CLEAN ENERGY SOLUTIONS CENTER
ASSISTING COUNTRIES WITH CLEAN ENERGY POLICY

Energy Scenarios to 2040: What it Takes to Reach INDCs and Beyond

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Webinar Panelists

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This Transcript

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Sean Esterly

Hello, everyone. I am Sean Esterly with the National Renewable Energy Laboratory. Welcome to today's webinar, which is being hosted by the Clean Energy Solutions Center in partnership with Enter Data. Today's webinar is focused on the Energy Scenarios to 2040: what it takes to reach INDC and beyond. One important to note to mention before we begin the broadcast is that the Clean Energy Solutions Center did not endorse or recommend specific products or services. Information provided in this webinar is featured in the Solutions Center's Resource Library as one of many best practices resources reviewed and selected by technical experts.

I just want to go over some of the webinar features for everyone in the audience. You do have two options used for audio. You may either listen through your computer or over your telephone. If you choose to listen through your computer, please select mic and speakers options in the audio pane. If you choose to dial in by phone, please select the telephone option and it will display the number and audio pin that you should use to dial in. If anyone is experiencing any technical difficulties with the webinar, you may contact the GoToWebinar Help Desk at the number displayed at the bottom of the slide. That number is 888-259-3826 and they can help you there.

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will be posting PDF copies of the presentation at cleanenergysolutions.org/training. Also, we will be posting the audio recording of today's webinar to the Solutions Center training page within a few days of today's broadcast. Also, a reminder, we are now adding all records to the solutions on our YouTube channel where you will also find other informative webinars, as well as video interviews with thought leaders on clear energy policy products.

We have a great agenda put together for you today, which is centered around the presentations form our guest panelists, Manfred Hafner and Yasmine Arsalane. These panelists have been kind enough to join us to provide an overview of the results related to the Ener-Blue scenarios. INDC's, it's impact on different energy sources and geographical regions, as well as the challenges and implementation, as well as a few other energy scenarios. Before we begin their presentations, I will provide a short, informative overview of the Clean Energy Solutions Center initiative. Following the presentations, we will have the question and answer sessions where the panelist will address questions submitted by the audience, followed by closing remarks and a brief survey. For everyone.

First, I provide a bit of background in terms of how the solution came to be formed. The solution is one of 13 initiatives of the Clean Energy Ministerial that was launched in April 2011. It is primarily lead by Australia, the United States and other CEM partners. Outcomes of this unique initiative include support of developing countries and emerging economics through enhancement of resources on policies relating to energy access, low cost policy assistance, and peer to peer learning and training tools such as the webinar you are now attending.

Our four primary goals for the Solutions Center, first goal is to serve as a clearinghouse of clean energy policy resources. The second is to share policy best practices, data, and analysis tools, specifically clean energy policies and programs. The third is to delivery dynamic services that enable expert assistance, learning, and peer-to-peer sharing of experiences. Then finally, the Centers fosters dialogue on emerging policy issues and innovation around the globe.

The primary audience is specific energy policy marks and analysts from government and technical organizations in all countries, but the Solutions Center also tries to engage with the private sector, NGO, and civil society.

This slide gives an overview of one of the marquee features that the Solutions Centers provides, which is the no cost expert policy assistance, known as Ask an Expert. The Ask an Expert program has established a broad team of over 40 experts from around the globe who are available to provide remote policy of advice and analysis to all countries at no cost. For example, in the area of energy forecasting, we are very pleased to have _____ Casita, a project manager with Inner Data service as one of our experts. If you have a need for policy assistance and energy forecasting or any other clean energy sector, we do encourage you to use this valuable service Again, the assistance is provided to you free of charge. If you have a question for our experts, please go to cleanenergysolutions.org/expert and you can submit it through the

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simple online form there. We also encourage you to spread the word about this to those in your network and organizations that may be able to take advantage of this service.

Now, I would like to provide brief introductions for todays' distinguished panelists. Our first speaker is Dr. Manfred Hafner, who is a partner and Vice President of Consulting with Enerdata. He is a recognized expert on energy scenario building, supply/demand assessment, energy policy analysis, marketing strategy studies on all energy sources, and with a special focus on gas and power markets.

Then our second speaker that we will be hearing from is Yasmine Arsalane. Yasmine is the Project Manager in Global Energy Forecasting with Enerdata. She specializes in the modeling of energy marks as a senior analyst. With that, I would like to now go ahead and turn things over to Manfred.

Manfred Hafner Thank you very much. Here were in the number. We will start our presentation on energy scenarios to 2040. The subject will be _____ is what it takes to reach the INDC's and in particular to go beyond the INDC's to reach the one and a half or two degrees Centigrade, increase of temperature above the preindustrial levels which have been addressed at the COP 21 in Paris the end of last year.

Just one word about Enerdata, the company which did this analysis. Enerdata is an independent energy research and consulting company, which has been around for 25 years now. It specialized in analysis and forecasting of global energy and climate issues. It has a global reach. The clients are global, located in Europe, Asia, and the America's, and in Africa.

Today's workshop, webinar will start with a small introduction about the methodology of our assessment and our scenario overview. Then we will present the two main scenarios, which we have developed. One is called the Ener-Blue scenario, which is based on the INDC's and the other one which we call the Ener-Green scenarios, which limits the temperature increase at a maximum of about two degrees Centigrade above the preindustrial levels. Then we will address supply issues of the three scenarios because we have a third one, which is going to be presented shortly. The new are going to make focuses, one on China, and one on Europe. I give now the floor to Yasmine, who will start with the presentation.

Yasmine Arsalane Thank you. First, I will address the question of our scenarios and how we make them here at the Enerdata. Every year, we publish what we call our Ener-future scenarios to describe possible visions of energy market futures for the next 25 years. How we do that, our methodologies to explore alternative assumptions for key drivers such as resources, climate and energy policies, and available technological options. These key drivers will shape our energy future. What if resources are more abundant than we think now or what if the opposite and we are facing a scarcity of resources? The point of exploring this assumption is to try and better understand our energy future, and deal with uncertainties around three main questions.

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The first one, being what are going to be energy needs in 2040. At the global level, that is also regional dynamics. We want also to know what will be the energy mix and also the question of efficiency of this demand.

The second question we want to answer concerning our energy future is the supply. How can we provide for this increasing need that we are going to face in 2040? Will there be enough energy available? At what cost? What are going to be the trade patterns? What are the bills for the end user consumer?

The third question we want to address is the sustainability of those visions for our future. The sustainability can be about climate questions, but also energy security. We explored these alternative assumptions with however identical macroeconomic assumptions such as population, and GDP growth, which are identical across our scenarios.

With these questions and uncertainties, they led us to explore three main possible visions for the next 25 years concerning energy future. First of all, what we call our Ener-Blue scenario, which is based on the assumption that national targets decided at the COP 21 last December are achieved in 2030, but no further climate action is taken after that. The growth in CO2 emission continue, but is slowed down by this national policies taken at COP 21. This is not enough, however. Temperature increase at the end of the century is still about three or four degrees centigrade.

Concerning demand, this scenario is based on an increase in developing countries of the demand. That is in OECD countries. INDC's policies allow us to stabilize this demand. In the end, for answering the supply question of the scenario, the increase in demand at the global level apply tensions on available resources. So this leads to increasing energy prices and because of that, we diversify towards other sources of energy, such as renewables, which becomes less and less costly.

Then we wanted to address the question what if we go further with those national targets decided at the INDC? What if we commit ourselves to really ambitious climate policy to prevent the temperature increase to go above two degrees centigrade at the end of the century? This would need reinforcements of the climate policy. That is the INDC's decided at the COP 21 to be regularly reviewed every five years to be sure that they are still in line with the final target of two degrees. This would mean in terms of denying that, we would stabilize our energy needs. This would imply importance and ambitious efficiency policies and those targets would be regularly updated.

Concerning energy supply and prices, we have made the assumption in the scenario that there is a phase out of fossil fuels subsidies and also the development of renewables is really strong in this scenario, since there are really less and less costly and more and more competitive compared to fossil fuel energy sources, which are penalized by climate policies. For the _____ this would mean that the price of energy would increase because of this climate and energy and policy constraints.

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Our third scenario, our third vision, for the next 25 years would be Ener-Brown scenario, which is a completely different world where we explored the possibility that resources for fossil fuel are really more other than with us. They are also less costly. Under development is less costly than we thought. There is a really huge renaissance of fossils fuels in this scenario. This scenario concerning and energy policies, INDC's targets are not reached. Climate is not the priority in governments in this scenario. This results in soaring GHG emission. In the end, this could lead to a temperature increase unsustainable, which is like five or six degrees at the end of the century.

Concerning demand, I think there are only a few climate policy and energy policies. The energy intensity is only improved a little. We face, in this scenario, a high growth of energy, especially in developing countries. In these scenarios, concerning supply, since resources are really abundant, energy price is really low. This is why energy demand growth is so strong. There is, although a small effort on renewables, which still develops on these scenarios.

In this slide, we can see how those scenarios are contrasted, concerning key outputs of our energy future. First, primary demand, we see that this absence of climate policy combined with low fossil fuel prices would results in a soaring energy demand in our scenario Ener-Brown. In our scenario Ener-Blue, those climate policies and energy policies are not sufficient enough to prevent the increase of energy demand. It is only in our ambitious climate policy scenario, Ener-Green, that the demands are realized.

We also see some common features between those scenarios. For instance, if we look at energy intensity, we see that there is improvement of the amount of energy used per unit of GDP in all scenarios. However, the difference in the scenario would still be important at the global level.

Another common feature is the share of fossil fuel in energy mix, which decreases in all three scenarios. We are, at the moment, at around 80 percent of fossil fuels in the energy mix. We will reach 75 percent in Ener-Brown, 70 percent in Ener-Blue, and there will be a real effort in Ener-Green, in which we will reach 50 percent. Only half of the demand would be considered as fossil fuel.

Those three drivers will have a huge impact on emission levels. We see that there is unsustainable path concerning CO2 emission in our Ener-Brown scenarios, a stabilization thanks to INDC's in our Ener-Blue scenarios, and there is still a huge gap to fill to reach the two degree, which is Ener-Green.

In the following slide, I will focus on our essential scenario, Ener-Blue, which is based on the INDC target achievements. First of all, what is driving energy demand? What we see here is that the population will increase in the following 25 years. We will reach nine billion inhabitants in 2040, which is almost two billion more than today. Also, the economy will continue to grow at a very significant pace, especially in non-OECD countries. In non-OECD countries, we almost see a fourfold increase of GDP as compared to 2010.

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This would mean that in 2040, the GDP would be three times higher than in 2010 at the global level.

As the world grows, we need more energy to fuel this level of activity. This is why with no surprise, there is a growth in energy demands in this scenario. It's mainly led by non-OECD countries since their growth is more significant than OECD countries. However, we can see that we have an improvement. We are more efficient in this energy demand. Energy demand grew at a slower pace than GDP growth. We are more efficient.

Here we can see how originally, the original dynamics for this energy demand growth. We can see that between 2014 and 2040, we would need four more billion tons of _____ equivalents to fuel the higher energy, higher economic growth. What we can see also is that China is one of the biggest markets today. It will remain the biggest market tomorrow. It will also be the highest growth in energy demand. Out of the four billion _____ equivalents more than half will be necessary only for China.

Now, we can a view of what fuels are necessary to provide for these increasing needs. On the left hand side, we can see demand in OECD countries in our scenario Ener-Blue, whereas on the right hand side, this is non-OECD countries. What is striking here is the difference in dynamic again. The demand stabilized in OECD countries where we face a real boom in energy demand in OECD countries as explained earlier because of the difference in activity growth in those regions of the world.

Concerning fuels, that are needed in these two regions, with more important climate and energy targets in OECD countries, we can see that we need less oil, less coal, whereas gas increases a little bit, its market share. These are progressively replaced by non-carbon fuels. In non-OECD countries, we can see that there an increase in energy fuels, especially in gas, which we will see increasing a lot for the next 25 years.

In both regions, we see an important increase in renewables, which is helped by their decreasing costs. This helps a lot to gain an increase in their market shares. At the end of the simulation period 20140, we can see that in both regions the share of fossil fuels is less important than today.

These policies that countries committed in COP 21 are very different across regions. We can see that the United States committed to reduce around 28 percent by 2025, as compared to 2005. Whereas China described its target at carbon intensity, meaning as a quantity reduction in the quantity of emission as compared to their GDP. This is really difficult to compare countries when they provide targets that are not based on the same indicator. What we try to do is to compare these countries based on the same indicator. We translated those commitments a reduction efforts in terms of CO2 intensity of GDP, which is the ratio of CO2 emissions to GDP here excluding land use change and forestry.

We recalculated them as compared to 1990 to have the same indicator as compared to the same base year, which was not the case in the original

commitment. This allows us to see which are the countries that committed to the most important efforts concerning this indicator. What we see here is that for instance, this would mean for Europe, a decrease of 63 percent, whereas for the U.S. 70 percent. China is really more ambitious than countries as compared to 1990 with a target of 75 percent. The darker the color, the more ambitious is the country. We can see that Brazil would only stabilize its CO2 intensity in 2030, as compared to 1990.

How would they achieve these targets? One of the key factors would be to become more efficient. We can see in this graph, that non-OECD energy intensity would converge towards OECD energy intensity and this would imply that less energy is consumed for the same amount of GDP. What is also interesting in this graph is that china, which has a huge energy intensity at the moment, would converge towards United States levels at the 2040 horizon timeframe. This is possible because non-OECD countries have huge potential for reducing their intensity and become more and more efficient, whereas OECD countries have already made some important efforts in the past.

Here we can see that between 2010 and 2030, two groups of countries behaved very differently. What we see here is that how the emissions per capita evolves when we increase the wealth of a country, which is represented by the GDP per capita. For extent, we can see that between 2010 and 2030 as GDP of EU-28 increase. They reduced the amount of CO2 per capita. This group of developed countries emit less and less as they become richer and richer. Whereas developing countries see their emissions per capita increasing while, their wealth increases. What we can see is that the possible evolution of this country as they become richer and richer is first a development that led to increase of emissions then the a decrees of emissions when they become as rick as developed countries.

At the world level, there is an increase of wealth that is no increase of CO2 per capita at the world level. However, if stabilization of CO2 emissions per capita is not enough to cope with the global climate challenge of limiting the temperature increase to two degrees only, which is what we are going to see in the next few slides. We see here the stabilization in the Ener-Blue scenarios of the global GHG emissions. We see that they are more or less in line with INDC commitment for 2030. What we can see is that there is still a huge gap. That it will require huge efforts in climate policy to get compatible with this two degree target.

This huge gap would be mainly filled by a non-OECD countries efforts. We can see that it will require a huge reduction and only a third will come from OECD countries, only a third. China will represent a third, a well, of the global additional efforts that would be needed to reach this two-degree objective. Whereas Europe only represents five percent of these efforts. Then we can compare how the energy mix would be in 2030 and 2040 in those two scenarios.

First of all, what we can see is that the global level of demand is reduced in the Ener-Green scenarios as compared to Ener-Blue. In 2014, we will globally have energy demand of 40 billion tons of oil equivalent in Ener-

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Green compared to 17 in Ener-Blue. There is this difference of levels that is not only what we can see in those graphs is that fossil fuels would still represent a huge part of the energy mix in 2040 in Ener-Blue scenario, almost three quarters of the energy demand. Whereas in Ener-Green scenario, it will represent only half of the total mix in 2040. There is a huge decrease of fossil fuels in this two degree scenario.

The second thing is that they would be mainly replaced by renewables, which would represent almost 40 percent of the energy mix in 2040. The third thing I see interesting in this slide is that among fossil fuels, coal would be the few that would be the most impacted by carbon policies. This is especially the case in the power sector, for instance. What we see in life is the market share of coal in power generation today. About 40 percent of the power production today is generated from coal. With the development of climate policy and ambitious targets concerning climate, this would be reduced to only 13 percent. We can see the huge difference, especially in South Africa and, of course, China, and India.

Now, we can see which sectors would be concerned with the reduction of emissions. So here is the final demand by sector in Ener-Blue and here in Ener-Green scenarios. We would need to reduce the energy demand by 24 percent at the concerning final demand. All sectors would need to make an effort that especially industry which would need to reduce and would represent 43 percent of this decrease between Ener-Blue and Ener-Green. Also, interesting would be the increasing share of power in final demand, which will help reduce the carbon content of the final demand. In both scenarios, this share increases, but the level reach in the two degree scenario is much higher.

Now, comes the questions of the costs. This climate policy would need to imply important efforts and these efforts and investments are costly. We presented here, the cost in both scenarios, divided in three main costs. Cost linked to CO2 reduction investment costs, costs linked to energy efficiency, costs linked to renewable, and also to infrastructure in the power sector.

We also wanted to show that energy consumption involves costs linked to the supply and imports are deal is also something that should be taken into account when exploring those goals. So what we can see here is that of course, there is a huge difference between Ener-Blue and Ener-Green scenarios in 2040. The abatement cost could represent 3.5 percent of GDP for the 2030-2040 period in Ener-Green, which is significantly higher than the 0.5 of Ener-Blue, but it could be utterly compensated by a reduction of the import deal with the decrease of demand involved with climate policy. There is a reduction of primary energy expenses in Ener-Green as compared to Ener-Brown. This could not compensate completely the CO2 costs, but we didn't show all of the beneficial advantages of reducing CO2 emissions such as the reduction in pollution and environmental advantages.

Now, I will hand things over to Manfred with the focus now on supply.

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Manfred Hafner Thank you, Yasmine. From this line, we can see again the three scenarios, the overview of the three scenarios both worldwide, so demand, and supply. The first thing we can see is what Yasmine already mentioned. There is an increase of energy demand in Ener-Blue while Ener-Green scenario reaches a certain stabilization of demand over the next decade. The other side, Ener-Brown, which is the scenario based the _____ available of the chief fossil fuels. We see strong increase in demand, which is much higher than the one in Ener-Blue.

When we look at the fuel mix inside these different scenarios, we realize that while today, about 80 percent of the total fuel mix is based on fossil fuels. This is expected to reduce to 70 percent in 2040 in the Ener-Blue scenario. It is expected to increase about 75, 76 percent in the Ener-Brown scenario. It is expected to half, to reduce by 50 percent in the Ener-Green scenario.

The low carbon energy mix, which is both nuclear and renewables, which is about 16 percent today. It will reach by 2040 about one quarter of the mix in the Ener-Brown scenario, one third of the mix in the Ener-Blue scenario, and one-half of the mix in the Ener-Green scenario. The Ener-Green scenario is the only scenario where fossil fuels reduce significantly also in absolute terms a reduction of about 40 percent compared to today and the largest reduction is based on coal.

Now, here we see the picture on oil. We can see that while today's oil demand worldwide is about 88 million barrels a day, this should slightly increase and then stabilize in the Ener-Blue scenario to reach a level of about 100 million barrels a day. It is expected to rapidly strongly increase in the Ener-Brown scenario. You can see here, to reach a level 110 or slightly above million barrels a day. This is, by the way, a scenario, which is close to the one published by BP in its outlook of January of this year. It is close to how the industry sees the development in its most likely scenario. On the other side, we know and we see here that in the case of a constraint scenario, our Ener-Green scenario, we will see likely a strong decrease by about 25, 27 percent of oil demand over the next two decades and a half by 2040, which is here.

Now, when we look at the composition of the production worldwide, we realize we can look at the graph on the lower right, the bottom right. We can realize that the Saudi Arabia will in the Ener-Blue scenario where demand and production stays overall more or less constant from 2020 onwards. We have an increase on supply from Saudi Arabia. At the same time, a decrease of supply by the U.S.A., due to the fact in the U.S.A., that the strong increase in the type oil development is not really sustainable over the very long _____ We also see a slight reduction in oil supply from Russia because of the very high oil production today. The limited reserves and therefore are not being able to increase even further its production potential.

On the other side, we can see an increase in, quite significant increase percentagewise at least in the production of oil in China, as well as the Middle East in General and I would like to point out obviously Iraq and Iran, which is now coming on the market again.

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Fundamentally, as far as demand is concerned, it's quite interesting to note that China becomes the biggest oil consumer around 2020 followed by the U.S. and India. Presently, the U.S. is the number one oil consumer. Now, we move to natural gas. The natural gas picture is somewhat similar even though more bullish for gas than for oil. We see that even in the Ener-Blue scenario, we have an increase, a relatively strong increase, plus 25 percent on gas, more of gas consumption, which should increase from a normal level of 3,500 billion cubic meters to 4,500 in the Ener-Blue scenario. It will be even stronger in the Ener-Brown scenario with an increase, a global increase of about 50 percent. And of course, in the Ener-Green scenario, which after having constraints from the coal, oil, also needs to constrain gas, which is the most benign fossil fuels as far as climate is concerned. Even gas in this scenario will need to reduce by about 25 percent compared to today. There are about seven countries. This is quite interesting. Seven countries which concentrate 60 percent of the global production, these seven countries we can see them here on the lower right hand side of the graph.

Today as we know, the U.S. is the largest gas producer, followed by Russia. It used to be the other way around, but thanks to the U.S. _____, the U.S. has over the last few years overtaken Russia. Now, over the longer run, we see Russia to have, obviously, a higher potential because of the huge gas resources in Russia or the huge conventional gas resources of Russia. But both the U.S. and Russia will represent about a third of noble gas production worldwide. Then we can see an increase of gas production in Iran, as well as in China. While Canada and some other countries will use global gas reduction.

Now, this is the graph, which shows the global coal production. It is quite interesting to notice that there was a huge increase over the last decade and a half up to very recently. Now we expect a stabilization of the coal demand and supply over the next few decades in our Ener-Blue scenario. Now this huge increase was based over the last decade and a half, was based mainly on the explosion of gas, coal demand and production in China, which represented about 80 percent of this increase, this global increase, from 3,000 million tons of coal equivalent in 2000 to 7,000 today. Eighty percent of this comes from China, which is part of this green part here.

Then, it's quite interesting to see that yes, in the Ener-Brown scenario, coal demand and production is expected to increase slightly. In the Ener-Blue scenario, it is not expected to decrease strongly. It is expected to stabilize. This is due to the fact that China, which is responsible today of about 50 percent of the total coal demand, the INDC's, which China has put forward, do not force China to strongly reduce coal demand in the INDC scenario which is our Ener-Blue scenario.

Now, when we look at the Ener-Green scenario, which is the one which limits the temperature increase at about two degree maximum, we see that coal demand needs to reduce very strongly worldwide and in particular also in China, which has _____ _____ coal demand today. So the Chinese coal demand represents today a 3.4 million tons of coal equivalent. In the Ener-

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Green scenario, it will reduce by half to about 1.7 billion tons of coal equivalent. Also, the supply in China will renew very strongly by about 70 percent, 67 percent, or reduction. So the picture as far as coal is concerned is obviously a picture where we can remember that coal is China and China is coal. Whatever happens in China, this will terribly affect international coal markets.

Nuclear is expected to increase its installed capacity in all scenarios, even in our Ener-Blue scenario or our Ener-Brown scenario, installed capacity of nuclear power plants worldwide is expected to double, almost double, in the Ener-Brown scenario, double in the Ener-Blue scenario, and be multiplied by a factor of 2.5 in the Ener-Green scenario. The Ener-Green scenario being a low carbon fossil fuels scenario, so no carbon energy scenario. Fundamentally, as far as supply, policies are concerned, needs to strongly pursue both a renewable energies and nuclear energy.

Where is this strong increase in nuclear power plant development happening and supposed to happen in the future in all of these scenarios? Well, it's China, which we represent about 22 percent of total addition by 2040. It will have gone in India, Russia, and the Middle East.

While in other OECD countries, overall as a whole, the share and the total installed capacity will remain constant, except countries like Germany, which will phase out, which are phasing out. Their nuclear reactor raising capacities. Overall, it will remain about constant.

Now, let us start with renewables. The renewables is stored capacities will explode over the next decade in all scenarios. Globally, and this is quite interesting to note this. Globally, over the last few years, renewable energy sources have already represented almost half of the total power generation capacity additions on the worldwide level.

Though this almost half, 45 percent of total additions, one third was coming from hydro, additional hydro plants, mainly in developing countries in China. One third was from wind, and one third from solar over the last two years. Forty percent of all of this additional renewable energy capacity addition over the last few years have been gained in China, followed by Europe, and the United States of America.

Now, the outlook is that the OECD countries will overall as a whole will not see any more net expansion of fossil fuel _____ in capacity. While renewable energy sources are expected to be built mainly very strongly -why the OECD countries are mainly being built based on the renewable energy sources and the other side, the non-OECD countries, we need to base their development, which is increasing very strongly overall, both on fossil fuel , oil generation and renewable energy sources.

Now on the upper part of this graph, we see wind installed capacities. You can see the huge increase globally of this capacity expected over the next two decades and a half. The Ener-Blue scenario, it will be multiplied by a factor of six, increased from 400 gigawatts today to 1,900 gigawatts. The Ener-

Green scenario, it will develop much stronger and in the Ener-Brown scenario, it will develop slightly less, but not that much less than in the Ener-Blue scenario.

As far as solar is concerned, we see a very similar outcomes, but due to the fact that solar technologists are less advanced in their technological _____ the increase of penetration will be even stronger percentage wise for solar than for wind. China represents more than 40 percent of the total wind installed capacity and more than 30 percent of the total solar installed capacity respected. China is the big player here as well again.

So let's have a small focus on China since we have seen that China is so important. China as we explained earlier on, in order to reduce their emission to respect what they have promised to respect in Paris at the COP 21, which is to follow and complete their INDC's, which is our Ener-Blue scenarios , which sees the surface _____ of emissions. It will need to make certain efforts compared to what they would do in the Ener-Brown scenario. Then let's see what it would take them to reduce their emissions to a scenario, which is conductible to the two degrees centigrade scenario. Our Ener-Green scenario, and here on the right hand of the graph we can see that this huge effort will be based mainly on power generation and the industry, both of which are mainly based today on coal. A huge degrease of coal demand.

When we look at the power generation installed capacity additions over the last decade and a half, over the next few years, up to 2020 and then the next decade, we can see quite an interesting pattern that in the past, this decade, the fossil fuels base, in particular coal based power generation plants were the ones which were booed most in China. We also see that over the present decade, in the second half of the present decade, that we see now renewables to be installed very strongly as we mentioned earlier, but the most interesting part is that over the next decade, according to also to the plants, which are the governmental plants of China. Yes, it will still continue to build coal power plants, but much less than they use to build over the last decades. Overall, the renewable additions we will represent it almost twice as much as the fossil fuel and in particular the coal power plants.

A very important switch in policy more so in China, as far as our generation is concerned. The targets, the official targets in China by 2020 of 200 gigawatts of wind installed, and 100 gigabits of solar installed, and about 85 gigawatts of nuclear installed. Huge additions whether China is really on track to meet its targets. Very impressive.

Now let's have a last regional focus on the European Union. The European Union has target to decrease it's greenhouse gases compared to 1990 by 2020 by 20 percent. This, as we can see, even in the Ener-Brown scenario, it is already happening. This is fueled by the fact that a lot of things have already been implemented. Europe has spent a lot of money. It has developed strong quantities to instrument to implement renewable energy sources, as well as to promote energy efficiency. But, a very important element has also been the economic crisis in Europe, which has meant that GDP and therefore industry

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output and _____ demand was very strongly reduced. Consequently, the reduction of greenhouse gases was made much easier.

Now, in order to reach the 2040 reduction compared to 1990 by 2030, compared to 1990, we need to implement this Ener-Blue scenario, which Europe has committed. This means strong continued strong policies, as far as energy demand reduction. Therefore, energy efficiency, as well as renewable energy, which are the two components on which Europe basically ____ policies for reduction of CO2 emissions right now.

Now, if we want to go further to the Ener-Green scenario, from the Ener-Blue to the Ener-Green scenarios, we realize we need the much larger spectrum of measures and instruments, yes. Energy demand and renewables are still responsible for the _____ of the measures, but there are many others, which come into play at that stage. Even here, it is quite interested to realize that once the Ener-Blue scenario has been implemented to go to Ener-Green, the demand for that shifts. The marginal cost curves to make additional reductions of CO2 based on energy efficiency would become increasingly expensive. Therefore, renewables and many other measures, which right now are _____ expenses will be become, will make more sense to be implemented, which will need to be implemented in order to reach the Ener-Green scenario.

Now, I am coming to my end to end. This is my last slide before the conclusions. Here, what we see is when we look at the right part of the slide, we can see that today in Europe, the fossil fuel based _____ costs are much lower than the wind offshore, than solar, and then renewable energy sources. With a little exception of wind onshore, which provided wind conditions are good, is already able to compete with gas, as well as with coal. This implies the present policy environment in Europe with the COP in Paris.

When we look at the future, 2020 and 2030, where_____ progressively be eliminated, but they will be replaced by a carbon value. This carbon value, which is a carbon tax or a carbon market, which will need to be added to the electricity price. In our Ener-Green scenario, in order to reduce the risk from the emissions, this carbon value needs to reach very important levels and therefore, the fossil fuel energy sources and in particular coal, will progressively become very expensive and the gas will become more expensive as well. At the same time, we will continue to see relatively strong decrease of the renewable energy sources _____ as we have seen in the past due to the learning curve, which we will continue play its role.

Over time, due to very high carbon values in the Ener-Green scenario, we can see a very strong reduction, the phasing out of the coal generation and the very strong increase of wind generation, of solar generation, of other renewable generation biomass, and nuclear will in 2040 have a similar level as it has today.

My very last slide refers to the conclusions. The upper part I am not going to read that again. You can read it yourself. You should have understood it by now, the definition of our three scenarios. Just to summarize the main

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conclusions in the Ener-Blue scenario, while demand will still increase, this increase will happen in non-OECD countries. The increases are relatively important, overall 30 percent and non-OECD countries 50 percent. The demand will stabilize in the Ener-Green scenario, while in the Ener-Brown scenario, it will increase much more strongly than the Ener-Blue scenario.

As far as the energy mix transformation is concerned, I will remind that today fossil fuels represent about 80 percent of the fuel mix. This will be reduced to 70 percent in the Ener-Blue scenario by 2040. It will reduce, but still reduce in the Ener-Brown scenario and need to be reduced very strongly to 50 percent in the Ener-Green scenario, which also means that in the Ener-Green scenario by 2040, we still have 50 percent of fossil fuel based energy mix, which just shows the huge inertia of the energy systems.

The renewable energy sources share will reach a level of more than 20 percent by 2040 in the Ener-Blue scenario, while we look at the mix of energy of renewable energy and nuclear in the Ener-Green scenario. This represents 70 percent of power generation capacity, power generation output in 2040. It is quite interesting to see that in the Ener-Brown scenario, of the 75 percent which is still fossil based, 40 percent of this will be based on natural gas, no, 40 percent of the natural gas supply will count on the shale gas supplies which are expected in this scenario to develop and be exported from the U.S. in many regions.

We will have greenhouse gas emission stabilization in the Ener-Blue scenario. It will reduce by half in Ener-Green scenario. It will continue to increase in the Ener-Brown scenario. The Ener-Green scenario reduction will be mainly based on non-OECD countries because it is those who increase their energy demand the most. Also because OECD countries have already done a lot in their energy decarbonization part.

Finally, the cost, the shift from Ener-Blue to Ener-Green will unfortunate, not count for free as Yasmine has told us. The CO2 shadow price, the value of carbon which is needed to move the energy system from the Ener-Blue scenario to the Ener-Green scenario will need to reach a level of €400 to €500 per pound of CO2 equivalent or per ton of CO2 equivalent, which is very high. This is a shadow price, which is not necessarily what you will see. This includes also going back on the regulation part of this, our last part of this policy that can be implemented through regulation. Therefore, we aren't going to see this price, but still it is a cost to society.

This just means and I will end with this, that of course, we think and we need to move from the Ener-Blue scenario to the Ener-Green scenario. This will be costly, but the benefits, overall macroeconomic benefits might overplay and especially the climate benefits will for sure overplay the costs, but in order for this to happen, we continue to need very strong political support and the strong policy measures and instruments to make this scenario happen. Otherwise, it will not happen. We might even risk to see an Ener-Brown scenario with a non-sustainable temperature increase of five to six degrees Centigrade. With this, I thank you very much. Yasmine and I, we continue to be here to respond to your questions.

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Sean Esterly Great, thank you so much, Manfred and Yasmine for the presentation. We do have about 15 minutes for questions. We will go ahead and move right into those. Just a reminder of the audience, if you have any questions for the panelists, you can submit those through the question pane. I am going to start with the earliest ones we received and just work our way through. This question is for everybody, both of the panelists. Is CCS clean carbon storage included in greenhouse gas emissions results?

Manfred Hafner Can you hear us?

Sean Esterly Yes, we can.

Yasmine Arsalane Okay, so how about CCS. We included the technology call options in our scenarios, but we don't see a strong development of this technology until 2035, which is almost the time frame of our simulation. We think at the 2050 maybe horizon at the world level, we would reach a maximum CCS capacity of 1,000 gigawatts, which is really a small, small amount of capacities as compared to the necessary power needs at the world level.

Sean Esterly Great, thank you. Again, this question is for both of you. What are some reasons that the INDC goals may not be reached in the Brown scenario?

Manfred Hafner The reason today we see that very low energy prices globally, very low oil prices in this Brown scenario. The assumption has been made that this low oil price environment and therefore gas price environment and coal price environments, we continue for relatively long period, which makes the implementation of the Blue type of scenario, the INDC's, which makes implementation of energy efficiency, or renewable energy much more expensive, obviously. There is a risk that if the present low price environment is not the counterbalance that was proper climate policies, that countries will not be able to implement them. In that case, we might end up with an Ener-Brown type of scenario.

Sean Esterly Thank you, Manfred. Can you explain a bit a more what primary energy expenses are? I believe it was on a couple of slides. Just the cost of procuring gas and coal supply?

Yasmine Arsalane Yes, this the cost linked with the fact that not all countries are provided with important resources. Therefore, need to resort to imports. These imports are linked with an import price, which is set at the international level or regional. In those scenarios, we considered that those expenses would be much higher in the case of not ambitious climate policy because we would need to resort to more imports since the demand is higher. This is what we meant with the primary energy imports bill.

Sean Esterly Thank you, Yasmine. This one is a little more specific. It has a country question. They noticed that on the biggest producers' projections, they are wondering if you expect Argentina's large shale gas reserves to be developed by 2040.

Manfred Hafner Yes.

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Sean Esterly Very good, excellent. Next question, what do you think of minimum energy performance standards as policy measures to encourage efficient product penetration in emerging markets, thus encouraging energy demand reduction? How could this policy measure be best promoted?

Yasmine Arsalane Can you please repeat the question?

Sean Esterly Yeah, definitely. What are your opinions on minimum energy performance standards as policy measures to encourage efficient product penetration in emerging markets and thus encouraging energy demand reductions?

Manfred Hafner So these are good instruments, but in emerging markets, you might need to use also very targeted policies to drive renewable energy resources. In this market, _____ might be very often better tool to promote renewable energy sources.

Sean Esterly Thank you, Manfred. Since most INDC's end in 2030, what were your assumptions through 2040, a continuation of the trend?

Yasmine Arsalane Yes, absolutely, we based the projection after 2030 based on the UNFCCC trajectory they provided. The RCP's, the representative carbon pathway, which provide some elements about the reduction needed to reach the two degree targets and these representative carbon pathway are split between different regions of the world, which helps defining from which countries the effort should come.

Sean Esterly Thank you, Yasmine. This next question is more of a clarification on the different scenarios. It asks of the Ener-Green scenario is the only one that leads to temperature elevation stabilization. All of the other scenarios lead to temperature increase averaged by 2,100, but still not stabilized. Is that correct?

Yasmine Arsalane Yes, absolutely.

Sean Esterly So in other words the temperature would continue to increase?

Yasmine Arsalane Yeah, the point was to explore a world where only INDC's were reaching 2030. We wanted to explore the possibility of what would happen to the climate if only those targets committed for 2030 happened and the answer is that it would lead to an increase of temperature. And only establishment of emissions. We need to move to more stringent climate policy than those INDC to fill the gap with the United Nations targets for the end of the century.

Sean Esterly Great, thank you. Did you include land use, land use change in forestry emissions in your comparisons for emissions reduction? If so, why or why not?

Yasmine Arsalane We didn't include them because our scenarios are based on an energy model. We are not specialists of the land use change related engines. We couldn't include them in our projections. However, when we recalculated the target,

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the INDC commitments, we took this account. For instance, Brazil committed to reduce its emission by, if I remember well, 43 percent against the baseline. These 43 percent included reductions made by land use change and forestry. When we wanted to know what was the target of Brazil concerning energy related emission, we came to the conclusion that it would result on a small increase or a stabilization of energy related engine. At some point, we took that into account in our analysis.

Sean Esterly Thank you again, Yasmine. Moving on to the next question, how did you allocate the additional carbon reductions in the various regions?

Yasmine Arsalane I think I already provided some elements. It was the first trends provided by the commitments in 2025 or 2030 of the INDC's. That is also the representative carbon pathway of the UNFCCC, which provides and that gets indicative splits by region. We used that, but not also we tried to look at some comparison indicators such as the level of emission per capita, the level of emission by unit of GDP and tried to make a fair repartition of the remaining emissions reduction.

Sean Esterly Thank you, was hydropower included in the modeling of renewables?

Yasmine Arsalane Yes, of course.

Sean Esterly Next question is asking if you think the 400 E.U. per ton of CO2 is realistic? There is static vision today, but there are many changes that may appear before reaching that shadow price level. What are your thoughts on that?

Manfred Hafner When you go back, if you go back ten years or 20 years, let's go back ten years, the projections we had ten years ago and the reality of the energy systems we have today is completely different. We are no longer in business as usual world. This has already changed. Why has it changed? Because we had many, many policies which regulations, which have forced our energy systems already now to change. Having said that, we do not see today, any carbon price of any significant value, but the shadow carbon price is already very important because this is the shadow carbon price is the cost, the implicit cost of the policies transferred into a carbon value price to drive these policies. So since all of this, most of that been done with regulation.

Now, it is difficult to model regulation for the next decades. What we have decided to do is not to model regulation, but to drive our scenario with a shadow carbon prison, part of which will be based on regulation. Part of which will be a real carbon value, which we see. We need to very well understand the meaning of this shadow carbon price. It is people get afraid about it. it is something which when you have a policy, the end, the total cost of society might be higher than having used a pure market approach, but you don't see the cost, first thing.

Second thing, we are not advocating to you to have these very high explicit carbon prices. Simply because we do not necessarily think that the market will be able to do everything by its own. We need to continue to have regulation. We need to have a double system, a system which will be based

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on both policies and regulation on the one hand side, and on market mechanisms on the other side. But then what we have mentioned is $400.00 to $500.00 or Euros ton of CO2 emissions by 2040. This is a total cost for the Ener-Green scenario of both of these set of measures. So yes, if we want to reach an Ener-Green scenario, this is what we need, but this is not what we will see because of the regulation part.

Sean Esterly Thank you, Manfred. We have time for maybe one or two more questions. This next one asks what will be the role of transport technologies in alleviating emissions such as electric cars, national gas, biofuels, hydrogen. Will oil still dominate the transport sector in the long run?

Yasmine Arsalane Yes, transport sector is one of the sectors, which is one of the most difficult to decarbonize. Liquid fuels alternatives are difficult to develop. However, in our Ener-Green scenarios, we do see the high penetration of alternatives such as electric vehicle, hydrogen, and also based on biomass liquid fuels. This is options that we did take into account in our scenarios.

Sean Esterly Thank you, Yasmine, one more question. It's a big question, but I will have to ask for a brief as a response as you can provide. What advice would you recommend for developing countries as energy emerging markets to full plug into the scenario so they are not caught off guard?

Manfred Hafner Sorry, I did not catch your second part of the question.

Sean Esterly Yeah, what advice would you recommend for developing countries as an energy emerging market to fully plug into the scenarios? These projected scenarios?

Manfred Hafner Well, the first advice I would give them is to reduce energy subsidies. I have an echo. Can you hear me properly?

Sean Esterly Yes, we can, yeah.

Manfred Hafner Okay, developing countries have subsidized energy prices, which is completely non-economic. The reason why-it's also not useful. It's non-economic because very low energy prices, in particularly when they are subsidized, by countries which are poor, which do not have the means to subsidize them, is that the low prices, they just mean higher demand over time. So we need to increase prices. We are not advocating to have high-energy prices for the very poor. What we are against is having subsidies, what we call universal subsidies, which are the subsidies, which are normally implemented in all developing countries. What we need to have is targeted subsidies for the poor.

Right now, the way we have the subsidies today, they benefit mainly the well off and the rich because it is only the well off and the rich who can afford more energy consumption equipment and therefore consume more. The poor, they cannot even afford the equipment. We need to move from universal subsidies to targeted subsidies. This would be much cheaper for the countries. I would just like to remind that for instance in the _____ region, North Africa,

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Middle East, subsidies are very high and for instance in Egypt, just to give you an example, or Jordan, in 2015, with the energy prices already reduced, the oil prices are already reduced, it was even higher before, this subsidies represented about ten percent of GDP, a huge amount. The country cannot really afford that. In additional, they are not useful because they subsidize the rich. The problem is how to remove them because it is always the elites, the rich, who make the laws, but this is something which is completely non-efficient.

In addition to that, of course, promote the supply side, the policies, like renewables, but before we address supply side policies, we should start addressing demand side policies. Pricing is a very good thing, but obviously, this is to be complemented with regulatory policies as well.

Sean Esterly

Great, thank you very much, again, to both the panelists, Manfred and Yasmine for addressing those questions and for the presentations. We are almost out of time, so we are going to move right ahead now. If we didn't have time to get to your question, I do apologize, but we will save those and email those to the panelists so they can respond to you in the time following the webinar.

So now, we do have a quick survey for all of our attendees. The first question is displayed on the screen for you. That question is the Webinar contented provided me with useful information and insight. Please respond directly respond directly into the screen there. It will help us evaluate and improve our webinars. The next question is the Webinar's presenters were effective. The third question is overall, the Webinar met my expectations. Then just do a quick yes or no question for you. The first one is do you anticipate using the information presented in this webinar directly in your work and/or organization? The final question for you is do you anticipate applying the information presented to develop or revise policies or programs in your country of focus.

All right, thank you so much for answering our survey. On behalf of the Clean Energy Solutions Center, I would like to extend a thank you to our panelists today and also to our attendees for participating in the webinar. We very much appreciate everyone's time. I do invite everyone to check the Solutions Center website. If you would like to view the slides and listen to a recording of today's presentation, as well as previously held webinars, you will want to go to the training tab on the website and then to the previously held webinars to access today's webinar. We do have the PDF version of the slides posted now. Please allow about one week for the recording to be posted. Also, just a reminder, we are now posting webinar recordings to the Clean Energy Solutions on our YouTube channel. We also invite you to inform your colleagues and those in your network about the Solutions Center Resources and services including the no cost Ask an Expert policy support. With that, I hope everyone has a great rest of the day and we hope to see you again at future Clean Energy Solutions Center events. This concludes our webinar.

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