that Asia decarbonizes, especially emerging Asia. It will depend significantly on how fast Asia, emerging Asia decarbonizes if you want to achieve these long-term targets, because most of the generation is still coming from coal in these countries. And there will be more and more competition between coal, gas, and renewables.

Policies. That's the important policy message. New renewable policies

require new approaches because they are not any more, as our executive director said many times, a romantic story. So they are becoming a real mainstream market, but their profile and their factors that attract their investment is different than fossil fuel options. So they require not anymore high levels of incentives but they require a market framework that they can operate, which we can discuss during the discussion.

Also, the grid integration will remain an important challenge that countries will have to tackle. And at the IEA, we basically have a special unit that works on the grid integration, and we will continue to strengthen that.

Thank you very much. I present this on behalf of a large team, and I'm looking forward to discussions and questions. Thank you.

(Applause)

MR. EBINGER: While we're getting set up for the Q&A, I just would like to formally introduce Allison Archambault, who is the president of Earth Spark and oversees all the organization's day-to-day operations and management. She is also a founding principal of Fresh Generation, LLC, through which she consulted energy companies, governments, and advocacy groups on a variety of renewable and other energy issues. I won't read the rest of her bio; you have it in front of you. But we're delighted to have you here with us.

We're going to shift gears a little bit. Originally, I was scheduled to be also a panelist with Bruce Jones moderating, but I will not be a panelist, but I will provide a few questions to get us going and then we want to move for the remainder of the time to the floor as rapidly as possible.

I'd like to start with one question, and maybe it's most apropos for the U.S. than maybe some other countries. How important is it that we build long-distance

transmission lines in order to fully utilize the vast renewable energy resources we have sometimes far away from major load centers?

MR. BAHAR: So this is -- globally building the transmission lines remains one of the most important challenges in Europe; I guess in the U.S. as well. Our grid integration study actually shows four or five options how you can integrate renewables, and obviously, building new lines, which many countries are trying to do, is one of the more important ones, but it's also expensive. So there are cheaper options that our study found out but it's difficult to explore, such as a demand response, which are extremely cheaper, which has come into play with the IT industry entering into the field and mostly in San Francisco and California right now. But transmission lines will remain the same, but who will give the right signals to transmission lines as well? With distributed generation increasing, with utilities afraid of losing their revenues, that remains a big question mark. And as I said in my talk, it's a black box to us how fast distributed generation can move and how it can affect the transmission lines. But China is building fast, long transmission lines from east to west. Most of the renewables are in the east; most of the demand is in the west. Sorry, west to the east. But they are also starting to question the cost of these lines and if they can actually promote the buildout of renewables closer to demand centers. But it remains an important decision, an important investment decision, but it requires, I guess, the right signals to build those transmission lines in addition to all the challenges which are environmental and social which many countries are dealing with.

MR. EBINGER: Just one other question and then I'll let Allison, if she has something she wants to ask you.

You show the aggregate targets for the EU, but can you add any

specifics on the differences between -- rather than the five principal countries in the EU, what is happening in the former satellite countries of the Soviet Union and in Eastern Europe in general? And also, can you make any observations about what is happening with renewables in Russia?

MR. BAHAR: So the policy uncertainty in Eastern Europe has been the major block of renewables over the past two years. In Ukraine and Romania and in all the countries in this region, this is the slowest growth that we see going forward. The reason is that some of the countries provided some incentives two years ago and then they took it all away and then they changed them retroactively.

Ukraine is an interesting story because Ukraine actually strengthened its incentives on renewables because of energy security reasons. However, the implementation remains difficult in the current political agenda but it has feed-in tariffs which are generous, and they were designed and increased and modified because of energy security modifications.

Russia launched renewable energy tenders to basically -- but demand is not growing in Russia that much. They launched solar PV and wind targets. For some tenders there was a lot of interest; for others, there was underbidding so it was not addressed. But it's important to attract foreign investment into Russia. Most of the companies were Russian companies. These tenders were comparative and resulted in kind of a competitive pricing but their implementation, it's a question mark. In our forecast, we did not take into account all the tendered projects to come online over the medium term. We took only a certain part because challenges remain in Russia.

There is also the local content requirement, which in a country like Russia where the renewable supply chain is currently limited, if you want to meet the

local content requirement, you will automatically have more expensive inputs. So in the beginning at least. You have another example, which is Brazil, which is an opposite example, but you will in the beginning have more expensive inputs, and that's why results in Russia were not the lowest in the world. There are like some countries that achieved (inaudible) price of Russia in their first tender.

MR. EBINGER: Thank you. Allison, did you want to ask him?

MS. ARCHAMBAULT: Well, one of the things that I thought was the most interesting in your presentation and in the overall forecast touches on your first question about the black box and distributed generation. And then the role of efficiency in storage and smart grid. And I think that black box, in that black box is the answer to your question. We just need to understand what's in there, and it's very policy driven. So I really appreciated that part.

MR. BAHAR: Sure. So in some countries currently, with high retail prices, in Europe, in for instance, Spain, where the government took out all the incentives, still people are building solar PV panels on their roofs. In Germany, it's the only market segment where there is national PV which will grow, which will continue to be -- to continue because of high retail prices. In France, prices are slow. It's not in the same pocket. But there are different drivers in different countries. But the question is that when utilities will see this as a business opportunity, combining with the services industry. So it's been a very long time that -- we were all paying our bills. Our only interaction with the utility was that you receive a bill; you pay the bill. You receive the bill; you pay the bill. That's it. Now it's slowly changing. Now the utilities who are providing retail services are becoming service providers, which means they install a PV panel. They put you a smart grid. They capitalize on the demand response. They try to

increase the efficiency. As you said, this is the new proposition.

But how this new proposition can accelerate in developed countries, it's kind of obvious at this point. But in developing countries it's a little bit more like a question mark in my opinion. Most of the capacity forecast on PV in our forecast will come from metered scale, about 60 to 65 percent, and the rest mostly will come from residential and commercial. A big question is also the commercial, where companies can see the benefits of installing PV, such as in Japan where prices are extremely high but you have regulatory barriers on installing these solar PV panels on the long flat roofs of industry.

MR. EBINGER: Did you have another question?

MS. ARCHAMBAULT: Well, the other thing, I appreciate your opening with how are we going to achieve energy access and the climate goals. And I work mostly in emerging markets and really appreciate the opportunity for innovation to short of showcase how smart grid and micro grids and sort of the local energy supplies can really show what is possible. I really liked your statement about how the tenders for renewable energy are really driving down the cost and changing the perception of renewable energy and proving out what is possible I think is one of the fundamental drivers for the financing costs, but also just for what people think of when they're going to change out their boilers.

MR. EBINGER: If I could just add to that before you respond. You know, in the last few weeks there have been a lot of articles about India and its potential air conditioning load and how this might wreck asunder what we really think is India's electricity demand; that it may be much higher, or at least the unmet demand. Do you think there is any danger of that, that if electricity demand in some of these countries with

large underserved populations, but also middle-class populations, that can now afford energy-intensive appliances, that if we're wrong, can renewables step up to meet the additional load that may be hidden out there?

MR. BAHAR: Very good question, and also a very difficult one.

So we actually looked at in Indonesia about this micro grid, how solar PV panels with some storage options, in this case, battery storage, can meet some of the villages' demand needs beyond like 24/7 electrification. And we found out that it's actually on par. If you install these combined micro grids with solar PV and some storage, with diesel being extremely expensive to reach in these regions, we saw that there are benefits. We have a little box in the book about this. So, but the important thing is how do you attract investment in these regions? So capital investment is so high in the beginning, and without government support in terms of the financing, it will be very, very difficult to do this. That's the major challenge that we see. Although the costs are there, this does not necessarily mean that this will be deployed.

On additional load in many countries, China -- I'll start with China and then move to India. In China, if distributed generation takes off, which hasn't started yet, neither in India, if it takes off at the industrial scale and at the residential scale, we will see probably our forecast, if the barriers there are met, our forecast probably will be completely wrong. I'm saying this with my all honesty because currently, we only look at the policies in place. We do not imagine new policies. So we only look at the policies in place, and then challenges in place, and then we assess the countries and their growth that way.

For India, it's even a blacker box than China because these two countries, especially India, has the lowest system costs for solar PV globally by far. It's

about -- the install capacity of 2015 had $1,000. It's the lowest in the world, but this is commissioned. For new projects, people are talking about $600-$700 per kilowatt. So these are extremely low costs. But the problem in India to achieve this will be again financing. Currently, the interest rates on a consumer financing rate are about 13 to 14 percent in India, so unless you find a solution, and just to compare, it's 0.5 percent in France, probably 1 percent in the United States, or 1.5 percent in the United States in the government bond returns, and in India, the consumer rate reaches 13 to 14 percent. Unless you solve the financing problem, I think which will be an important topic in COP22 next week, starting next week, it will be very difficult to take off that part.

Let's say you shaved the peak in India, the air conditioning peak. What will happen to commercial generation? That is also another question because if somebody goes in, if renewables go in, somebody needs to go out, obviously, in terms of this peak demand where all of the generators are making money, which will disappear -- which disappeared in many states, in some states in the United States, or (inaudible) famous duck curve. And also, in Europe, there is no peak. When there is sun in Germany, there is no peak in Germany. Peak pricing has disappeared almost.

MR. EBINGER: Okay. We will go to the floor. I will withdraw from answering any questions. You can direct the questions to either panelist, or if one is directed to Heymi because he made the presentation and you want to weigh in, feel free to do so.

Do we have any questions from the floor? We've got a mic here.

MS. ARCHAMBAULT: While we're getting the question, if I could just follow up. I think there's somebody from U.S. Trade and Development Agency here. And I think it's important to sort of back out and look at all the different policy tools, and

addressing that sort of cheaper micro grid cost, but then the cost of financing. They are doing some really good work and funded some market studies for us and Haiti and doing some other market assessments, sort of de-risk the access to information and hopefully that brings down the cost of financing.

MR. EBINGER: Will you please identify yourself and ask a question?

MR. SAUNDRY: Sure. Peter Saundry, Johns Hopkins, and National Council for Science and the Environment.

Two questions. One, we've seen a lot of reports about a fairly dramatic slowdown in investment and renewables in the first half of this year. How much does that affect what you've presented today? And the second one is on the decarbonization, you didn't say much about nuclear. Is there a significant role for nuclear in the decarbonization above and beyond the renewables? Thanks.

MR. BAHAR: So I guess you're talking about the Bloomberg New Energy Finance's announcement on Q3. So it actually shows our forecast. So they announced financing rates, which means project financing, which means it will be built in two to three years. So when I show the annual editions in the (inaudible), you saw a little dip in 2017-18. This is that decrease in financing probably. You will see maybe financing will pick up immediately on projects. It will be commissioned faster than expected. But overall, that announcement actually shows our slight decrease in annual additions in 2017-18.

On nuclear, that's also a very difficult question, and also political. Of course, nuclear offers something for low carbon generation. But obviously, the current environment in nuclear, we only see in our long-term scenarios that it will be developed in China, mostly. Not only in China, but most of the new generation from nuclear will come

from China. China was the leader of the nuclear investment last year, and China has plans to continue to invest in nuclear. But this nuclear deployment will really depend on the country specifics and regulations. There are other countries who are building nuclear, who want to build nuclear, such as Russia, such as Turkey, such as there are two reactors in Finland, one reactor in France, which their costs almost doubled or tripled at this point. So nuclear has its own challenges, has its own advantages, but in this kind of financing environment, it's a big challenge to put that much money into the nuclear generation, investment costs. Their generation costs are extremely low, but to make that investment you need a little bit of government -- I want to say support, but intervention maybe.

MR. EBINGER: Bill?

MR. EIKER: Bill Eiker, consultant.

Question about, you mentioned battery storage. And sort of that aspect of dealing with the intermittency questions. So I'm wondering if you could give us a little more detail of how your projections dealt with dealing with intermittency. What do you see happening on the investment side? What do you see happening on the technology development side? What do you see happening on the regulatory policy side? Because they're all sort of in the mix here with intermittency and I'm wondering what assumptions you made and what you see.

MR. BAHAR: So globally, we have a lot of storage capacity but it's not battery. It's pumped hydro storage. And some countries will continue to invest in pumped hydro storage, such as there are some opportunities in Europe. There are some opportunities in China. They will continue to be built. But the problem is that remuneration of storage. So it used to be that those pumped storage plans were

basically doing the trading, pumping up and then providing electricity. However, with the peak prices all around the world going down, so they don't have much incentive. Actually, they provide more value than just generating electricity. So the question here, how a new regulation -- it doesn't exist at this point as far as I know -- how to remunerate pumped idle storage or solar terminal electricity storage, which is another storage capacity that will grow, that will continue to grow. How to remunerate them, how to give the value that they provide to the system, not only the value that they just generate electricity.

On the battery side, on the lithium battery or any other technology, coming five years, their impact in our forecast is limited. Some countries, some states in the United States, and some residential-level storage will be built in the U.S. and Europe, but still, when you look at the prices, it is still very expensive. Everybody is taking about task level but when you look at the prices and the generation costs, it is still very, very high. Of course, the costs will go down very fast, probably there will be another solar PV story in the coming five, six years, but in our forecast it remains a little bit limited, and at the grid-level storage it's even more limited. I know in some U.S. states, in order to deal with the variability of renewables they start investing in this but it is -- it will be kind of limited, at least in our four or five year forecast.

MR. EBINGER: Did you want to add anything?

MS. ARCHAMBAULT: Oh, no. I just thought that that was a great answer to your transmission line question.

MR. EBINGER: It was a great answer.

Okay. Way in the back?

MS. BLOODGOOD: Hi, Laura Bloodgood from the U.S. International

Trade Commission.

You briefly mentioned the transport sector. We've seen some new developments, certainly the aviation agreement. I'd love to hear your views on how important that might be towards decarbonization. Also, electric vehicles, we're hearing a lot of announcements from automakers, more investment in there.

MR. BAHAR: So in terms of the electric vehicles, we have a forecast on electric vehicles. Actually, electric vehicles in terms of there are two degree scenarios. They are the third technology which are in line with their fastest growth, although a very small base right now. But it's one of the technologies which are, I think, not fully on track, if I remember correctly, I have to check that, but it's not red. It's either orange or green.

It will grow, the electric cars, probably extremely faster than many people expected. But when you look at the overall scheme of the transport sector, it will remain extremely small as well compared to what we have in terms of demand, because we are talking about an unbelievable demand that is growing in part. Not in OECD countries, but non-OECD countries. And this is an important contribution by the electric vehicles, but it will be rather small. I'm talking about the coming five years.

Going back to the aviation and biofuels. So advanced biofuels were extremely -- it's one of the segments of biofuels which promised a lot. Over the last five years there has been good investments but those plans are operating right now at a very low level. And with the current low fossil fuel prices, the breakeven point is not doing very well for them. So we will see -- so we are not seeing in our forecast a lot of new plants, advanced biofuel plants to be built.

And of course, there's a sustainability question of biofuels in Asia which I think policymakers should really, really, really take into account. I show that Asia will

grow fastest but there is also a question mark of sustainability there, which is an important issue.

And for currently the airline companies, their announcements, it's kind of voluntary right now, and I don't know, probably Professor Ebinger will know better than me. The voluntary starting points have not been very successful in terms of the massive deployment. I think it requires a real regulatory structure or targets or mandates or all these other policy schemes in order to be deployed.

MR. EBINGER: On the aisle here.

MR. MOSCAR: Nels Moscar with the Danish Embassy.

I just wanted to hear if you had any specific, effective policies that could scale up renewable energy in the heat sector, and if you could differentiate by region. Thanks.

MR. BAHAR: So we have an extended heat analysis. Although I presented one slide because the interest is mostly based on electricity. So I will highly recommend to read the heat section of the book, which is about 57 pages, which is a significant part of the book.

So there are policies. The successful policies that we saw were combined in combination with energy efficiency. So how you can combine energy efficiency policies with renewable heat policies and create a better value for the customer. So in the end, if we are going towards a distributed generation, which everyone talks about -- it will be democratization of the energy, people will produce their energy -- if we are going towards trusting customer choice and customer behavior, you need a hook to get the customer. And the hook is you pay less. So that's why energy efficiency measures, combined with renewable heat and smart homes, will be an

important measure. And there are some countries already using your boiler, your electric heat boiler as a storage capacity to provide demand response to the grid. So these things, they're very pilot scale but it exists.

Another important incentive is basically the capital grants that are very widely spread in the United States and Canada at the state level to basically give you some sort of money. It has been successful. But the most important thing is the existing fleet, building fleet. How do you change that? So for new buildings, you can put a regulation with energy efficiency. How do you change the existing building? Retrofitting a building with renewable heat or industry is extremely difficult because a renewable heat boiler has to be bigger than -- its output is less efficient. It has to be bigger than an oil boiler or a gas boiler in the industry. So how do you find the place first to store all this fuel that you are going to put in? Second, how do you build retrofitted buildings to fit a bigger boiler? That's a bigger question as well. So most of the policies will go towards the new buildings and then combine with energy efficiency. And in Europe you have very successful examples of those, like in Germany, like in the Nordic countries.

I want to ask you a question.

MS. ARCHAMBAULT: Yes.

MR. BAHAR: So where do you see actually -- one of our -- we did not -- we are not focusing that much on off- grid, to be honest, because it's very -- it remains very small for our forecast. We would like to improve this more. But where do you see the markets going on the off-grid side? Is it an option? Will it be an important option for the electrification? Or will it be a combination of grid expansion? I mean, we are still trying to understand that phenomenon.

MS. ARCHAMBAULT: Yes, and yes, and yes.

So 1.1 billion people still don't have any access to electricity, and another billion people have very spotty access to electricity. So it is grid extension. It is micro grids in these communities that have some density of demand. And beyond those, for the last hut on the last mountain, small scale solar systems are great appropriate solutions. So it's sort of a bullseye approach where you sort of need to do an analysis of least cost delivery. But, looking at energy services and looking at deep efficiency smart grid storage, I mean, I'm a big believer that these emerging market micro grids are where a lot of the innovation is going to happen that can then be ported back to the larger grid systems.

MR. EBINGER: Can I just ask you also on that same note, in some very small island economies, say in the Caribbean, how do renewables compare and cost to say either imported diesel or increasingly people interested in small-scale floating LNG plants?

MS. ARCHAMBAULT: Yeah, well, it's a great question, and it really depends on the policy, right, behind it. And so that we are continuing to invest in infrastructure for fossil fuels is a major issue around the world, and especially when you have no status quo, you have no incumbent infrastructure, again, it's a great opportunity to really do this deep assessment. And there's this perception that to pull people out of poverty you must have sort of, you know, coal, which is just not true. And also, when you look at building the infrastructure for LNG, for example, you really should be thinking about this is a 50-year investment. Let's look at what the alternative is for a cleaner energy economy. And oftentimes you can get lower levelized costs of electricity with clean distributed energy.

MR. EBINGER: Thank you.

Anybody else?

Yes, ma'am?

SPEAKER: Hello, I'm (inaudible) from the Belfer Center at Harvard.

My question is on innovation. There's a lot going on. Also, besides the renewable targets, there's mission innovation (inaudible) COP21. There's the Breakthrough Energy Coalition, and a few days ago, Elan Musk talked about his new solar tiles. I'm wondering how does that affect or do you account for that in your medium-term outlook, or this is according to you, much more in the long term? Thank you.

MR. BAHAR: A certain level of learning of current technologies, we take them into account in our forecast. That's why we do an assessment of how cost of certain technologies, such as turbines, such as modules, such as balance of system costs will decline in a certain way. We do this for important countries, like key markets, and we divide balance of system versus modules, for PV for instance, turbine versus other costs for onshore wind and local costs and international comparison. So we have a database that we assess these things. This is how we become this general cost reduction, like 15 percent additional for wind and another quarter for solar PV in the coming five years. But these are coming from learning, obviously. And these are coming from market forces where model capacities are oversupplied. Turbine capacity is oversupplied globally, which means the prices will remain slightly low.

But if you are asking, if you are trying to predict the breakthrough innovations, definitely not. So it's not in our forecast. It has never been in our forecast, this significant decline of cost of solar PV between 2010 and 2011. No one even thought about this that it would decline so fast. We adjusted our cost according to that but we do not take into account innovation.

But what we do take into account, in certain renewable technologies, what are the innovation prospects and what are the parts that can be improved? For instance, in ocean technology, what we have a chapter of, we are talking about what are the new technologies that are coming in line? What are the test periods? The same thing for floating offshore wind turbines. But we are approaching them in a very descriptive way I will say. We explain in the chapter but we do not say how. And innovation, IEA collects innovation data from IEA countries, but this is not R&D data, R&DD data. But this doesn't necessarily mean that the data that countries provide necessarily turns into this kind of breakthrough innovation both on the public and private side. So that's why it is very difficult for us in this five-year period to -- even in the long-term models, it's impossible to predict such an innovation. They are usually using learning curves over the longer term with certain constraints.

MS. ARCHAMBAULT: I thought you did a very humble and thoughtful job of contextualizing the report saying we only look at the policies that are in place and we assess the trends that have been established. And I think that's sort of a challenge for everyone else in the room to disrupt those in a way that does make these forecasts --

MR. BAHAR: And we are happy to, I mean, there has been -- we are happy to revise up our forecast if the policies get better, cross the line faster. I mean, this is not -- but we just look at exactly what is the current market today and how it will evolve over the medium term. I think this is IEA's role, to look at the overall --

MR. EBINGER: With the explosion that you have for renewables, do you see any constraints in terms of productive capacity for either solar panels or wind turbines? And the other -- well, let me ask that first.

MR. BAHAR: Okay. So on the wind turbine side, which is my expertise

a little bit, currently in the U.S., some of the wind turbines are producing 55 percent capacity factors, which is -- the average gas fleet in the U.S. has 51 percent, if I remember correctly. So I think wind turbines have seen incredible innovation and will continue to (inaudible). The offshore wind turbines, now they are 8 to 10 megawatts per turbine that will be built in the coming years. So we are talking about an increase in size. Of course, we can install these turbines in the sea. It doesn't bother anyone. But it's becoming more and more difficult in terms of limit, social acceptance for onshore wind turbines or land-based turbines. In many countries in the world, larger turbines create social acceptance problems. And this is one of the limits, I think.

Another endless innovation that will create an endless market is the floating offshore wind, which means that you don't have to have a cement structure to keep the offshore wind turbine to sea. This is mostly important in Asia where the water is not shallow at all. So if Japanese innovators unlock this innovation in coming years, it can grow extremely fast.

On modules, modules are becoming more and more efficient, which are in our model as well. We increased capacity factors for new models coming online. But the biggest innovation will come from building integrated. Then there is no end. So if we can integrate flexible modules into buildings, in existing building surfaces and new building surfaces, that will be really an endless step towards achieving a zero energy building structure. There is still a lot of innovation going on that one, and I think this is another black box that might be unlocked in coming five years, maybe beyond.

MR. EBINGER: And an ancillary question. If you kind of look out 5-10 years, in terms of the manufacturers of various renewable technologies, which countries are going to be the big winners in terms of having major export markets for their goods?

MR. BAHAR: China, China, China. But there is actually some -- let's put some nuance in it.

So China is the largest solar PV panel and module producer. It is the largest exporter of solar PV (inaudible). It's the largest producer of wind turbines, but it is not the largest exporter of wind turbines. So that's the important caveat.

Chinese manufacturers remain mostly domestic-oriented because there is a booming demand. Last year they installed 33 gigawatts, which was the record of all. So that's why it's mostly in the domestic market. And for solar PV, I think China will remain in the coming 5 to 10 years, the majority producer and exporter. Even if it's not coming from China, it will come from the plants that are installed by Chinese investors in Malaysia, Thailand, and other southeast Asian countries, because in order to overcome certain trade barriers, Chinese investors start investing in many different regions, including Europe as well, including Turkey as well, so they're investing in many parts in order to produce their panels. In the end, producing a panel, it's an assembly manufacturing facility, so it's very easy to move. It's very easy to scale up.

MR. EBINGER: Allison, do you have any concluding point? We're almost out of time.

MS. ARCHAMBAULT: I think I wanted to go back to the one from the Belfer Center and talk about innovation and where innovation is necessary. And I think there's this big focus on sort of innovation in the lab from some of these groups that are really talking about breakthrough things. And what we're finding a lot is that it's really the de-risking by doing, the other D, that needs to be really invested in and explored. Because it's the innovation in the business models in emerging markets, and also, I mean, disrupting the status quo in established markets is incredibly challenging. So, de-

risking by doing, investing in sort of innovation research for deployment, and combining existing technologies. We don't really need another solar panel; we need to be able to deploy all these great technologies that we already have. We could solve a lot of the problems just with that.

MR. EBINGER: Heymi, any concluding thought?

MR. BAHAR: One note on the innovation in business models, which is I think a great point. I think for the medium term, innovation in business models will be more important than innovation in technology, technology breakthroughs, in my opinion. Because are in kind of a turning point of the transformation of the energy systems globally, which is led by renewables. So we were talking with Professor Ebinger this morning before the talk. Current electricity markets, or retail markets, are not designed for zero marginal cost renewables. They're not designed for them. They're designed for marginal cost generation coming from fossil fuels. Now, you put all these additional zero marginal cost renewables, they disrupt the market. So I think the important thing is to find -- I don't know who will find this new business model or new electricity market -- which will combine short-term price signals, which currently we have in the wholesale market, with long-term price signals which will give incentives for grid investments for renewable energy investments for also fossil fuel investment that we will need, long-term incentive and predictability or visibility that will attract investment.

And utilities will be part of this. And now several utilities in Europe are choosing to get out of their fossil fuel businesses and basically investing in renewables and separating these two, which means that they are seeing a great value in their new business. So they are trying to separate them so that the profitable business remains. And many utilities are trying to get into this renewable business, installing panels

themselves. In the U.S., several utilities first resisted, then they installed themselves in order to be competitive to Solar City or Sun Run. So these things will come. But it will be slow.

And another very important point to finish, we really need to find a business model or market framework that gives value to the generation of any technology, which means that where and when it is generated, the only model that I know is from Mexico. New energy markets perform while the government gives signals where the investments should be done in terms of the location an hourly signal when they will remunerate them more or less according to their value to the system. Well, of course, these concepts are currently a little bit difficult to grasp, but it will be more and more important. We need electricity generation where and when it is valued, and in order to value that we need market frameworks to support that, which we will see in the coming five years, changing completely the market.

MR. EBINGER: Well, I want to thank Heymi and the IEA for asking Brookings to have this unique opportunity to release your report, and I want to thank you, Allison, for a very vigorous set of questions.

Please join me in thanking our panelists.

(Applause)

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