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The Future of Solar Policies

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Webinar Presenter

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Toby Couture Welcome to the International Solar Alliance Expert Training Course. This is session 18, on the future of solar policy. This webinar series is supported by the International Solar Alliance and the Clean Energy Solutions Center. I am Toby Couture from E3 Analytics, and I'll be leading this exciting and pathbreaking new discussion into the future of solar PV policy. This training is part of module three, which looks specifically at the topic of the future of solar policy.

In this module a number of different topics are covered, major trends that are reshaping the sector. And we try to take a look at where things are going in the years ahead. It's important to underscore at the outset that much of this, particularly in this presentation, remains speculative. Nobody can predict the future. There is a lot of uncertainty around where the market is going. And of course many different people in the industry have different views on what the future is going to look like.

So I want to kick off by caveating everything in this presentation in particular by simply saying, the future is uncertain, and nobody ultimately knows what the future holds, both technologically in terms of technological innovation but also in terms of market development. So important to keep that in mind as we push forward. So quick overview of the presentation. This—we'll look at the history of solar policy and discuss a little bit where we're coming from, where we've been, and then discuss in open—in an open way future pathways that are being discussed, future trends that are—we're already starting to see the beginnings of that could redefine this discussion and the policy landscape in the years ahead.

And then a few concluding remarks, followed by the knowledge check, where there'll be a couple multiple choice questions at the end. So the aim of the

presentation is to understand the history of solar policy. It's always important to put things into context to know where we're coming from in order to understand where we're going. It's to understand the challenges and the market realities that are starting to reshape the future of solar, understand the different pathways that the future could take. A form of scenario analysis, so to speak, for policy wonks, as well as for companies.

And to understand the impacts of near-zero marginal cost electricity on electricity markets. We'll unpack that a little bit further in the slides ahead. So taking a step back, a bit of history. For most of the last three to four decades, solar policy has been based around a combination of tax incentives, rebates, grants, mandates, which include targets and things like renewable portfolio standards, renewable energy standards that set legally binding targets as a percentage of the electricity mix in a given utility or in a given jurisdiction. We've seen the use of preferential treatment mechanisms, things like priority grid access, must take provisions, essentially priority dispatch, where solar gets essentially taken first whenever and wherever it's produced as a priority in the dispatch order.

We've seen feed-in tariffs, which have been a major part of the policy landscape in recent decades, particularly in markets in Europe and in parts of Asia. We've seen net metering and policies relating to net metering, like net billing, and a range of others. On some of these topics we've already covered the fundamentals in some of the presentations, so I encourage you to look at some of the other sessions, particularly on net metering, on solar subsidies. But in recent years, solar policy has begun to evolve.

And we've seen a discussion emerging around so-called subsidy free solar. And if you Google quickly subsidy free solar you'll see lots of articles come up, lots of discussion, a range of different things happening in different parts of the world that are starting to be called subsidy free solar. So the implication there is solar power is increasingly cost competitive. It's increasingly able to compete in the market, and therefore we don't need policy anymore. We don't need subsidies anymore. Solar is market ready and ready to scale on its own terms.

So we'll unpack that debate a little bit and try to understand a little bit more what's going on and try to also put it into context. Recent solar auctions in Europe have resulted in contracts being signed with zero premium attached. So in other words, in many auctions in Europe, the principle has been based on a type of feed-in premium. So basically, you—what is being bid is actually the premium, in other words, the bonus that you think you need as a company above the wholesale market price. So if the wholesale market price has been hovering between, say, two and six cents per kilowatt hour, your—you do your own forecasting or hire out private price forecasters and estimate what you think you need above that forecasted market price to make your project bankable.

And what you're actually then bidding on is the premium, not the whole contract price. In other words, just the top up. And we've seen a couple projects in Europe, not only in solar but also in wind power, fitting in at zero,

essentially zero premium, which leads you to the view that companies essentially think that they can develop projects and finance them largely on the back of wholesale market prices, in combination often, as we'll see, with other bilateral PPAS, so other power purchase agreements in—as a bit of a hedging mechanism. We'll look at that a little bit more closely towards the end of the presentation.

But it's important to understand that these projects are happening and that they're being referred to as solar free—or subsidy free solar projects. We've seen some of them being discussed and built in Germany, Italy, Spain, and elsewhere, either directly using wholesale market prices or in most cases in combination with corporate PPAs. In other words, where a company buys a slice, in some cases a substantial slice, of the total output of the project, leaving the remainder of the output to be sold on the market. And that's one way to essentially mitigate the risk of exposing yourself fully to wholesale market prices.

So on the one hand this is a very exciting development. This is a sign that solar is increasingly cost competitive. And there's lots to applaud here. There's lots to be—to rejoice in here. This is a positive story. The—as we'll see, however, as with most things in electricity markets, the deeper you look, the more complicated it gets. And we'll, again, try to unpack that through the slides here.

So taking a step back again historically, there are three—it's possible to break down a history of renewable energy policy into three basic phases. And you can see here on the graph on the right the early commercialization phase, which is sort of the beginning, the policy support phase, and then the policy framework phase. And all of it is in function here of the cost range, essentially, of renewable energy technologies. So as renewable energy technologies get cheaper, we move out of the commercialization phase into the policy support phase.

Policy support phase is really where we saw feed-in tariffs and scale-up mechanisms like that that were adopted where renewables are still more expensive than fossil fuels or than conventional electricity on the grid but are starting to get competitive. And now where we're entering is where renewable energy technologies are increasingly competitive, are increasingly in the same price range as fossil fuels. And therefore we're seeing a shift in policy. And that has important implications for the future of electricity markets but also, again, for the topic of our presentation here, on the future of solar policy.

Now this was laid out in a paper for the IEA RETD in 2016. And the graph here is really there just to help conceptualize the evolution of solar policy in a visual way and try to understand where we are today. Another key component here that's worth taking a moment to underscore is the policy bedrock, which cuts across all phases. And you can see it there in black underneath, though let's look at that a little bit more closely. The policy bedrock, which cuts across all phases from beginning to end, refers to the basic elements that are required for electricity markets to function and for investments in new generation to happen.

So we're talking about things like grid access rules, permitting procedures, planning and forecasting guidelines and rules, zoning. Where can you build a solar project? Where can't you? What are the various requirements, environmental impact assessments, and so forth? So all of those things, regardless how cheap renewables get, all of those things are baked into the landscape. Those are what we call here the policy bedrock.

So although those can be referred to as policy elements, they are considered here as really part of the bedrock. And clearly that means that they're not—we don't usually think of these things as subsidies. And yet they are in some sense necessary to electricity market development and investment. So they're—they are part of the landscape. And I think when people talk about abandoning solar policy altogether, surely what's meant is not eliminating grid access rules or grid interconnection rules.

Those need to be in place. Otherwise investments don't—simply don't take place. So important again to just nuance this a bit further and to understand that a lot of the rhetoric and a lot of the terminology used is often a bit overly simplistic. The bedrock is likely to remain. The policy framework phase, which is, again, where we are today essentially with solar PV technology, refers to the point at which solar is beyond the cost of or at least in line with the cost of conventional generation. And yet as we just discussed, basic rules and provisions are still needed to make sure that projects are investable.

And that's where, again, part of this presentation starts to focus. So as we enter this policy framework phase, solar is evolving rapidly. But the question—solar policy is evolving rapidly. The question, ultimately, is, into what? So are we evolving into a pure, subsidy free, free market, no government intervention environment? Or is there still a role for government policy? And if so, what does that role look like? And what are some of the industry representatives saying?

What are some of the solar companies saying? What are—where is this trend going? And I think that's really the big question that informs—that this presentation attempts to unpack. So this presentation lays out a number of ideas on potential future pathways. But it's important to note, as I said at the outset, that much of this remain hypothetical. So it's speculative. As Niels Bohr, the famous physicist, once said, "Making predictions is hard. Especially about the future."

And it's in that spirit that this presentation has been developed. So a further challenge here is that there are more than two ways to take. There are multiple different pathways. And that's what inform—that's what makes this so challenging. There is no, quote, unquote, "silver bullet." And it's also an open question, as we'll see towards the end, whether markets will converge all on the same basic policy framework or whether we're more likely to see continued divergence with a wide range of different strategies and approach, to dealing with low-cost solar. So again, much to discuss, much to reflect on.

So let's dive in and help set the stage on this discussion. Many used to think that older policies, so policies that were used in the early commercialization

phase mostly of renewable energy development and the policy support phase, like cash grants and rebates, would stop being used as the cost of solar declined. And yet, such policies remain widely in use in many of the most advanced solar PV markets. So we see the US had the treasury grant program. Up until recently they provided direct cash grants for solar projects.

Australia continues to make use at the state level of a number of different rebate programs. And yet solar in Australia and in much of the US is cost competitive. So many would argue, well, why are we still offering cash grants and rebates if solar power's already cost competitive? So there's an important question there around policy. There's an important question there around the influence of the industry on policy decision making, whether the resistance of the sector to abandon policy, to abandon rebates, for example, is part of the reason why we keep seeing these same old tools being used.

Fundamentally maybe it's a lack of imagination, and it's also a fear that if we take the—not the punch bowl. But if we take the—in a way, the subsidies away, the rebates away, that the market will collapse. And that fear indeed does appear to be justified, even in 2019, when solar is at its cheapest point ever, where it's now possible to generate electricity on a solar rooftop for less than ten cents, in some cases even less than five cents per kilowatt hour on larger commercial rooftops. Even at these low prices, there are still concerns that if we take away the rebates, the market will grind to a halt.

And indeed, the article here, which you can see, from Australia from *Renew Economy,* indicates that in Victoria, a state in Australia where rebates were recently scrapped when the funding ran out, the market also stopped. And the challenge there is that investors and homeowners and businesses will often wait—when they're used to getting rebates for solar, they'll often wait until the subsidies are available again before investing because they think, oh, the government will come out with a new rebate program. Therefore, we'll just wait, which means the solar industry collapses in the meantime waiting for the government to prime the pump again.

This can happen even in markets where it makes economic sense to invest. So again, this is—the difficulty here for many economists is—they would say, "Well, why are you continuing to subsidize this? It's—makes economic sense. You're just distorting the market. You're distorting investor expectations." The reality is, this does continue to happen. And it leads to start and stop cycles of development. So the history on this—and Australia is just one example. But the history of grant and rebate programs is precisely that.

They can help get the market going, but eventually when the funds run out, the market tends to grind to a halt and experience a pause—and sometimes quite a dramatic pause and quite a protracted pause as the market waits for more guidance and for more—ultimately for more rebates. So there's a—there's an important issue there. The theory used to be that those would be phased out as—again, as solar got cheaper and cheaper. Unfortunately, that's not what we are seeing, as the case of Australia shows.

So now there's an active debate in Australia. Should we scrap rebates altogether? And of course the solar industry fears that because they think that the investment will grind to a halt. And thousands of jobs will be lost, which indeed may well be the case in the short term because of the dependency of the market on—at least the expectations are primed to expect those subsidies. So there's a bit of a Pavlovian effect here of expectation, and that's a difficult cycle to break.

There is also evidence to suggest that grants and rebates, somewhat perversely, have pushed up solar PV install costs as installers inflate their prices in response. So when there's a rebate, they know the customer's getting a couple thousand dollars back. It tends to create a little bit more wiggle room, and everybody prices that in and prices their quotes a bit upward. And there is evidence to suggest, certainly from when you compare Germany and the US, for example, where tax incentives dominate and are a major part of the landscape.

In Germany there—the market regulations and policies are different. The—that solar install costs in the US remain stubbornly higher than in Germany. And there's a number of different factors at play. But of course one of them—one of the factors that's pointed to is that the tax incentives are, again—everybody's taking a cut. It's not just the investor that's getting a piece of that. Everybody's essentially taking a cut of the subsidy, effectively the tax incentive being offered.

So the case for phasing out subsidies, grants, and rebates is strong. The history suggests that some of the negative effects are very real and that—also economic realities suggest now that solar PV is effectively cost competitive. So does it—do solar—does solar still need policy supports like these—grants, rebates, and other things? Or should we shift our policy focus and policy support into other kinds of policies, more market enabling policies? So that's the underlying debate.

But the big question is, well, if we scrap them, what should take their place? Now, some argue that the—there are continuing distortions in the electricity market and indeed in the energy sector more broadly because of subsidization of various forms, the non-internalization of environmental externalities, a number of advantages that traditional utilities and traditional power plants have—conventional power plants have in the system, market power, the fact that many of the existing assets on the electricity system at least in developing—in developed countries are already amortized. In other words, they've already been paid for, which means their production costs are just a function of their variable costs.

It makes it very difficult to enter into a market as a new technology, as a new investment, when you're competing against a bunch of already paid for power plants. So there are inherent imbalances in the electricity market. And some people argue, well, that's what justifies the continued existence of these subsidies, because those plants, those projects benefitted from subsidies at the time, and they're amortized or largely already paid off. So we need to level

the playing field, so to speak, by adding and maintaining these rebates and grants and subsidies.

So again, different views. All of these different positions in a way have their own—are legitimate. And the challenge again for policymakers is how to cut through the weeds here and blaze a path forward. Some argue that solar—because of the fact that solar PV is now mature—it's considered a mature technology. It's trusted by banks in the performance. The history and track record of performance is there. The energy—the efficiency of the production is predictable and well known.

Forecasting has never been better. It's a mature technology. It's also increasingly a very low-cost technology. Solar PV is emerging in a growing number of markets as the lowest cost source of new power generation, which means in many cases it can be produced on site for less than the utility's price in many parts of the world. That in itself, again, is something to celebrate and is transformative. On the back of that, many argue that there's no longer any need for further policy and regulatory support.

In other words, PV is mature. Remove all forms of policy and regulatory support and subsidies, and the market will simply take care of the rest. And at first glance, the emergence of so-called subsidy free solar projects seems to play into that narrative. It suggests solar is cheap enough. Solar can compete. Let's do away with all policy and regulatory support and let the market, again, take care of the rest. That remains an important view and in—within the sector.

In addition, new business models are also emerging and entering where policy has left a gap. So we're starting to see, for example, the rise of solar leasing that enables these companies to provide solar to people as a third party and essentially doing the installation, taking care in many cases even of the financing, and thereby overcoming many of the barriers that held people and companies back from investing in solar. Lack of familiarity, the time, the permitting, the paperwork. Solar leasing companies are increasingly taking care of all that and offering turnkey, door-to-door solutions to make—to help people go solar.

So that's another way that's enabling solar to essentially break through without the need for explicit subsidies. Now, in the US, for example, where solar leasing is growing most rapidly, the market continues to benefit from tax incentives. So there are—there is the investment tax credit, which offers 30 per cent off essentially as a—an investment tax credit, and a number of other tax related incentives, which means the market is not, again, unsubsidized. And solar leasing projects are also supported and enabled often by net metering rules—net metering policies.

So even these solar business models in a way rely on an existing policy and regulatory and indeed fiscal framework to continue to thrive. So if you removed net metering policies, it would be a lot tougher for solar leasing companies to lock up companies. They would have to start connecting batteries to all of these systems 'cause you couldn't inject the excess into the

grid, which would make it more costly for households, thereby pricing out a number of potential customers. So the policy environment continues to shape the presence of these new business models in many important ways.

So it's—although they're happening on a market basis, policy is often there in the background when you lift the curtain, so to speak. Similarly, corporates—so corporate power purchase agreements, big companies that are signing direct contracts with renewable energy producers, solar producers, peer-to-peer sharing platforms, which we covered in another training session, aggregators, et cetera, are starting to redefine the terms on which solar power is bought and sold. So if companies are buying solar, then maybe we don't need as much government policy anymore because it's no longer about the utility. It's more about what companies in the private market are doing.

Companies are deciding on a private basis solar makes economic sense. We will buy it. Why do we need policy to govern and support that? Again, that's the simplistic view. When you start to unpack it, you realize that even corporate PPAs rely often on the existing regulatory and fiscal environment. They often—they all use the tax credits that are available and are often partially—the economics of those projects are partially based on that. And of course, they rely still on many of the key bedrock elements that we discussed at the beginning—things like basic permitting, zoning, market access, grid access.

Those things are still baked in and are still part of the landscape. So we're not talking about doing away with those. What's more at issue is, could the corporate PPA market thrive in the absence of subsidies in the sense of tax incentives? And indeed, a number of projects in Europe in the Netherlands and elsewhere are starting to show that indeed in the absence of tax incentives and in—and those kinds of subsidies that, yes, it is possible to sign corporate PPAs in today's world with solar projects. So there is a case starting to emerge that's somewhat different from the US case that does enable solar to be bankable, at least on a small—on a scale of the companies PPA.

Instead of one off-taker, there are now many. So the utility used to be the only off-taker in the market, in essentially what we called a monopsony agreement instead of monopoly, where you control everything that is sold. A monopsony is when you control—you are the only buyer. But we're seeing the death of this single buyer as, again, companies in particular but also households and businesses, emerge as new buyers of solar PV, buying directly without relying on government policy explicitly or government price supports. So again, this is shaking up the market.

The peer-to-peer story is also unfolding, enabling customers, residential, commercial, industrial to share power with one another, effectively cutting out the middleman. You can have a look at the straining session specifically on peer-to-peer power trading and block chain for a bit of a deeper dive into that. Block chain in these applications are enabling people to buy solar directly from other peer suppliers on the network and even connecting that with storage and other applications. So again, the question is, well, is policy necessary here? Are subsidies necessary here?

Such markets can arguably function without explicit subsidies or support mechanisms. Some would argue therefore, again, that there's a case for scrapping it all and letting the market thrive in this way. One of the big challenges, however, as a quick caveat, which we'll come back to at the end, is that we may be able to get to markets with 500 megawatts a year in a given country or a thousand megawatts a year of solar PV on the back of corporate PPAs and peer-to-peer power sharing. The question is, can we really get to gigawatt scale?

Can we get to hundreds of gigawatts in major markets, say, tens of gigawatts, even to hundreds of gigawatts in major markets like India and China and Indonesia and Nigeria on the back of these kinds of solutions alone? And that is a much, much more challenging proposition. So I think there's consensus broadly in the market that we can easily get to several hundred megawatts a year, maybe even a few thousand megawatts a year in individual countries like Germany, France, the Netherlands, the US, on the back of these market-driven corporate PPAs and peer-to-peer power sharing and solar leasing. But does that get us to large enough numbers?

Do we get to ten, 20, 50 gigawatts of installed PV capacity that way? That's another question altogether. So another major trend here that's emerging and that you've perhaps read about is the ride of grid defection and so-called load defection. A growing number of customers are finding it possible to disconnect fully from the grid by combining solar PV with storage. So the use of solar PV and storage applications can indeed make economic sense.

There are communities like Parkhurst in a neighborhood outside of Johannesburg that have effectively decided to do just that, cut the cord with the supplier and try to essentially build a mini grid supplying the community using solar and storage technologies. So the economics of doing that are getting better and better. And this could have significant implications for the future of electricity markets, not to mention utility revenues. So there’s a very important discussion here that's also connected to this broader conversation around solar policy because solar policy is no longer just about solar PV.

It's also increasingly about PV plus storage and what those kinds of combinations can unlock in the market in terms of investment and in terms of market development. There are a couple great pieces done by Rocky Mountain Institute, which I've put here at the bottom, on both grid defection and load defection that are worth a look at to help put this into context. This is not surprising, that we're seeing a lot of people wanting to defect from their utility. Many people don't like their utility and would love to supply their own power.

But wanting that and being able to do it are two different things. And that, until recently, was the reality. Now, it's increasingly the case that PV, as we saw, is cheaper than the retail price. So if you look at the comparison here across the board, across a couple key markets, you can see here the current retail rate in Euro cents per kilowatt hour and then the approximate levelized cost of energy of customer-sited solar PV in each of these different markets.

So that's for—it's a levelized price of your production over the course of the ownership of that PV project.

So somewhere around eight cents in Germany, six cents in Hawaii, somewhere around five cents in Australia, in the range of eight cents in New York, and again, somewhere around 11 in Cape Verde off the coast of Africa. So you can see here on the far right that the LCOE is a fraction of the retail price, which means, again, the economics of investing in solar are increasingly compelling. We are well beyond—we are way beyond grid parity in many of these markets. And that's an important threshold. That's an important reality and, again, has important implications for the future of solar policy.

The challenge is we don't have a clear consensus among policymakers and among analysts around what that means and how do we go—how do we move forward from here. Another major trend that's connected to the rise of grid defection and solar plus storage and these new business models making solar possible for more people is that in some feeders, residential solar now surpasses 200 per cent of minimum daytime load in certain parts of Hawaii. Though solar is now meeting more than the load on individual feeders during daytime hours, creating a host of different challenges, also opportunities. At the same time, that means that there is less electricity left for traditional utilities to supply.

So where utilities used to forecast how much residual electricity demand they had to meet on a given feeder, now the utility is having to deal, at least in Hawaii, with how much power is going to be coming out of that feeder and feeding upstream into the network. So it's a completely different—it's a complete paradigm shift in the way that the power system has traditionally been managed and operated. At the same time, you can see here from data in—from Australia that electricity demand forecasts showing rising electricity demand growth continue to misfire. And electricity demand from the network continues to go down.

This is driven in significant part by the rise of rooftop solar. There are now somewhere in the range of two million individual rooftop solar systems in Australia. And in some parts of Australia over 30 per cent, in some cases in some postcodes, even over 50 per cent of households have solar on their roof. So again, very significant implications potentially for utilities long-term if this trend continues. Which brings us to this bigger combination, the bigger threat, arguably, than even standalone solar on a rooftop, is the combination of solar plus storage. This is what some are calling the solar plus storage tsunami.

And as solar plus storage gets cheaper and cheaper and starts to undercut the grid price, it's possible for households to not only top up or not only offset part of their electricity demand with solar and inject the rest into the grid. It's possible for people to displace their entire power supply and effectively, again, to cut the wire, in theory. Now, the number of wire cuttings remains small, remains a relatively small part of the market. What's more interesting is where it's starting to be used in areas. For example, Australia's national

regulator recently found that for many of the remote communities in Australia, it's actually cheaper to cut the distribution wire altogether, stop maintaining it, and invest in solar plus storage on site.

So investing in micro generation with storage directly within the villages, rather than maintaining and expensive and long transmission and distribution network. There were estimates in Australia that the cost per customer per year of maintaining the distribution wires is somewhere around the order of 15 to—over $15,000.00, over $20,000.00 that—per household, per year, just to maintain the—to clear the brush along the distribution poles. So maintaining that kind of distribution infrastructure does not make sense in a growing number of cases. And it also doesn't make sense in much of Africa, where it may increasingly be cheaper to do solar plus storage in a distributed way and provide localized solutions that are adapted to customers' needs instead of building out costly and high maintenance distribution infrastructure.

Interestingly and perhaps unsurprisingly, islands are coming to the same conclusion. This provides a quick snapshot of some solar PV plus storage projects from around the world that've been signed in recent years. You can see here a number of projects in Hawaii with combined prices between eight and 12 cents US per kilowatt hour. In the Caribbean, in the Cook Islands, and in Palau, the—even in the most remote island regions we're still talking about fairly competitive pricing compared to diesel, which often has to be driven in by barge and some cases even flown in. So the economics of solar plus storage are increasingly compelling in these areas.

And as that spreads to markets like Australia, Latin America, Africa, again, this could really shake up the conversation around solar policy and may indeed lead to a whole—to a need for a whole new set of tools to deal with. And as we saw much of Africa—as we are seeing now with the rise of pay as you go solar on individual rooftops, there is potential for economic solar throughout much of Africa to displace and outprice the available supply and also to provide supply where there is none currently. Terrific little video done here, which I've provided the link to, looking at the potential of solar to displace diesel generators, particularly within Nigeria.

And again, the potential for this market segment to grow is tremendous. So where do we go from here? We've seen—we've looked at some of the trends. We've looked at some of the issues, some of the history setting the stage. Are subsidies still needed? Or is solar mature and market ready? Can we essentially pull back all policy and regulatory support and expect the market to continue to thrive? Is policy in any form still needed? Are there trends from markets around the world that provide insights as we've been seeing?

And more fundamentally, is there one way forward policy-wise? Are we going to see global policy convergence for the low-cost solar PV? Or rather are we going to see policy divergence and continued divergence worldwide with different market and regulatory and policy frameworks in different countries and different parts? All open questions. Difficult, again, no—and no easy answers. And there's a further elephant in the room that complicates the picture even further.

Rising shares of solar PV in the grid push wholesale prices down. You can see here from the graph that as the penetration of solar PV rises in the grid—these dots represent the value factor of solar on the grid. And you can see here that the trend is clear and downward. So the higher the solar penetration, the lower the quote, unquote, "value" of solar to the electricity system is because again, you have a supply and demand issue. Abundant supply during the sunny, daytime hours produces more power, which pushes down wholesale market prices, leading to what's called the cannibalization effect.

The cannibalization effect refers to the fact that as solar floods into the market, it essentially erodes its own revenues because wholesale market prices respond to supply and demand. When there's abundant supply, all of the solar projects are producing, which depresses the prices because there isn't enough demand, so thereby cannibalizing their own revenues. This raises a host of issues for what we talked about at the beginning, mainly these subsidy free solar PV projects. If these solar PV projects are truly subsidy free and are going 100 per cent on wholesale market sales, that may work in the short term with low levels of penetration for solar PV, but there seems—there's broad consensus among researchers and analysts that that can't be a long-term solution to getting to 20, 30, 40, or even 50 and above percentage points of solar PV in the grid.

So if we're going to meet a substantial share of our electricity needs with solar, wholesale market prices are unlikely to provide a sufficient price signal to do so, which again raises the question, what kinds of policy tools are needed, then, to deal with this cannibalization effect? Do we need price supports? Do we need a price floor saying, for example, that minimum—at a minimum solar PV output during the day will be remunerated at a price floor of two cents per kilowatt hour, just as a worst case scenario for investors to de-risk the investment proposition? Some would argue that leads to other market inefficiencies because you don't allow market prices to go negative, which a growing number of hour—a substantial number of hours of the year already are negative.

Market prices are negative in markets like Germany. Some would argue that you distort the rash—distort the functioning of the market by putting a price floor. But in order to maintain investment levels, it's not clear that we're going to get billions of dollars flooding into the solar market if wholesale prices are increasingly very, very low or negative during the daytime. So something has to give, which again raises the question, what should policy look like to deal with this new reality? That's why a number of corporate PPA projects and a number of these so-called subsidy free solar projects are in fact using hedging strategies.

In other words, they are selling part of the power on the wholesale market or as part of the feed-in tariff framework in place in the country, and at the same time they're signing these contracts with corporate off-takers, with companies, to buy a portion of the power. So essentially they're diversifying their risk by diversifying their off-takers. So they have a fixed contract for the PPA portion of the supply and are accepting market risk—merchant risk, as

it's called, on the electricity being sold directly to the market. Now, one of the challenges with this, of course, is that if there's more risk, it means your cost of capital goes up.

So the banks are less likely to finance these kinds of projects. And where they do, they aren't going in with 90—providing 90 per cent of the financing to the project. They're providing more like 50 to 60 per cent, leaving equity investors to put up the other 40 to 50 per cent, which means the cost of capital is higher, which, again, has the perverse consequence of actually making solar costlier. Because if your cost of financing goes up, the cost of solar goes up. And that is in itself—raises a host of issues around the future of policy and what the right role, what the right function of policy is in this so-called brave, new world.

A few concluding remarks as we wrap up and some reflections. So we've talked a lot about different policies. We talked a lot in the beginning about rebates and grants and some of the earlier tools that were used. We also talked briefly about mandates, like RPSs, that set a minimum target. Regardless of what happens in the rest of the market, it's likely that targets are going to remain an important part of the landscape, partly because governments like setting targets. Utilities also like setting targets. And those are unlikely to go away.

So that component of the policy landscape, to put it that way, I would argue is likely to stick around. Again, I underscore that all of this is conjecture. All of this is speculative. And many of you listening who've made it this far into the presentation may also have your own views and opinions on this. So take all of this with a grain of salt. These are open reflections. Nothing is set in stone.

Another point is that streamlined permitting and interconnection procedures are likely to remain key. In other words, you don't build projects without clear permitting. And one of the big issues that's facing many of these large scale, competitive, solar PV projects is that they run into permitting and interconnection barriers. So it will remain—it's likely to remain important to simply remove barriers and make sure that market access is secured and that there are no unnecessary barriers to investment. And that's not the case in many markets, whether you're talking about Latin America, Africa, parts of Asia, even North America and Europe.

There are abundant barriers to accessing the electricity market. And those barriers will need to continue to come down for us to continue to scale up solar in many cases, no matter how cheap it gets. So another aspect that's likely here to stay is the rise of corporate and so-called bilateral PPAs. Companies want cheap power supply. Companies also like the branding effect of being able to buy 100 per cent solar from a particular company.

This makes sense, and that market segment is likely going to continue to grow across the world, as long as regulation does not outright prohibit it, which it continues to do in many countries. So again, that comes back to the point about removing barriers. Hybrid PPAs are likely to continue growing. That's what we saw at the end with these hedging type arrangements, where

part of the contract is locked into a PPA—a part of the output, rather, of a solar project is locked into a PPA and part of it is exposed to market prices and is sold directly on the market. So we're likely to see that hybrid—these hybrid structures remain a major growth engine, a major part of the solar PV investment landscape.

Another key point is that these new business models that we touched on—leasing, peer-to-peer power sharing, virtual net metering—are likely to continue to grow in importance, as well, as, again, the market becomes increasingly decentralized and as businesses get savvier and better at providing solar solutions to households and businesses. Alternative policies like solar mandates—for example, this is a different kind of mandate than the one that's in RPS, but mandates like an obligation to include solar for some share on all new construction—is likely to become more widespread. We've seen recent laws adopted in France, as well as in Spain. And countries like Israel have had this for years, mandating that solar be integrated into buildings of certain types according to something building codes.

So we're likely as solar gets cheaper and cheaper and the economics are there—there's no negative downside to including such a mandate. I think we're likely to see those become more and more widespread than they are today, which is, again, a policy tool but a different one from the ones we've discussed so far with rebates and feed-in tariffs and all the rest. The self-consumption market is going to become a major part of the market and is likely to remain a major part of the market as households continue to invest and businesses continue to invest to meet their own needs. And finally, the economics of solar plus storage are a major, potentially redefining trend reshaping the industry's future and potentially even the power sector in the process.

So that's another major area to watch and major trend to pay attention to. It remains the case that despite all of these innovations and all of these new business models, that keeping lenders, i.e. banks, involved in the financing of solar PV projects requires bankable business models. Solar PV projects need to pencil out. They need to be economic. They need to be financeable. Otherwise we don't get the scale of investment needed in power markets in the years ahead to meet climate and energy and other related goals. So it's critical to keep the flow of low-cost finance to the sector open.

And it's unclear, at least to me, that spot-market prices can do that alone, largely because of the cannibalization effect that we discussed earlier, the so-called elephant in the room. So solar has to still remain bankable in order for it to scale, even if it's the cheapest source of new power supply. So even if there's no cheaper source of power, we still need a fundamentally bankable proposition, a fundamentally investible proposition. And if wholesale market prices remain negative during the daytime for a growing number of hours of the day, it simply will not be bankable.

So we're going to need other solutions. And some of that may involve, which is already happening, integrating storage, integrating power to gas, power to hydrogen, power to X, power to other applications. Some of that may indeed

help. Demand response is also likely to help by being able to shift more load to the daytime. But again, the fundamentals need to—still need to work for projects to be investible. And that's unlikely to change. Open questions. We've talked a lot about feed-in tariffs and wholesale market prices. Some are arguing that we need to shift potentially to payments based on value and away from per kilowatt hour LCOE based payments like feed-in tariffs and PPAs.

That's a whole other avenue for discussion, how to define value. What is the value or solar? And how can that be paid for? Should it be paid for on a capacity basis, back to capacity payments? Or should it be—remain on a kilowatt hour basis? Or maybe do we have hybrid approaches with both capacity and value based components? This gets very, very technical, and I—we don't have time, unfortunately, in the remaining minutes to unpack all of that. But these are other potential topics certainly worthy of more research, more analysis, and more thoughtful reflection.

Technology-neutral auctions as a long-term solution, potentially. Maybe auctions, if allowed to continue because of the competitive economics, are enough. We just continue signing contracts and letting auctions determine the suppliers. Maybe. What about carbon pricing? We haven't talked much about externalities and other factors? Certainly can't hurt. What about financial de-risking mechanisms, things like low-interest loans or off-taker guarantees? In many markets, particularly in emerging countries in Africa, in Latin America, utilities are not always fully solvent.

So it's going to be difficult to get a lot of solar built, large scale solar in particular, without off-taker guarantees. So again, this may be another avenue, another way in which, another pathway for solar policy to evolve in these markets. And indeed, that's arguably the way that it already is evolving, as many of the project being built in Africa, the large scale projects, are being built with various forms of partial or complete off-taker guarantees, sovereign guarantees, and so forth. So again, important questions and possibilities here.

One important point as we wrap up is that we are not moving fast enough. If you look at renewable energy growth here in solar PV, we've had a number of boom years, and things were going quite steadily, quite rapidly. But it really does look like from 2017 to 2018 that we are starting to flatten out. And there are important—this underscores the need for scalable markets, the need for more investment. It is far too soon for the PV industry to be plateauing. We are likely to need much more ambitious, much more rapid growth.

And that means that we are likely to continue to need policy and regulatory guidance, policy and regulatory frameworks, to pick up on our earlier language, to continue to ensure that projects are bankable. And those are likely to include a number of key elements among the ones we've discussed here. The reason this is so important ultimately is that solar remains our most abundant energy resource. If you look here at the natural availability of renewable energy sources versus world energy demand on the far left, you can see here that solar is by far and away our largest available energy source. And the potential, again, to continue tapping it remains vast.

There's a—an interesting, in closing, historical anecdote that is useful here to help sort of wrap all of this up. A 19th Century French economist, Frederic Bastiat, wrote a satirical letter on behalf of the candle industry at the time, which was feeling threatened by the rise and emergence of the lightbulb and the fear that the lightbulb would put the candle industry out of business. And you can see here a little cartoon. I'll read this to set the stage.

He writes, "We are suffering from the ruinous competition of a rival who apparently works under conditions so far superior to our for their production of light that he is flooding the domestic market with it at an incredibly low price; for the moment he appears in the morning, our sales cease, all the customers turn to him, and a branch of our industry whose ramifications are innumerable is all at once reduced to complete stagnation. This rival is none other than the sun."

So he writes—he continues, "We ask you lawmakers to be so good as to pass a law requiring the closing of all windows, dormers, skylights, inside and outside shutters, curtains, casements, bullseyes, deadlights, and blinds—in short, all openings through which the light of the sun can enter houses. Make your choice, but be logical. How inconsistent it would be to admit the light of the sun, whose price is zero all day long."

And indeed, this underscores the fact that, as solar PV gets cheaper and cheaper, the marginal cost of supply is effectively zero. And we need electricity markets that can deal with that, that are potentially built or redesigned, restructured around that. And ultimately we need policy that recognizes that. And currently we aren't there yet. Hopefully this little anecdote helps put this into perspective and also sheds light on some of the challenges that we face.

Hopefully this presentation has given a good, thought-provoking overview of some of the trends. I have been unable to cover everything that's happening in the market. But hopefully it touched on enough to really give you a sense of some of the debate, some of the issues at play and given you food for thought for where the future of solar policy could be heading in the years ahead. I have provided a few articles as further reading here to stimulate discussion further. And we'd like to thank the International Solar Alliance as well as the Clean Energy Solutions Center for supporting this webinar series.

I am Toby Couture from E3 Analytics. And we'd like to invite you now to take a few moments to answer the knowledge checkpoint in a few quick multiple choice questions. Wishing you all a great day and look forward to being with you again next time. Thanks a lot and all the best.