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Subsidy-Free Solar

—Transcript of a webinar offered by the Clean Energy Solutions Center on 24 September 2019—
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Webinar Presenter

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Toby Couture Good morning, everyone. Welcome to the International Solar Alliance Expert Training Course. This is session 15, focusing on Subsidy-Free Solar. I am Toby Couture and I'll be delivering this training session. This training series is supported by the International Solar Alliance, in partnership with the Clean Energy Solutions Center. This training is part of module three, which looks at the future of solar policy.

Provide a quick overview of the content of this presentation. This is increasingly a very hot topic. You have perhaps heard on media reports or in articles about the rise of subsidy-free solar. The focus today is to try to unpack that and look at what we mean by subsidy-free solar, try to understand the trend, try to understand the markets where this is happening. After that, we'll have a few concluding remarks, a bit of further reading as well as some multiple-choice questions at the end.

So, let's look at the learning objective. First, the aim is to understand the rise of subsidy-free solar. Where does this come from? Why are we talking about it now? Understand what we mean by subsidy-free solar, in particular looking at two different market segments where one can talk about subsidy-free solar. We'll try to understand the different jurisdictions where it has emerged and, fundamentally, to understand what the rise of subsidy-free solar means for the sector. Is this the dawn of a new future for solar or is this yet another temporary transition into something different as challenges in, for example, wholesale markets make the direct exposure to wholesale market prices problematic for projects like solar with high upfront capital costs or at least whether high, they're at least most of the cost in an investment of a solar PV project are borne up front when you make the initial investment and you purchase the panels, the mounting infrastructure, and the construction

associated with it. So, we'll try to unpack these issues looking specifically in the wholesale markets discussion.

So, without further ado, let's dive in. For most of the last three to four decades, solar policy has involved a wide range of different subsidies; tax-incentives, rebates, grants, mandates, various forms of preferential treatment such as priority grid access, in some cases not only grid access but priority dispatch within the merit order, feed-in tariffs, net metering, among others. A wide range of policies, a wide range of different incentives. For a deeper look at some of this, I encourage you to have a look at session 14 where we provide an overview of solar subsidies of various kinds that have been used over the decades.

Of course, in addition to this, it's important not to forget the importance of R&D, research and developed, in the emergence of the solar industry, and the solar sector, more broadly. This was a critical part, particularly in the early decades when it was funded by governments. In recent years, industry has largely taken over much of the R&D investment, at least in the standard commercial PV market segment. But research and development continues and product improvement and the cell efficiencies and so forth continue to improve. We're even seeing the emergence of new technologies like transparent solar cells that can actually collect solar energy both on the way down as well as bouncing off the ground on the way back up and hitting the underneath of the panel surface. Indeed, a growing number of projects in desert projects, in particular, are starting to use these technologies because they can improve yield. Apparently, the costs for such projects, the gain in efficiency justifies the additional cost of the panels. So, again, although we don't' talk about R&D in the solar sector anymore, it remains very much a dynamic and improving technology.

However, as the topic of this presentation underscores, we have seen the emergence in recent years of projects, announcements of projects, and the construction of projects that require very little or no explicit subsidy. This has led to some solar project being declared subsidy-free. Again, for many in the business press and sort of from an economic—many economists argue that and have been arguing for decades that this is ultimately the Holy Grail, having scalable, investable solar power projects that can be done without government support, without government subsidies so that the market can be opened up and we can have competition and the cheapest technology will win. In this case, if solar PV can emerge as the cheapest technology, the we don't need subsidies anymore and the market—again, the theory goes—can scale on its own in the absence of explicit government supports or government subsidies.

Now, this is a major issue, of course, in markets that have large legacy subsidies like Germany, Spain, and so forth. But it's particularly important in markets in the developing world where electricity prices are often subsidized and purchasing power income levels are much lower and concerns over electricity-price increases are much more acute, much more acutely felt. So, the potential that solar could become cheaper, even for these households and

businesses in developing countries and could even help bring electricity rates down or curb downward the rate of increase in electricity prices is quite exciting. We'll look a little bit at that in some of the slides ahead.

Indeed, you've no doubt heard of recent solar PV auctions, particularly in Europe that have resulted in contracts with zero premium attached. In other words, projects participated in a competitive auction in order to essentially gain the right to bid into the wholesale market and obtain the wholesale market price with no premium, no bonus. Simply, in order to win, essentially, the permit to build a particular solar project as part of the quota that's been allocated. So, subsidy-free solar projects are now being built in a wide range of markets throughout the EU. Some of them within traditional auction policies. Some of the outside of traditional government or utility-run auction policies. Again, we'll unpack some of those examples in the slides to come so that you can better understand where these projects are and, fundamentally, how they work. I've provided a few links here below. There'll be some more in the slides to come.

Now, in theory, the move beyond subsidies could put the industry on a more stable footing. In other words, less reliant on government support, as I pointed out a few moments ago, and perhaps, even more importantly, less exposed to the risks of stop and start cycles caused by inconsistent government policy. We've seen start and stop development in major markets like Australia, Spain, the U.S., and indeed, here even in Germany caused by either changes in policy, by a tightening in policy, or by a discontinuation of existing policies. That start and stop cycle has led to some even referring to or coining the phrase the solar coasting. In other words, the up and down cycles of the solar industry are like a roller coaster pulling investors along with them and developers and, indeed, the solar industry with all of the jobs in installation, construction, and so forth associated with it. So, the prospect of moving to a subsidy-free future where solar can fully compete on wholesale market prices and be financed and scaled on that basis opens up the possibility that the market could indeed move beyond the start and stop cycles and get away, again, from being reliant on government policy and regulatory frameworks.

Now, it's important to underscore, at this stage, that not all government policy is or constitutes subsidies. There are a lot of things that are part of the regulatory framework in a given country, in a given jurisdiction such as access to the grid, grid interconnection standards, basic permitting rules, land access rules, zoning. All of those kinds of things are not subsidies. They are rules that govern the evolution of the sector, just like the construction sector. Whether you're building a new shopping mall, a parking lot, a residential development, you are subject to rules and regulations; governing, zoning, water canalization, environmental impact, and so forth. The same applies in the solar sector. So, even if we say subsidy-free solar, what is not meant by that is the complete removal of all regulations and all rules. The sector still, as all sectors still, operates within an overarching government enabling framework.

What we're talking about here is specifically the price and incentive landscape. What are projects getting in terms of pricing? Who's paying for that solar electricity? Are there any subsidies or incentives provided? For example, among the most common are tax incentives, either VAT exemptions, tax exemptions for—tax holidays are commonly used. What we're talking about here is fundamental the removal of those kinds of subsidies and not the removal of all governing or enabling regulations.

Now, in the absence of clear subsidies, in the absence of government-backed feed-in tariffs or other direct tax and other subsidies, investors are starting to assess solar PV on its own economic merits and financial fundamentals. In other words, investors want to know, "Can solar PV projects produce sufficient cashflows to pay for themselves in a reasonable time frame?" That's really the fundamental question. Do solar projects offer other benefits such as hedging, portfolio benefits in terms of diversification for larger investment funds or investment firms, branding benefits—for example, for corporate clients that are starting to sign corporate PPAs or power purchase agreements with solar projects—or energy security related benefits, and how are those various benefits priced into the overall decision making. So, even if the solar is not benefitting from direct subsidies, it's providing a number of additional benefits that can make it bankable and financially attractive, economically attractive, even if the payback time remains, say, longer than what the company would traditionally expect for investments in its core business.

Fundamentally, this shift to assessing PV projects on the basis of their cashflows shifts the emphasis to the electricity market. What is happening in the electricity market? Who is buying power in the electricity market? Who can, who is allowed to purchase power? Is it all on the wholesale market? Is there a single buyer, as is the case in many markets around the world? One national utility that is designated as the single buyer. Or can companies, institutions, even local governments purchase power, purchase electricity from solar projects directly themselves on a bilateral basis? So, this shift to looking at the financials fundamentals of projects forces investors, forces developers to crack open the market and look at, "Who are the different buyers? How does the electricity market work? Can we pull together a sufficient amount of revenue from the sale of the electricity generated by the solar project in order to pull a bankable project together?"

As we'll see, in many cases, projects are starting to combine different revenue streams. They're combining wholesale market sales with a partial power purchase agreement for a portion of the output. So, for example, if a project produces 100-gigawatt hours per year of electricity from the solar project, they may strike an arrangement to sell 50 gigawatt hours of that output to a company and market the remaining 50-gigawatt hours directly on the wholesale market, thereby providing, essentially, some price protection, a bit of diversification within the project itself, within the revenue streams. What we're seeing is, indeed, that approach is becoming increasingly common. It's one of the key ingredients that's making—one of the key tools being used to make subsidy-free solar possible.

Indeed, many subsidy solar projects announced thus far that you read in newspaper articles and in media coverage have not been true merchant power plants that sell 100 per cent of their output directly on the spot-market. We see that the term subsidy-free solar continues to be used quite loosely. It raises the question and a number of the other issues around what constitutes a subsidy, what do we mean by solar subsidies. For that, again, I point you to the previous training on fund subsidies specifically.

Most projects that have achieved subsidy-free financial close—in other words, that don't benefit from a feed-in tariff, that don't benefit from explicit government subsidies or price supports—have succeed in locking in partial or full PPAs with corporate off-takers or with institutional buyers. For example, institutions, municipalities, universities, and so on. So, this is, again, one of the key tools that companies and project developers are using. This enables the developer to lock in a portion of the project sales at a firm PPA price, which reduces the risk and can even improve the returns versus a long-term fixed feed-in tariff. Because many of the PPAs that are signed with corporate off-takers come with escalation clauses in them. In other words, the price rises over time slightly to track inflation and to track the expectation that electricity prices in the market themselves will increase over time.

So, some feed-in tariffs, such as in Germany, were inflation neutral. In other words, there was zero inflation adjustment. The tariff price was nominal. This means that by signing a PPA with a corporate buyer that has an inflation indexation included can actually, potentially, improve returns versus a long-term feed-in tariff that would have been offered under the government feed-in tariff policy. So, it's not all bad. Some developers, indeed, are finding that there can be some advantages of locking in these kinds of projects. We're seeing more and more enthusiasm from some of the bigger players in the sector. Again, lots of questions marks. Lots of uncertainty remains around the long-term trajectory here. But I think it's fair to say that there definitely is an excitement around this innovation and these kinds of development that are sweeping this sector. We'll look at a few of these more closely in the slides to follow.

So, as I pointed out at the outset, it's important to distinguish between the different market segments. So, broadly speaking, we have the residential and commercial market and the wholesale market. The first is behind the meter. That means it's for customers who are using PV for self-consumption first and exporting their excess generation to the grid. The others on the wholesale market are typically not for self-consumption or they are sold bilaterally with a corporate off-taker or institutional off-taker. Broadly speaking, number one, the first category is happening at the distribution level. So, distribution connected projects. Number two is mostly happening at the transmission level, but there are exceptions.

So, let's look at the first of these, the residential and commercial market, and try to understand the rise of subsidy-free solar in this market segment. Subsidy-free solar in this market segment means that customers can save money on their power bills by investing in solar, even without explicit

subsidies, rebates, or tax incentives. For example, this could involve a pure-play self-consumption project on a supermarket, for example. So, you have a supermarket, grocery store, large roof space. They install PV on the roof. Of a standard supermarket, you're looking at somewhere between 30 and 50 per cent of the onsite electricity demand that can be met with the onsite solar. It'll rarely exceed the daytime power needs of a supermarket. So, essentially, you have a pure self-consumption based behind-the-meter solar project that doesn't necessarily need subsidies because it doesn't even connect to the grid. It's essentially a private purchase that the supermarket makes to reduce its purchases from the utility.

In that configuration, the decisive factor of whether this is an economically attractive proposition or not comes down to the retail price that the customer pays. If the retail price is sufficiently high, the economics can pencil out which means the project can be invested in, can be developed behind-the-meter, and can be effectively subsidy-free because it's, again, a private purchase. From the utility standpoint, this basically just registers as demand loss or load loss. So, it's essentially energy efficiency from the utility standpoint. From the customer standpoint, they are able to save money by reducing their purchases from the utility and they are able to then become more self-sufficient.

Another pathway can be achieved by solar leasing. For example, where a third-party developer will come in and offer either a household or a company the ability to install solar on their roof on a turnkey basis and sign some kind of agreement that's typically lower than the retail price offered by the utility. So, this, again, is kind of subsidy—can be subsidy-free if there's no government subsidies entailed. This is not the case in the U.S. In the U.S., the solar leasing market, which remains the world's largest solar leasing market remains heavily dependent on the presence of federal tax incentives. That's one of the key things that's made this business model work in the U.S.

Now, in the case of solar leasing, you don't need those tax incentives increasingly as solar gets cheaper and cheaper. There would be a subsidy-free business model to be built around solar leasing if the retail prices are high enough. Now, if the project is grid connected and if it relies on exporting the net excess generation, it continues to rely on the grid, which means there's still some kind of reliance on the tariff and pricing conditions offered by the off-taker or by the utility.

Now, if you look worldwide I've selected a few examples here and updated this to 2019 showing, essentially, the current retail price in different markets. The second column shows the approximate levelized cost of electricity generation from customer-sited PV in these different markets. Then PV as a per centage, the cost of PV as a percentage of the retail rate. You can see here that in Germany, Hawaii, and Australia, it's somewhere between 20 and 30 per cent of the retail price. In other words, significantly cheaper. We're talking a quarter of the price of the full retail price paid with taxes. So, very attractive to engage in self-consumption in these markets if you have suitable roof space, if you have access to capital, and so on.

In New York, also quite attractive. You can see here at 44 per cent of retail prices. Here in Cape Verde, on the west coast of Africa, with fairly high retail rates—it's an island—PV is a bit higher because of financial costs, financial—essentially, the cost of capital. But you can see here that even in Cape Verde, it's quite attractive.

However, even if the levelized cost of solar is significantly below retail prices, this does not automatically translate into rapid sustained market growth. Solar PV projects, particularly ones that are large enough, still rely on the grid to export their excess. Now, this changes once you start adding storage into the equation. For that, we'll look at our second market segment, the one with storage. But even if you don't have storage, many barriers persist and I've hinted at a few of these, even when it's economic.

You have the upfront cost. A solar system for a traditional residential household will cost you anywhere from €1,000 up to, say, €5,000 at current market prices. Not all households have that kind of disposable income, particularly not in developing countries. Even in markets across Europe, sometimes the upfront cost is a major barrier, which is why we're seeing the emergence of leasing companies and others, such as in the U.S., and in markets like the Philippines that are taking that upfront cost away by enabling you to sign the lease agreement. It basically enables you to pay for your solar system over time, just like you would pay for a car on a lease.

Another key barrier here is awareness. Many customers don't know how cheap solar has become. Access to financing is another major barrier. Let's say you're a commercial customer and you really would like to do solar. You have the roof space, but you don't have the capital or you don't want to spend that much cash to finance a project. You'd like to get financing, but many banks won't provide financing for self-consumption-focused projects. So, again, further barrier that hinders the uptake, even if it's economic, even if the paybacks are quite attractive.

You need suitable roof space or suitable land space. There's also an issue around renters versus owners. In most cases, people developing solar projects are owners. For renters, a host of other issues emerges, again, that continue to act as a barrier to the market scaling up. So, economics is critical and is a very important part of this equation, but it is not the whole story as these barriers and examples underscore.

Now, what happens when you add solar plus storage? What happens if you have a solar—if solar plus storage can be developed on a subsidy-free basis and undercut the retail price? The addition of storage opens up a new category of subsidy-free solar. It particularly could be cost competitive and can be cost competitive in island regions where electricity prices are much higher. In jurisdictions like Hawaii, as we saw, retail prices are north of €0.30 per kilowatt hour. There are some markets in the Pacific Islands region where retail prices are north of €0.50 per kilowatt hour. In those kinds of jurisdictions, even solar plus storage can start to be attractive. Battery storage costs continue to come down. So, this market is certainly poised to grow.

Storage is also attractive in markets that have high demand charges. Demand charges are essentially a fixed charge added on as a per cent—on a dollar per kilowatt of peak demand basis. That means if you surpass a certain threshold, you pay often quite high demand charges for having surpassed a certain peak demand on the network. This can make the addition of storage quite attractive. Indeed, in many commercial PV projects around the world, one of the main rationales, one of the main economic drivers is not just reducing your electricity consumption from the utility. It's reducing your demand charges. Because the demand charges can make or break the economics of the project. So, in some cases, in the U.S., the addition of storage can have—in markets with high demand charges can actually lead to payback times of two years or less for storage investments. So, we are—even if there were no subsidies, no supports for storage, in many markets there are different kinds of support programs. But even without subsidies, storage can be an attractive investment particularly where demand charges are quite high.

But another attractive market for storage is in jurisdictions with costly diesel-based and/or fundamentally unreliable power supply. Many off-grid regions around the world that are reliant on diesel, like islands, are using heavy fuel oil. Markets like Jamaica, throughout the Caribbean, throughout the—indeed, the Pacific Island regions, as well as markets like Nigeria where a lot of the mini grids and a lot of the systems are diesel-based and where customers' only alternative to dealing with unreliable power supplies currently small-scale gasoline generators. Indeed, we're starting to see that solar PV is starting to be cost competitive with gasoline generators and that's opening up the potential for cost competitive solar plus storage solutions there. We'll look at that a little bit more closely in a moment.

In such context, solar PV can be competitive even without subsidies. The challenge as ever remains the upfront costs.

In Nigeria, customer spend over $12 billion per year on small gasoline generator use, broken down roughly as follows, with roughly $8 billion per year spent on fuel alone. Fuel is obviously subsidized, which is another factor. Underlying all of this, we talk about the end of solar subsidies and yet many governments continue to subsidize fossil fuels. So, there is a major disconnect here. Some would argue that before we start talking about phasing out solar subsidies, we should phase our fossil fuel subsidies and then maybe we wouldn't need any subsidies at all. We could have, essentially, the much sought-after level playing field for different generation technologies.

The problem with the level playing field argument is that it's not that simple. Different technologies have different characteristics. Some are variable. Some are dispatchable. Some have variable costs. Some have virtually no variable costs. All of those things impact how the electricity system adopts technologies even if all technologies were the same price or if all, for example, solar technologies were cheaper, there are other considerations that drive the power mix in different jurisdictions including politics and resource availability and jobs and so forth. So, what we're seeing here is a market like

in Nigeria where off-grid generators used by households or even within the grid to deal with power reliability issues.

Yet, the difference here is stark. A 1.5-kVA generator which is a standard household generator size costs about $150.00 U.S. for the entry level product. An equivalent solar plus storage system will cost somewhere around $2,500.00 U.S. currently. That's with all the wiring and all the lighting and everything set up. Essentially like a pay-go system. Now, that's a fairly substantial cost difference. But the generator needs to use fuel. So, there is a pay-back time. Estimates by Dahlberg—I've provided the report here and a link to it—suggests that the solar plus storage systems are competitive within six to nine years. But, again, because of the upfront cost of $2,500.00 it's too expensive for many households to afford upfront and people continue to use the gasoline generators because, again, they have a low upfront cost and can be—they're fundamentally more affordable.

Now, shifting from that to larger-scale markets, we're seeing a number of projects being developed around the world with solar plus storage at very attractive prices. Starting from the left here, you can see in Hawaii, a group of seven PV plus storage projects, a total of 262 megawatts. So, very sizable PV installations, 20-year PPAs between $0.08 and $0.12 U.S. Now, in the U.S., there is the ITC, the Investment Tax Credit that does significantly impact the equation here. But if you add, say, 25 per cent, 30 per cent to that, you still end up in quite attractive PPA price ranges when you compare to the retail prices in Hawaii. So, solar plus storage in Hawaii can undercut the grid price. That, in itself is a major achievement.

In Guadalupe, Martinique, a couple of projects, a little bit smaller, a few years ago, signing a PPA price average across a basket of projects of around $0.134 U.S. per kilowatt hour. A project proposed in Palau, a bit further out, a bit higher logistical risks, priced in at $0.18 to $0.20 a kilowatt hour. In the Cooke Islands, between $0.15 and $0.20 per kilowatt hour for a smaller scale, more island-dimensioned projects but still show that solar plus storage is increasingly economic and can increasingly compete on a standalone basis against the grid price. So, this opens up the possibility for cost-competitive, subsidy-free solar plus storage in a wide range of markets worldwide, particularly in island markets and in jurisdictions reliant on diesel or heavy-fuel oil that's not too heavily subsidized.

An analysis here—I pulled this graph together drawing on some numbers from Lazard, the LCOE analysis that they do. You can see here for—there are three different groupings. One is for residential. You see there at the bottom, Resi. C&I is commercial and industrial. Then the green on the far right is utility scale. You can see here that across the three different market segments, the LCOE of solar plus storage ranges for utility-scale projects between $0.10 and $0.20 a kilowatt hour or, say, $100.00 to $200.00 per megawatt hour which, again, is consistent with the ranges we just saw from our island projects on the previous slide. You can see here for commercial projects the approximate LCOE there in the range between, say, $0.30 and $0.40 per kilowatt hour. For residential-scale projects, somewhere between $0.50 and $0.70 per kilowatt hour. So, the ranges vary.

This is the LCOE assuming no subsidies but also assuming that there is no demand charges. So, if you add demand charges to this commercial/industrial category and the cost savings there from reducing demand charges, the true cost savings can be much higher than suggested by these LCOEs. So, it gives you an idea of where the market plays out. Again, I underscore across all three segments battery costs are coming down rapidly. So, this is a dynamic space and getting more attractive, more economic by the day.

Solar PV plus storage is also starting to emerge as a cheaper way to supply remote communities, even without subsidies. A recent analysis, which I've provided a link to here, from Australia's National Regulator found that solar plus storage is the cheapest way to maintain electricity access in remote communities. So, they're starting to actually phase out or scale back the maintenance of long distribution lines and islanding remote communities so that they can run on a solar plus storage system because it's cheaper. This is, again, without subsidies.

Once solar plus storage is competitive with grid supply, as we see in some of the island markets, and can offer reliability at the same level as the grid, all bets are off. It is conceivable that solar plus storage could disrupt much of the traditional utility sector. For residential households that have roof space, for even multi-unit buildings, for shopping malls, for larger institutions, universities, government buildings, manufacturing sites, industrial sites, even in agriculture, much of the power use could be transitioned to solar plus storage in the coming years if the economics continue in the direction they're going. This has potentially very transformative, very sweeping implications for the future of the electricity market and, indeed, for the future financial viability of many utilities.

However, some challenges do remain. As we come back to again and again, there are the upfront costs, which can be offset through leasing arrangements or through third party providers. There is the operations and maintenance risk, particularly with battery life, for example, battery replacement costs need to be priced in, as well as a host of issues around, say, material, scarcity, availability of lithium and cobalt and so on. A host of other issues that could emerge to introduce further complexities to this picture. But if the economics

are there, which they increasingly are now in 2019, entering into 2020, we are really entering a brave, new world.

So, let's look at how these trends play out in the wholesale market. This is where projects are reliant either on a corporate buyer or a direct wholesale market sale. Subsidy-free solar has started to emerge in a number of markets, particularly markets with deregulated or liberalized electricity markets, such as in Europe where electricity prices have traditionally been higher. There are broadly two types that we're going to focus on here. One is direct wholesale price competition and the other is corporate or institutional PPAs where 100 per cent or at least a substantial portion of the output is sold to a corporate or other buyer. These can be "subsidy-free."

In many of the deal announcements around these "subsidy-free" projects, it is sometimes unclear whether the project has secured a PPA or whether it involves pure merchant sales. Merchant sales means pure exposure to dynamic wholesale market prices. Now, there are other products in ultra-city markets that are not just the real-time price. There's day ahead markets and other products that solar projects can technically also participate in. So, it's a bit more nuanced than just talking about the wholesale market price. But for the purposes of this presentation, the important thing is that the sale is happening on a dynamic basis, based on dynamic market prices and is not supported by explicit government subsidies or price supports.

But because it's not often clear in some of these announcements, when you read these headlines and press releases, the examples I've included here include a mix of both. In other words, some projects are going merchant. Some projects are combining with PPAs.

Let's start with Spain. Spain has gone from a European "symbol of policy U-turns to the continent's zero-subsidy hotspot." Very significant turnaround. Spain, as many of you no doubt know, was criticized over many years for retroactive policy changes to its feed-in tariff policy which led to widespread uncertainty and capital flight from the electricity sector and raised a host of questions around feed-in tariffs and around that government policy in the renewable sector, in general. In response, now, wholesale market prices in Spain are inching upward which makes these market-based projects selling directly on wholesale marketing increasingly viable.

A 50-megawatt plant near Madrid was recently signed and managed a secured debt financing on a 50/50 basis with debt equity, which is pretty remarkable. Still quite high equity shares traditionally under feed-in tariffs with long-term price guarantee. Projects were financing more on an 80/20 debt equity basis or even 90/10. So, you can see here that the higher risk is being reflected through a much more equity heavy capital structure.

Another 50-megawatt project is being developed near Seville combined with a 12-year corporate PPA. So, a bit of a hybrid arrangement. A 79-megawatt pure merchant power project was recently signed, again, in August of this year. Another link to that. With 75 per cent debt and 25 per cent equity with power sold directly on the spot-market. So, a pure merchant project managed

to secure a 75 per cent of debt which is remarkable. Again, these are very surprising developments to many in the market who are following this and, again, is a sign of some of the trends that are reshaping the market. As we'll see at the end of this presentation, there are still risks on the horizon here. So, I have to caveat a lot of this and it's important to look at a lot of the enthusiasm in this industry for these pure merchant projects to take them with a bit of—with a grain of salt, if not a chunk.

Portugal has recently finalized the largest so-called subsidy-free solar PV project in Europe, in September of this year. A 221-megawatt project built with an international consortium. You can see here nearing completion.

In Italy, Italy has recently seen five new solar PV projects without subsidies totaling 64-megawatts of installed capacity across five different sites. Developers managed to secure project finance debt for the project despite the lack of the government price supports of subsidies. Again, electricity prices in Italy are quite high, particularly retail prices. The ability to sign PPAs with manufacturers, with corporates is possible and is starting to make some of these projects, indeed, quite attractive. That's why we're seeing more and more interest in Italy. The developer, in particular, that's developed these sites is looking now to expand across a range of different sites around the country. So, we are, arguably, at a tipping point or beyond a tipping point in Italy as well.

Germany, along the bastion of feed-in tariffs in Europe has seen a few as its phased away from feed-in tariffs for larger scale projects. It's seen a few subsidy-free solar PV projects being signed in recent months. There was an 8.8-megawatt project signed in May 2019 by a long-term corporate PPA. The project was actually in addition to an existing PV site. So, they gained a bit more land, were able to expand it by 8.8 megawatts and had less construction risk and less concerns over grid access because all of the equipment and substation and so on was already there. But in addition to this smaller project, there are an estimated 500 megawatts of solar PV projects being developed across a range of sites in Brandenburg and Mecklenburg-Vorpommern. In those regions, to be developing solar PV projects without subsidies is, again, a sign that the German market is catching up, if you will, with its Spanish and Portuguese and, indeed, Italian counterparts.

EnBV which is a large utility, EnBW announced a single 175-megawatt PV project slated to start construction towards the end of this year. Also touted as a subsidy-free solar project. So, again, very, very significant project, sizes. Some of them involve corporate PPAs. Again, a sign of where things are trending.

Shifting to an island market in Europe, Cyprus currently relies on heavy fuel oil and diesel to power its grid. It currently has 120-megawatts of solar PV with targets to reach 360 by the end of next year. Historically, it's relied on either net metering or feed-in tariffs and, more recently, on auctions to procure new or renewable capacity. The last round of auctions, a few years ago, yielded prices between $0.07 and $0.10. Now, new projects are starting

to come in saying, "We can easily beat $0.07 to $0.10. Let us develop projects essentially on a subsidy-free basis."

So, they struck a new agreement where the new projects to be built are to rely strictly on the variable avoided costs which basically means the fuel costs plus operation costs of the heavy fuel oil and diesel plants which range on current numbers from between $0.12 to roughly $0.05 per kilowatt hour. So, somewhere in that range, the price will be dynamic and adjusted over time by the government and the utility. It gives you an idea, solar is now able to develop within that range in markets like Cyprus, essentially accepting whatever that variable price is.

This is similar to what's known as PURPA in the United States, which basically sets a similar avoided cost pricing obligation. So, basically, the avoided cost refers to what it would cost the utility to purchase or buy that power or generate that power itself. Avoided costs are starting to be enough to finance solar projects. So, again, this is a sign of so-called subsidy-free solar starting to sneak in in another market under a different set of regulatory frameworks. Because there's no wholesale market in Cyprus, it's quite a small electricity system, the use of avoided cost pricing provides the nearest benchmark for that.

Finally, China, never to be left behind in discussions of the global solar industry, has published an 18-month roadmap recently to transition to unsubsidized solar PV in the country. It's basically going until the end of next year. Some projects are already going ahead outside of the official government quotas and grid parity is increasingly widespread across the country. So, we're seeing a tipping point also being reached here in China.

I've included a few maps from a recent article published in the journal, *Nature Energy*, with citation here. You can see here user-side grid parity in the darker, on the left-hand side, with the different ranges in Renminbi. Then grid parity, plant-side, for larger-scale projects within different regions and where it's attractive and where it's been achieved. So, you get a sense here of grid parity starting to become the case pretty well across significant parts of China.

Indeed, this is mostly driven by solar PV cost decline which has been pushed forward by China. Solar PV is now broadly competitive with coal, even without pricing in environmental externalities. You can see here on the far-right, in green is the LCOE high and low for solar PV, current electricity market prices, the range, and then as well as the range of coal—for diesel and for ice coal benchmark price. So, PV is already competitive with coal in China and is poised to become more so. If environmental externalities were included in terms of all of the health and associated water and other factors, it would be even more so. So, again, China is also on the cusp of a potentially substantial transformation to subsidy-free solar in the years ahead.

So, a few concluding remarks. One aspect that we haven't talked about yet around all of this and it looms in the background for many projects that are starting to sell their power directly on wholesale markets is the

cannibalization effect. As the share of solar PV in a market grows, wholesale market prices tend to trend downwards. You can see here, as the penetration of PV grows, that impacts the revenues, essentially, that projects would be able to derive for their daytime power output. In other words, subsidy-free solar may work for the first few projects that get connected, but even those first few projects could have some rude awakenings in the years ahead of the share of PV in the market continues to grow as it is expected to.

Now as the share PV grows, that means wholesale market prices decline, which means that projects without contracts, without off-take agreements are basically going to be faced with those lower wholesale market prices. We are even seeing hours of the day in European power markets where prices are negative which, again, has significant implications for the bankability of projects relying on wholesale market prices. So, I think there's a more fundamental question here to ask around the attractiveness of these merchant power projects. The economics, certainly, pencil out in the short-term if you're looking at it for the next year or two and looking at the wholesale market prices over those kinds of time horizons.

The more fundamental question is, "How justified are those assumptions around long-term trends of wholesale market prices?" Will wholesale market prices remain high enough to support bankability? Are there any other exits, any other options? For example, a merchant project then five years into the project sign in a PPA with a corporate buyer for its output and basically reduce its exposure to wholesale market prices in the process? There may be, and I suspect that most projects signing merchant deals currently have plan Bs or plan Cs built into their financials. Otherwise, I have a hard time seeing a lot of lenders keen to get involved. Because, again, the long-term prognosis, the long-term projections for wholesale market prices do not necessarily support the economics of these projects, if you assume that the share of solar will continue to grow.

That's why a number of projects are getting clever and are using hedging strategies via hybrid PPAs. In other words, a partial PPA with a corporate or institutional off-taker and selling the rest on the wholesale market. That is one way to mitigate the risks of these kinds of subsidy-free projects.

Fundamentally, it's unclear to many analysts whether spot-market prices along can provide the long-term investment certainty that the sector needs. We are currently seeing a boom and a bit of a transition and a lot of excitement around subsidy-free solar. Fundamentally, solar projects have to remain bankable. Even if they're the cheapest source of new electricity supply, we need to find good solutions to the problem of cannibalization. Part of that involves storage. Part of that involves probably more flexibility, more demand-side flexibility. Part of that involves larger balancing areas, more interconnections. But fundamentally, pricing has to support the financial fundamentals. It remains to be seen whether wholesale markets alone can provide adequate revenues in the long-term to enable the market to scale, certainly at the scale that we need in the years ahead.

So, a host of questions. I won't be able to get into all of the nuances and all of the debates and issues within the short time that we have here, but hopefully this has provided a useful overview of the debate around subsidy-free solar. I've provided here a few additional reports and citations that you can follow up if you're more interested in this topic and you want to dive in a little deeper. I'd like to thank you for your time, for participating in this training series. I'd like to thank the International Solar Alliance as well as the Clean Energy Solutions Center. I'm Toby Couture from E3 Analytics. I'd like to thank you, again, for taking the time and being with us today. I invite you now to stay on for a moment for a few multiple-choice questions. Have a great day.