

MICHAEL LIEBREICH, CHAIRMAN OF THE ADVISORY BOARD, BLOOMBERG NEW ENERGY FINANCE: Thank you very much and (INAUDIBLE) how quickly a year goes. What I'm trying to do is I'm trying to live up to that idea of living in the present and also looking at the future.

We'll start with a little bit of a look at some of the trends (INAUDIBLE) already yesterday and how some of that may play out in the future. And John already got us kicked off yesterday talking about the record level of investment. So that's where I'm going to take as my starting point.

This is investment energy it doesn't include a few big chunks that we also think are important, large hydro, natural gas, nuclear but you can see the trend there. The trend after some years of declining investment now in the last year 20(INAUDIBLE) in the light of some of the other trends in the energy sectors, in particular of course oil price crash.

A year ago it went past very quickly. We have to remember, where were we a year ago? That oil price crash was very recent. We talked about whether there would be a V-shaped recovery or whether it was a new normal, an L-shaped problem. L-shaped outturn.

Now we all know that it's lower for longer. We're in a low cost environment (INAUDIBLE). But did that stop investment in renewables? Absolutely not. And in fact look at it, that there you can see the orange line is actually the capital investment by the oil and gas companies and you can see if anybody's investment stalled you can see it's fossil fuels and not clean energy.

And in fact 2015 first year that the clean energy investment actually outpaced investment by those quoted oil and gas company. And if you look out for the future, projects that are cancelled by the fossil fuel industry don't just add up to a 1-year v-shaped drop in capital investment. These projects have been cancelled or put off; we're talking about in the region of trillions of dollars of investment that has actually been taken out of the pipeline of fossil fuel oil gas company.

Another important comparison, this time from the power sector is renewables investment compared to fossil fuel investment. Power generating side of things. Now this chart looks quite different from when we've looked at it in the past. We've done a lot of work on this. And used much better estimates of what fossil fuel generating costs for instance China and other parts of Asia. What we can see is renewable crossed over earlier than we had thought. In fact if you think of the trends that we were talking about yesterday and that we've seen for the last few years, that's actually not that surprising.

But there you can renewables out-investing fossil in the power system, at the power generating end, at a factor of about 2:1.

Each year it's becoming a tradition, we look at the world record in terms of the price of renewable energy. This one was from January 2016 Morocco. Not a country that a few years ago would have been thought of as a renewable energy powerhouse. Wind unsubsidized at 3¢ US per kilowatt hour. There is no other form of generating capacity that can produce power to build at 3¢ a kilowatt hour.

And solar, this is new news from last week. I had to change the picture from Peru where the price was 4.8¢ per kilowatt. I had a nice picture of Paddington Bear for our British friends in the audience. But I had to change it because just last week the results of the Mexican auction 3.6¢ US per kilowatt hour. The project is going to be built in 2018. There's some time for the costs to come down. But nonetheless extraordinary low cost.

And by the way, in terms of concerns about whether these projects will be built. We've been looking at whether low cost, the auction results that have resulted in such low costs, whether they have been built. And

there is no difference between the delivery of low cost projects over the last few years to projects under (INAUDIBLE) or other arrangement.

So all of this of course was under (INAUDIBLE) it wouldn't be right not for me to show an experience curve or two. There you've got the wind experience curve. We've done so more work on that. Our wind team showing that actually the experience curve is 19%. So for every doubling scale of the industry you get a 19% drop in cost. That's steeper than we had thought. And that's displayed in the price of turbines but also the yield from the turbines.

And solar of course we've known for some long time now has a steep experience curve. Costs are coming down.

One of the things that's been really important around the world though, is how those prices have made it to the end consumer. Because we all know policy matters. And I've already hinted about it. And it's about auctions.

We go back to the year 2000. And what you've got there is red. You'll see countries that have got feed-in tariffs or in a sense fixed prices and in blue market mechanisms. And as we run through year by year from the year 2000 we start to see the march of policy. But a lot of it is red. It's feed-in tariffs where the price are set by the Energy Ministries.

But around 2008 things start to change. It's a great privilege to have Mauricio Tolmasquim (PH) of Brazil, one of the architects of Brazil's reverse auction system launched in 2008. And then that approach marches around the world and you can see auction after auction.

And that matters. You can also see what happens in the year after auctions are introduced into fixed price markets we see a drop of between 15-50% averaging around 35% in the price of renewable energy. That's a sustained drop a few years later. The difference would be around 50%.

Price signals making price one of the key dimensions of competition. Very painful for some of the people in this room but it's absolutely at the heart of the success of the clear energy sector and the revolution that we've witnessed.

But of course renewable energy, clean energy doesn't happen in a vacuum. Last year we talked about the age of plenty. How energy costs are coming down across all forms of energy. Energy supply is becoming abundant. Well, let's take a look at how that has developed.

Natural gas last year it was a fresh development, something we looked at, something I postulated that the gas prices coming down, you see there in green at the bottom. That's the (INAUDIBLE). Then you see Europe in the middle, Asia on the top. The prices have started to come down.

And I postulated that this was a new era. That we'd gone through this period in the middle where you can see the 2007-2010. We saw relatively narrow spreads between Asia, European and US gas prices.

Then that period in the middle where the spread opened up. Very cheap American gas, very expensive Asian gas. And last year I said that we had seen the end of that, compression of prices was what we'd see going forwards. That is the out term in the intervening year. Cheap gas and universally cheap or cheaper gas seems to be a thing. And that's been very painful for some of the players here in the US.

We look here at the solvency, the ratios financial analytical ratios of independent oil and gas producers here in the US. On the vertical scale there you look at the interest cover, the number of times their profits could

cover their interest costs. On the horizontal scale you look at their leverage, their debt as a proportion of their assets. And that's 2008, 2009, 2010, '11, '12, '13, '14, and '15.

And what we've seen 52 companies oil and gas independents in Chapter 11, 69 companies currently being reviewed for downgrades. And it's going to get uglier. Because that surge of new debt, \$234 billion of new debt issued or outstanding at this point, the majority of it is going to need to be, is rolling in the next 4, 5, 6 years or even sooner.

What we're talking about is miscalculation of risk. We're talking about a business model that is predicated on never ending growth. Business model that is predicated on being able to find unlimited supplies of capital from foolish and perhaps greedy investors. But enough about Sam Edison (PH).

But the US oil and gas sector has not stood still and that's critically important to understand. Though we've seen during this period it looks like a wipeout, the rig counts down, the 12% 8-fold reduction in the rig counts in the period 2007-2016. But look at this, that is the output of gas. Extraordinary improvements in productivity. Output per rig up 11-fold during the same period. Now there are timing differences and this analysis is not very sophisticated.

But the message of innovation in unconventional oil and gas is an incredibly important one. And that gas now is moving around the world in ever larger volumes. There you can see new LNG projects coming on line most recently. That's Cheniere's first delivery in a ship called Asia Vision, proving how hard it is to do analysis in the energy sector because that ship was actually bound for Brazil.

But here you can see what's about to happen in LNG. The top few projects at the right are prior to their final investment decision, but nevertheless, surging volume of availability of LNG, which will take those cheap U.S. gas prices and gas prices from the gas powerhouses of Qatar and now Australia and move them around the world. So the age of energy plenty in gas is alive and well and gathering speed.

Let's look at coal. That's OECD coal consumption. It's not just flat. It's lining. New news, coal in China flattening and the only area of the world with growth coal is non OECD Asia. Non OECD non China Asia. Coal is having a torrid time and there's no better way of illustrating this than the story of the U.K. The industrial revolution that started, that was powered by U.K. coal, starting in the 18th century and then to the 19th century, this is the story of coal (inaudible) large. We've got to the point now in the U.K. where our use of coal, the demand for coal, is lower than it has been since 1860 or earlier. And this -- this is the future of coal.

That is the price of coal? Continued its glide path down since last year and that, too, has had implications for U.S. players. (Inaudible) coal, booming at the U.S., but a coal company never the less. James River, Walter Energy, Alpha Natural Resources -- I like their slogan, "we fuel progress around the world." Not anymore. Arch Coal and maybe or maybe not Peabody.

In terms of emissions, this change of fortunes of the coal industry could not have been more significant. Not the only thing driving what you see there, which is global emissions flattening out for the first time in history in the absence of a recession. We've seen emissions drop in the past in the '70s, in the '80s, even in 2009, but never when there wasn't a recession.

Now, here in the U.S., obviously the coal story was bound up with the clean power plant was launched by the president (inaudible) to drive coal out of the mix. And there's a big pictured, lesson, by the way, in the focus on coal and removing coal from the mix. Because if there's a pattern of the last 12 years of policy, clean energy, it has been to drive clean energy through incentives. Whether those incentives were beating (ph) tariffs, renewable portfolio standards or even reverse options, it was an incentive to add more capacity. And surprise, surprise, we've ended up with overcapacity and the focus now needs to be much more on

removing overcapacity, otherwise these collapses in wholesale prices seen around the world are not going to reverse. Makes it very, very difficult to keep the lights on (inaudible) when it isn't sunny and isn't windy.

Clean power plan, of course, famously put on hold for the moment by a Supreme Court knows how long that moment is going to last. But our analysis shows that actually that's not going to make much of a difference for the trajectory of the U.K. power system in the medium and potentially the long term. In the medium term, because of the PTC and ITC extension -- extensions are the production tax credit, the investment tax credit, or wind and solar -- This is what you would have seen in terms of the investment level had that not been prolonged there. You see wind -- and with the extension, that's what you're going to see.

The solar -- had the investment tax credit not been prolonged, you would have seen that. (Inaudible) investment 2017, now you're going to see that. The difference between those two scenarios, with and without the (inaudible) tax credit, totals around 40 gigawatts of production of installations. In the long term, the clean power plan -- whether it happens a lot -- may -- may not make a difference depending on the price of gas. If, as we think in the 5, 7, 10, 15 year time frame, the price of gas comes up, you don't need a clean power plan to shift the renewables for renewables to be healthy. If the gas price remains very low, the clean power plan will be a key part of the policy mix driving forward.

So -- it becomes very important here in the U.S. to understand the electoral process. What you see there is the green line is -- the green bars are investment in the U.S. quarterly. The orange is a moving average and for all the (inaudible) in the PTC and the ITC, I think there's a -- you could almost call it a -- well it's not a decade of oscillation -- I'm not a climate scientist -- but there's some sort of a long term trend as well around the four-year mark.

So we're watching the U.S. presidential race with great interest, not only from an entertainment point of view -- and it's worth -- it's worth having a look at some of the statements -- Donald Trump, of course, famously fought (ph) the wind farm off the coast of his golf course in Scotland and he said wind farms are a disaster for the environment. They kill the birds. They're very expensive in terms of energy and they're made in China. So Donald Trump clearly has a wind problem.

But you know, I promised myself I would stay out of American politics. I now have to be evenhanded and talk about a candidate who has a gas problem. I think we can move on.

Let's talk about China in a bit more detail. So China, we know, has been investing in clean energy. The first country to invest in more than 100 billion dollars in a year, broadly speaking it now accounts for a journey just under a third, all investment in clean energy globally and it has powered through the financial crises, barely see them there on the trend.

Now the Chinese economy is restructuring, changing very dramatically. What you can see there is GDP. We are told through official statistics that GDP has -- is on a glide path, now come down to around 7 percent per year. But we are told that energy demand has dropped -- growth in energy demand. Not the demand. The demand is in green, the growth, the orange line. Growth in energy demand has dropped to almost zero. As we've seen the use of coal has started to drop. Caveat in the past, every so often, every five years are revisions and the use of coal in the past has always been revised up. Caveat there. And emissions, we're told therefor have also flattened.

Let's dig in to the statistics that we know best. Our team in Beijing spends a lot of time on these very specifics (ph). And this is electricity consumption and its growth has dropped almost to zero. Now I've run - - the arithmetic, it's not even math, and I've tried to work out how you have an economy growing at seven percent and electricity growing at zero and a half percent and -- whether that is feasible, whether you can explain that just with a shift from heavy industry through services and other parts of the economy.

And my friends, I could not make the arithmetic add up. My sense is the GDP figure is one I would question. The electricity figure, we have much more faith in. We want to know what's happening in China in 2016 and I would suggest -- not just for the people in this room -- but for a lot of analysts on Wall Street, a lot of policymakers around the world, that's probably one of the key questions in the world right now. I'd look very hard at the electricity statistics coming out of China and I'd be asking our team there how to interpret them.

But what we also know, and we've seen already, is that China continues -- has been investing enormously in its clean energy. If you add in large hydro, which we also track, and you can see why we don't always include it when we look at trends because it's quite lumpy, that's large hydro. We can add, then, nuclear, we can add oil -- gold and gas power generating capacity investment. So look at those -- juxtapose those two charts. You've got electricity demand (inaudible) dropping to zero and yet enormous and even growing investments in generating capacity.

And not surprisingly, what we see is capacity factors dropping through the floor. Between 2011 and 2016, the average capacity factor of Chinese thermal power plants dropped from 61 percent to 49 percent. This is not sustainable. This is a microcosm of what is happening in the Chinese economy across other sectors as well; glass, (inaudible) -- we're finding out in the U.K. overinvestment, overcapacity and the overinvestment still continues today. We need to watch this very carefully.

So let's look at Europe. We'll move around. Europe has now reached very substantial penetrations of renewable energy in its electricity (inaudible). And a large proportion of that is variable renewables. When you see the big figures for Brazil and Canada, a lot of that is hydro. When you see Denmark, 57 percent renewable electricity, Denmark is pretty flat. There's not a lot of hydro there, let me tell you. Germany reaching -- this is 2014 figures that you can see there -- Germany, 26 percent, it's now over 30 percent. The U.K., 19 percent in 2014 and that is now over 25 percent.

But Europe has reached a point of deep penetration of renewable energy and it is grappling with the consequences of that. European investment in clean energy peaked in 2011 -- financial crisis, fiscal crisis, and now the need to deal with these deep penetrations, the restructuring of national power markets, the need to interconnect continuing to act as a damper on investment growth.

Think about that first chart that I showed. Investment, a new record. And if Europe was pulling its weight, think how much further, faster the growth would have been. Same, flat-lining since it changed its policy -- the retroactive changes to its policy environment, Germany there, struggling with the next stage of (inaudible) and France and the U.K. U.K., of course, the only shining light in Europe until the last election last year. Now we're likely to see that, perhaps go the way to Germany.

But last year we also Paris. Paris, at the end of last year. The question is, how significant was it? Very significant in ambition. The world must achieve greenhouse gas neutrality some time in the second half of the century. But in terms of the plans that were presented, very modest. If we are to see a real transformation in our energy system, then we need to see that blue line rather than the line that sums up the plans presented in Paris.

We can look at that in a bit more detail. I love this -- these pentagons. I used them a few years ago. Because you can really see energy mixes and how the world's energy mix moves around and where it needs to go. The area of the shape (ph) is our demand for energy. 1975, a lot of oil, very little nuclear yap (ph). See it evolving, 1990, '95, 2000, 2005, 2010, that's where we are. The center of mass of that shape is hardly move. That is what we need in 2040, to be on a two-degree scenario, and that is where we might need to be by 2100.

So truly, we need an energy miracle in the words of Bill Gates. And we do need an energy miracle. There's

no question we need an energy miracle. But I worry about characterizing miracles -- the definition of a miracle is that the case must be hopeful -- hopeless and the recovery instantaneous and total. So Bill Gates has said that in the next 15 years, I expect the world will discover a clean energy breakthrough that will save our planet and power our world. Not there are those people who still think that that is going to be nuclear. U.K. government amongst them. From the left you see Hinckley (ph), on the right, the green line is the expectation of the cost of that power plant, Hinckley. 126 percent of the wholesale power price. It seems pretty clear that current generation nuclear is not the miracle that we're looking for.

Bill Gates has investing in Terra power, (inaudible) next generation nuclear player. There are others, in fact, I think in this room, we have the CEO of (inaudible) potential next generation nuclear power player, Terrestrial Power. Small modular reactors might be a miracle. If you like your miracles bigger, there's always fusion. What they're building in France with the price of even that one project reached the point. Don't know when it's going to produce its first plasma. They don't know how much it's going to cost. Difficult to see Fusion -- not just in 15 years -- but even before.

There are other players in Fusion if you like your energy technology to look like a death star. That General Fusion, Canadian company -- like it really to look like a death star. Perhaps, that's more of a death donut. This thing is called the (inaudible). It's in Germany. It exists. It's been built. So Fusion -- certainly could fall under the category of a miracle. But let's look closer to home. Solar. What have we seen? We've seen the costs come down by a factor of 150 since 1975. We've seen volume up by 115,000. How much more miracally (ph) do you need your miracles to be?

In terms of scale, solar have seen seven doublings in 15 years. And even wind, four doublings in 15 years. To be a miracle you need scale and there you see the rate at which those technologies are growing. Now, of course, they'll saturate (ph). John Moore (ph) started us off showing an S-curve. They'll be the other half of the S. But when your penetrations are one percent and three percent, you don't worry about saturation.

Now Bill Gates also showed, in his concern for the need for a miracle, this picture. A girl studying by the light of a candle. Well that technology -- being as a pioneer from previous years -- that is a solar lamp and it costs two dollars. The entire population of children studying by candlelight could be given those lamps for a cost of just over one billion dollars, or more to the point that families could, perhaps, buy them for two dollars each (ph).

We've done a lot of work on rooftop solar. 99 million households by 2020 will be using rooftop solar systems, not just tiny lanterns, but also larger ones. This trend gets underestimated persistently. The IEA forecasts for wind and solar over years have gone up and up and up. In the case of wind, five times -- five-fold increase. In the case of solar, fourteen-fold increase since the year 2000. And those are our forecasts there. (Inaudible) that's what (inaudible) thinks is going to happen.

You know, how could they miss these sorts of growth rates? We go back to Bill Gates before 1995, the internet has all (ph) this potential, but it's important that expectations aren't cranked too high. But internet breed (ph) solar. The total number of users is still a very small portion of the population and just one year later what he said was now I assign the internet the highest level of importance. I want to make clear that our focus on the internet is crucial to every part of our business. This is the transformation that still needs to happen in large parts of the world's economy and corridors of power.

Electricity is not the whole energy system. We need to talk about a few other areas where there are potential miracles. This one I call the miracle of must (ph). In the first three days, 276,000 orders -- let's put that in perspective -- let's compare that to the great technology launchers -- great product launchers -- from other sectors. That 276 translates into nearly 12 billion dollars of sales in three days. You can compare it to the iPhone 6, 3 and a half billion dollars of sales in the first three days. Or since we've been talking about death stars, "Star Wars: Force Awakens" took a paltry half a billion dollars in its first three days.

It's not just about the Tesla though. At the end of the day, Volkswagen sells in 10 days -- every 10 days all year -- 300,000 vehicles. There are a number of cars, though, coming into the market that will be at the 200 mile range, \$30,000 price. These are normal family cars and they are perfect second cars. Nearly two thirds of U.S. households have second cars. Tell me why they wouldn't all -- or almost all go electric in the next decade?

The price of batteries is coming down 77 percent by the time the giga (ph) factories and other battery manufacturers gale (ph) up in 2018 and we project that out, experience curves, and you can see that cost parity with internal combustion cars will be between 2022, 2026, depending on price of oil and so on.

But John told us about our forecast in the kickoff yesterday. It's been discussed in the sessions on electric vehicles. There you see the market for cars growing, electric vehicles penetrating into and our central scenario is 35 percent of new cars by 2040 will be electric. It could be less. In a \$20 oil world, that will slow down. Absolutely. But in a world where people are sharing cars, you utilize your expensive batteries more, they will accelerate. Car sharing matters.

And it could be as high as 50 percent would be even higher by 2040 of new vehicles being electric. That will have profound implications for the world's economy. Let's look at just three of them. No. 1, where are cars bought and most probably made? China takes over as the leading region for car manufacturing and for innovation most likely as well. Electricity demand goes up an incremental 10 percent by 2040, but a lot more than that thereafter has caused cycle out of the fleet. And the destruction by 2040 of 13 million barrels a day, about 15 percent, 14 percent of the world's demand for oil.

Abdalla El-Badri is the secretary general of OPEC. OPEC has a very different view of electric vehicles. Their view is that they'll be around a percent or so by 2040 being sold. That's roughly where we are today. And he says if we don't see investment in oil, because of the demand, the oil price could be back up to 200 dollars.

Now I think this lies behind what will be seen by history as a classic miscalculation (inaudible) strategy with regards to oil production and pricing is predicated on two fallacies. One, the Americans are not innovative and that shale oil will always cost \$60 - \$90. So what we've seen about productivity is not factored in. And two, the demand for your product is inelastic and there are no substitutes. Two classic mistakes.

Now there will also be miracles, implications of the solar and the renewable energy shift and the electrification of vehicles nowhere more than in the grid. We have to have a grid to tie it all together. It's not just a smart grid. That was -- a few years ago we thought with digital technology it will all just happen. What we really need to do -- we're diving into this, we have our energy smart technologies team need to balance the grid years to months in advance. There's no point having a solution for the summer if it doesn't work in the winter. Days to minutes, you have to be able to deal with changing weather forecasts, short falls and so on and then the second time scale to ensure quality of power.

And where we are today, these are our technological solutions. You can see there a range of solutions, (inaudible) power generation, gas (inaudible), nuclear -- pumped hydro, of course. Renewable energy being used a little bit now for balancing. Battery storage starting to come. We're starting to see those projects. You heard about it here.

But in the future, new technologies that will be playing these roles of balancing long-term, medium-term, and short-term. We're talking demand response, battery storage, thermal storage, chemical storage, power to gas. And this is where we need to see -- also some miraculous thinking that for every miracle, a miracle is not -- a miracle makes it sound passive. We sit and we wait for a miracle. No, a miracle is an opportunity

and a miracle requires hard work. And it will be in the area of new services -- new service proposition for energy customers. That's a reason power storage, of course, but that would be -- tend to be up at the shorter time frame, batteries that store electricity from winter to summer, summer to winter. That's not going to be economic.

Something I call a grid chain, or heard of the block chain. The grid chain, where the block chain meets to smart grid. I could have called it smart block, but that wouldn't have worked. But the grid chain is all about payment systems, it's about liquidity. It's about making sure that multiple players, multiple owners of electric vehicles can pay for the charging -- they can pay utilities via the locations where the charging station is and it has to be frictionless and it has to be low cost. And these distributed ledger (ph) technologies and technologies like Ethereum, smart contracts, can transform the cost of settling payment within these complex new services.

Bulk storage, if you want to solve summer/winter, which we have to -- winter/summer -- then we need to be looking at thermal storage, chemical storage and also power to gas. Super grids, really just going beyond individual connections towards regional grids, regional integration and potentially even (inaudible) gas (ph).

Multiple miracles required multiple opportunity. I want to finish with one other thought about these transformations, the enablers of the transformation, the enablers of change, and that is what it's going to do to a crowd like this. What it's going to do to bring consumers around the world into the energy thing -- population. And that's about inclusion and it's about diversity. During this process, this move from the old energy system to the new energy system -- something I feel strongly about, I work on, I've written about it, what we cannot have is a situation at the end of it, the leadership of the energy sector looks just like it did before the transformation began. So we have also a social miracle that needs to happen in this sector.

I am proud and I am privileged to have spent the last 12 years working on this with many of you, with Ray -- excuse me -- with others, and I very much look forward to pushing this agenda forward with you, the miracle makers' future. Thank you.

(APPLAUSE)