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Peak energy, peak oil, and the rise of renewables: An executive's guide to the global energy system

Global energy demand is headed toward a plateau over the next ten to 20 years, as the world focuses on electrification, energy efficiency, and more service-driven economic growth.

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In this episode of the *McKinsey Podcast,* Simon London speaks with senior partners Namit Sharma and Christer Tryggestad about their research in the Global Energy Perspective 2019 and where global energy demand is headed in the decades to come.

Simon London: Hello, and welcome to this episode of the *McKinsey Podcast,* with me, Simon London. Today we'll be talking about energy—the world's appetite for energy and the sources that feed it, from oil and gas to wind and solar from hydroelectric to hydrogen. It's a big topic. The numbers involved are, of course, enormous, and so are the implications, not only for economics and industry structure but also for carbon emissions and climate. To talk through the facts and forecasts, I caught up in Amsterdam with McKinsey senior partners Namit Sharma and Christer Tryggestad. Namit and Christer, welcome to the podcast. Thanks for doing this.

Namit Sharma: Very happy to be here, Simon.

Christer Tryggestad: Thanks a lot for the invitation.

Simon London: So we're going to be talking about global energy demand at the highest level, so where it goes from here. In my not-very-educated, layperson's way, if you would ask me to guess, I would say energy demand probably tracks global GDP, plus or minus. Is that right?

Christer Tryggestad: Historically, that has been a correct observation. If you look at the last 100 years, we've seen energy demand grow around two to three percent per year, very much in line with global economic growth. Going forward, though, we see a delinking or decoupling of energy demand growth and economic growth.

While we see the economy continuing to grow at a fairly steady pace, we see energy demand decelerating quite significantly. For the next 15 years, maybe down to a bit less than a percent per year from two to three percent. And then from the mid-2030s we even see a flattening or a plateauing of energy demand.

Simon London: This is quite historically significant. Isn't it? This is like an epochal moment.

Namit Sharma: I think it's very significant. There are three or four things driving it. First, the shape of GDP is changing. Christer talked about the past 100 years, it was rapid initialization, first in the big Western economies, then China driving it in the early 2000s. Going forward we will see more services driving our GDP and economy. The energy that you need for services is inherently different or less than the energy used for the rapid initialization.

Second, and we all see it, we continue to get more efficient in how we use energy. We all have double-paned windows, so our heating is more efficient. We have appliances that continue to get more efficient. Our cars, including internal combustion engine or electric vehicles, they continue to get more efficient. That energy efficiency continues to drive down the overall demand for energy.

Another big trend is electrification. So not only do we get more efficient, everything is getting electrified, from road transport to people coming into the middle class and buying more appliances. Electricity is something that we think will grow twice the amount where it is today. That electricity is being powered by renewable sources.

All this together leads to a point where, yes, we will continue to grow our GDP; yes, the living standards will rise, but the energy that we will need will not track at the same growth rate. We will just need less energy. And at some point, I think around 2040, 2050, the energy demand will plateau.

Simon London: It will actually plateau? So we think global energy demand will actually reach a peak?

Namit Sharma: Yeah. By 2040, 2050.

Simon London: Wow. So, Christer, without getting too nerdy, just explain the research and what's behind it. What do you mean by the reference case?

Christer Tryggestad: Behind a lot of the work we do on the Global Energy Perspective at McKinsey

is what I call a "big energy demand model" where we model the demand for energy across segments. So it could be road transport, it could be industry, et cetera. We do that across the fuel types, so coal, gas, renewable, and we do that globally. We do it across 150 countries, regions across the world.

All that modeling is done bottom-up, where we look at the economics. It's basically economics driven, whether you build a power plant or whether you buy a car, it's driven by economic models on every single cell within that demand cube if you will. We don't take into account regulation, except existing regulation, which is included with forecasted trends.

Simon London: But we can't predict where regulation is going to go in future.

Christer Tryggestad: Exactly. What we're doing then is to say that from the time when the regulation is not forecasted anymore, we have no subsidies, we have no incentives. It's all based on fundamental economics.

Simon London: Namit mentioned electrification earlier. And the electrification of both industrial and consumer segments has been a big driver. Again, as a layperson, I'm thinking to myself, "Why does it matter whether I'm heating my home with electricity or natural gas? Why does it matter whether I'm powering my car with electricity, or gasoline? I'm still traveling the same number of miles." Is there something inherent about electrification which reduces demand for energy?

Christer Tryggestad: There's an inherent increased efficiency. Electrical engines are inherently more efficient than combustion engines. Absolutely. That is true. That's also the main driver of why we see that while the demand for electricity doubles over the next 25, 35 years, the demand for other fuels is practically flat from today until 2050.

It's the efficiency, as you say. It's also this potential cleanness. If you take electricity and you make it from clean sources, you also get the lowering of the CO2 emissions, which is another driver along with efficiency.

Namit Sharma: If you think about how we have been using fuels, we have been burning or combusting them. Now burning or combustion inherently is an inefficient process. And again, I think it might not be true and you might be able to make it more efficient, but inherently it's different when you're actually generating energy through other sources than burning or combusting.

Simon London: It's the combination of electrification with the rise of renewables. You put those two things together and it has quite a big, overall impact on how much energy needs to go into the system. That's a great segue into renewables. Just talk a little bit more, Christer, about what's going on. How fast are renewables growing, and why?

Christer Tryggestad: If you look at the past 20 years or so, renewables have grown from practically nothing, maybe 5, 6 percent of the installed capacity to now close to 50 percent of new installments. If you look forward, you will see a situation where two-thirds, or even more than that, of the power generated in the world is renewable by 2050.

Simon London: Oh, wow.

Christer Tryggestad: This has historically been driven by regulation, but right now and forward looking it's driven by economics. For every single country and region we look at, the cheapest source of new power-generation capacity is a renewable source. It's either solar or wind, depending a bit on the market.

It's even more strong when you look at 2030, because then you'll have the situation where it is cheaper to build new renewable generation capacity than it is to use the existing coal- or gas-based generation capacity. That's an obvious turning point.

We used to say that the cost game is practically won by renewables. The discussion is no longer on the cost of the technology itself; it's now becoming much more of a system-integration discussion. Because renewables are what we call intermittent—they produce power whenever the sun shines or when the wind blows. You need to make sure that you have power when you need it. That is the whole system-integration topic, where batteries or other flexible sources of power generation are needed to complement the renewables.

Simon London: I must say, again, it's an eye-opener for me, and maybe I've just not been paying attention, but I think it will be an eye-opener for many people. Today in most countries, most regions of the world, renewables are the sensible, economic choice if you're building new capacity. I wasn't even aware of that.

Christer Tryggestad: Yes, and it's been happening very fast. It's no surprise. The cost line of renewables over the past five to ten years has been amazing. That's the reason. This was not at all the case ten years ago.

Simon London: So just decompose renewables a little bit. What are we talking about, and what are the big winners here in terms of technologies?

Christer Tryggestad: The main growth technologies are solar power and wind power. Within wind it's a two-hand segment. It's onshore and offshore wind. Offshore wind is the newest and the fastest growth technology. It's still a little bit more costly than the others, but catching up fast.

Namit Sharma: Part of it is that there's a lot of investment that has gone into it. It started a little bit with Germany replacing nuclear and putting subsidies in solar. That was a big push for solar. The cost really came down because it was getting installed at scale. Wind has been also getting a lot of investments from a lot of companies. That just leads to stronger learning curves, stronger ecosystems or supply industry. And I think it just drives the overall cost down.

Simon London: Is there a role for hydrogen in all of this? I ask that question because we're here in Amsterdam, and I took a ride in a Tesla from the airport, which was interesting, so electric. I was talking to my driver about whether he liked his electric car, which he did. But he was convinced that the automotive fuel of the future was hydrogen and gave me a long explanation as to why. Where does hydrogen stand in this?

Christer Tryggestad: My view is there's a big role for hydrogen, but not necessarily in light-vehicle road transport. When it comes to light-vehicle passenger cars, the battery technology has already progressed so far, I think it's hard for hydrogen to catch up.

Our analysis shows that around the mid-2030s, hydrogen will also be cost competitive. A big discussion is going to be around how you make that hydrogen. Currently you make it based on natural gas, so steam reforming on natural gas. What we see as renewables grow is you get more price volatility on the power side. You get more times with very low power prices.

Then there's another way of making hydrogen, which is based on so-called electrolyzers, where you basically take water molecules and split it into hydrogen and oxygen, using power. That's where I think hydrogen will come into play big time, connected to renewables. You actually already see it in some of the recent offshore-wind auctions; there is a link where you also add hydrogen to the solution.

Namit Sharma: For me, hydrogen is quite uncertain. Again, in terms of the technology that we're talking about, whether it's renewables or electrification, hydrogen is in a different bracket. I think hydrogen does need to de-risk itself. We still need to see a lot of money going into hydrogen. Doesn't mean people are not playing.

Christer Tryggestad: I would make the distinction between the uses of hydrogen and how it is produced. Because already today there's a lot of hydrogen being used in fertilizer production, for

example. That hydrogen is being made from natural gas. The question is then, "Are there new uses for hydrogen, in addition to what we have today?" Then transport is the obvious question. That's a big question where the jury is still out.

Simon London: Can I just ask you to recap the big numbers around renewables?

Christer Tryggestad: Currently renewables is around 25 percent of total power generation globally.

Simon London: Power generation is electricity generation, right?

Christer Tryggestad: Electricity generation globally. That includes hydro. Most of that 25 percent is probably hydro. So around 20 percent is hydro; the rest is solar and wind. If you look to 2050, around 75 percent of the electricity produced will be based on renewable sources. Hydro will remain at roughly 20 percentage points, but then you have more than half being solar and wind.

Simon London: It's a big growth of solar and wind based on what we know today.

Christer Tryggestad: And that is produced power. If you look at the capacity installed, the numbers are even bigger because when you have a solar plant, the amount of capacity needed to produce the same amount of power for solar is higher than for many other sources of power generation.

Namit Sharma: The other important point is if you look at the new installations, we see very few new installations other than wind and solar. There are very few, if any, new gas plants built.

Simon London: If you look at what's being built today, where people are pouring concrete and building plants, it's wind and solar.

Christer Tryggestad: Maybe.

Simon London: Largely.

Christer Tryggestad: No. There are 200 coal plants being built in China. But I think the big shift that we're seeing due to the competitiveness of solar and wind—and we'll talk a little bit about the development year by year on our reference case—is that we expect a lot less coal built in that area than before. In the reference a year or a year and a half ago, we had almost a doubling of coal-based power-generation capacity in India. That number is a lot lower in the last reference scenario. The reason is that solar is getting so competitive that you'd rather build new solar and even add some battery storage instead of building new coal-based power generation.

Simon London: That underlines what a fluid situation it is. To some degree, because the economics are changing, national policies are changing, regulation is changing, the reference case, again, is our best guess based on some serious modeling, but it's going to move. What does all of this mean for oil? And when will we hit peak oil production? What's our latest thinking?

Namit Sharma: So peak oil demand—we're probably at more oil than we need. Let's talk about the big sectors of oil. Road transport is a big sector for oil. We need less oil for road transport, given the EV [electric-vehicle] uprising. Chemicals is also a big growth sector for oil, with plastics and all that stuff, that segment continues to grow. We will need more oil for chemicals. I think there's an increasing realization, mainly in Middle East, to stop using oil for power generation. That might sound strange, but Middle East was still using a lot of oil for power generation.

Pluses and minuses overall, we see in our reference case, over the next ten, 15 years, oil still grows by ten million barrels a day. For anchor today, we use around 100 million barrels a day, so over the next 15 years, ten years we get 10 percent growth for oil. In our reference case, apparently, that's when it peaks. After that we see a decline in overall demand for oil.

Simon London: And that peak comes roughly when?

Namit Sharma: Around 2033. But I have to be careful. We can talk about stories here, but I think four years ago we were putting oil demand peak as a sensitivity in our models.

Christer Tryggestad: It was not part of the reference.

Namit Sharma: Right. It was not part of the reference case. Before last year oil was peaking in 2047. Now we are saying oil peaks in 2033. If you actually, and given this reference case, as Christer said, we talked to all our global experts to understand what's going on and in some ways we have to build some sort of consensus. We also did an accelerated case. If you look at a couple of tipping points, like the EV uptick in China in 2020, if you look at the policy targets from the government and the OEM targets that are coming up, if you look at the regulations on plastics, we could actually see a further decrease in oil demand, especially in road transport, especially in chemicals, and you actually can see a peak in oil demand over the next decade.

Now, what does it mean? In the end, you could also say it means that instead of growing at 1 percent it will probably grow at zero percent or a bit negative. But you have to understand it's a commodity that declines every year by 3 to 5 percent. We will continue to need oil, even if the oil demand peaks. However, it will be a new concept, and we have to see how the geopolitical producer landscape aligns itself to this new reality whenever it becomes very clear.

Christer Tryggestad: In many ways, you can say that the question of when oil peaks is less important than the question of what happens afterwards. In the reference case you could almost say that oil plateaus. There is a decline rate of 0.5 percent or something a year until 2050. But it's relatively little compared to the 3 to 5 percent natural depletion of the oil fields.

In the accelerated scenario, in the sensitivity, we see a much steeper decline after the peak. The peak comes earlier, next decade, and the decline is steeper, two and a half percent per year. That means that you get a lot closer to the natural depletion rate and probably it will have a much bigger impact on the dynamics on the industry than if you had the reference scenario.

Simon London: You mentioned industry dynamics there. And, of course, a lot of the same companies that are big in gas are big in oil, so just compare the outlook for oil. What's the outlook for gas?

Christer Tryggestad: Gas, our analysis shows, is inherently more resilient than oil. And you can say that there are three main reasons why this is so. First, in many places gas is replacing a dirtier fuel, coal. A big driver, in many cases, of energy transition, is the climate. That is a positive. The other positive driving the resilience of gas is that even in a system where you have a lot of renewables, so you have the renewable transition, you need flexibility in the system, as I talked about. That is naturally provided by natural gas.

Simon London: And this is the baseload concept. You've got your renewables, but they tend to be quite volatile in what they're producing and when, so you still need this baseload and gas provides that.

Christer Tryggestad: So in the evenings in a place where solar energy is important, you need something else too. In the Netherlands, for example.

The third reason is that gas is, to a large extent, used in what we call hard-to-abate sectors. You use a lot of gas in the industry for medium and high-temperature heat. That is one of the sectors that is hardest to abate or to replace.

Simon London: What's an example of that?

Christer Tryggestad: Metals products is a typical example where you need high, high temperature.

Simon London: So if you're smelting something?

Christer Tryggestad: You burn the gas to get the heat. And to electrify that is quite tricky. That's the reason why inherently, gas is more robust than oil demand. Even though for gas we see a peak or a

plateauing towards the end of the period in the latest reference case.

Simon London: Which is 2050?

Christer Tryggestad: In the 2040s, we see gas peaking. Actually in the mid-2030s we see gas peaking. But it's really plateauing, not declining sharply. There is one big black swan here on gas, and that is hydrogen. And it's electrolyzer-based hydrogen. Because the alternative for natural gas in many of the hard-to-abate segments or sectors would be to use hydrogen based on electrolyzers. There's a lot of scaling discussions and different discussions around that, but that, for me, would be the one black swan.

Simon London: So it's possible that we could get this substitution of hydrogen for gas and some of these industrial applications. And that could change the picture.

Christer Tryggestad: Exactly. We could get the substitution of hydrogen for gas in some models, and, where we use the hydrogen based on gas, we could get a substitution to hydrogen based on electrolyzers.

Simon London: And then what about coal? It tends to be the most greenhouse-gas-emitting fuel source. What's the future of coal in all of this?

Namit Sharma: Coal is an interesting story. But I think one thing is pretty clear: coal is going to decline massively, for the reasons that you pointed out. In our analysis we see coal demand going down 40 to 50 percent from current levels over the coming two to three decades.

However, it will still remain in the system. And I think, as Christer mentioned before, there are still some coal plants planned to be built in Asia. Over time as our power systems develop based on renewable technologies, you might see further phasing out of coal.

Christer Tryggestad: When we say that there's a 40 percent decline, that's almost exclusively driven by China. And many other places it's flat or some places even a slight decline in the coal demand.

Simon London: So China is moving aggressively to phase out coal, but because it's such a big part of the energy system in China that does not happen overnight. That's for sure.

Namit Sharma: Indeed.

Simon London: That's a big takeaway for me from all of this research is despite these very big moves going on, on a number of areas, and this is an apt metaphor, but it is like turning the supertanker. The global energy system is like a supertanker in that it's got this momentum; there's a huge amount of sunk capacity and infrastructure and industry structure around it. That does not change overnight. And you're talking decades, not years, to look at these trends.

Namit Sharma: Indeed. It's a complex system, so you also need to be careful because not all fuels are easily replaceable. That's why when we talk about the implications, we do need to take into account that indeed there are some sectors where the growth is, but you will continue to need some other fossil fuels where economic rent can still be made.

Simon London: Right. Let's segue from there into greenhouse gas emissions [GHG]. Based on the modeling that we've got, what are the implications for GHG emissions and where are we? People tend to use the Paris scenarios.

Namit Sharma: I think there's good news and bad news. The good news is, based on all of the stuff we have talked about, the carbon emissions will decline. I think they'll be 20 percent lower by 2050 than where we are today. And that's in the reference case. However, I think the bad news is that they still remain far away from the two-degree pathway laid out in the 2016 Paris Agreement. Even in an accelerated scenario, we don't see achieving this two-degree scenario laid out in the Paris Agreement.

Christer Tryggestad: This is one of the challenges we receive on the reference case. It goes something like this. If you believe that climate change is for real, and most people do believe that climate change is real, does it then make sense to have a reference case that fails to reach the two-degree scenario and even more the 1.5 degree scenario to such a big extent?

Simon London: Because the argument being that if we are overshooting that pathway, there will be regulatory action.

Christer Tryggestad: Exactly. I think the only answer to that is to say that we want to develop, call it the economic, or the financially driven, reference case, and then we are happy to do analysis around that and figure out what will it actually take to get the two-degree or even the 1.5 degree scenario.

Simon London: I know you both work with big oil companies, big utilities. Maybe let's start with oil and gas companies. When you have C-suite conversations, I'm guessing they have digested a lot of this. This is their business. What's their response? How are they responding to this?

Namit Sharma: I think it's good to understand that companies are nuanced. You have the super, big global players. You have smaller regional players. And you have national oil companies. And, again, I think the conversation is nuanced across these players. But I think there are two dimensions to look at.

The first one, as we talked about, the good news for them is we will continue to need oil. If for nothing else, as we decline 3 to 5 percent every year, to put some numbers against it, this means that we need to find 43 million barrels per day of oil, new oil, in 2035. So there's still a lot of oil to be found and produced. Of course, as some of this transition takes shape, as some of the oil demand goes down, we got a peak in the demand, we need to ensure these barrels are resilient in the price environment that you might get into. That's the first question on the current portfolio. We have to find oil but it needs to be resilient barrels on the cost curve.

There's a second dimension to the question where power is a growing segment. In some ways it's the new business. So why would we not look at it? And I think they can look at it, but they also want to be very sharp on their investment thesis. Are the returns the same as my core business? Is the risk the same as my core business? I go down deep in the ocean, drill something versus setting up a windmill on land? It's a different risk, different return.

The other thing is the way you look at opportunities is different. It's very local. It's very specific opportunities all across the world. And you need, in some ways, more downstream commercial marketing capability, especially on the retail side. And I think some of them are evaluating options on what this business can mean for them. It's at least those two dimensions that my oil and gas clients are thinking about.

Simon London: And what about utilities? Because this is also a big change for utilities as well, the rise in renewables. You mentioned earlier, Christer, the challenge of integrating renewables into the existing power system. What's the discussion?

Christer Tryggestad: To some extent it's relatively similar to the oil companies. First, you will expect that because of electrification, it's a positive story because you will have increased demand for power. And that is true. On the demand side, the story's probably much more positive than for the oil and gas companies. However, it's a pretty big shift going from traditional, large, centralized power generation based on coal, gas, hydro, nuclear towards more renewables like wind/solar type of generation. Higher upfront capex [capital expenditures], less opex [operational expenditures]. Often smaller margins. So it's also quite a big change also for utilities. And you also get new competitors coming, like the oil companies, like the oil majors that are gigantic companies with big financial muscles.

You also see more light-footed renewable specialists, like solar developers. So you face a completely new competitive environment where I

also see many of the traditional utilities trying to find their way and find a new competitive model for them to survive and prosper.

Simon London: So, again, the industry dynamics are changing, and that will raise the question again of competencies, like what actually are we good at?

Namit Sharma: The good thing for utilities, and Christer, you might agree, but it's actually pretty simple. They need to figure out how to win in their current business, which is changing but they don't have the choice like the other companies.

Simon London: Power is not going away. Far from it.

Namit Sharma: No. And they're not getting into oil and gas. So in some ways the question is simple. The answer, of course, is very complex given all the complexities that you mentioned.

Simon London: So I think that's all we have time for today. But Christer and Namit, thank you so much for joining.

Christer Tryggestad: Thank you, Simon. It was a pleasure.

Namit Sharma: Thank you.

Simon London: Great. And thank you, as always, to you, our listeners, for tuning into this episode. To learn more about McKinsey's latest Global Energy Perspective, please visit McKinsey.com or check out the McKinsey Insights app.

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