CLEAN ENERGY SOLUTIONS CENTER
ASSISTING COUNTRIES WITH CLEAN ENERGY POLICY

Net Metering: Definition, Design and Considerations for Implementation

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Webinar Presenter

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Katie Today's webinar is focused on Net Metering: Definition, Design, and Considerations for Implementation. Before we begin I'll quickly go over some of the webinar features. For audio you have two options: you may either listen through your computer or over the telephone. If you choose to listen through your computer please select the "mic and speakers" option in the audio pane. Doing so will eliminate the possibility of feedback and echo. If you choose to dial in by phone please select the telephone option and a box on the right side will display the telephone number and audio PIN you should use to dial in. If anyone is having any technical difficulties with the webinar you may contact the GoToWebinar's helpdesk at 888-259-3826 for assistance.

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Finally, one important note of mention before we begin our presentation is that the Clean Energy Solutions Center does not endorse or recommend specific products or services. Information provided in this webinar is featured in the Solutions Center Resource Library as one of many best practices resources reviewed and selected by technical experts.

Today's webinar agenda is centered around the presentations from our guest panelist, Dr. David Jacobs, who has joined us to discuss incentives for regulation of self-consumption via net metering programs. Before we jump into the presentation I will provide a quick overview of the Clean Energy Solutions Center. Then following our presentation we'll have a questions and answer session where David will address questions submitted by the audience. At the end of the webinar you will automatically be prompted to fill out a brief survey as well, so thank you in advance for taking a moment to respond.

The Solutions Center was launched in 2011 under the Clean Energy Ministerial. The Clean Energy Ministerial is a high-level global forum to promote policies and programs that advance clean energy technology, to share lessons learned and best practices, and to encourage the transition to a global clean energy economy. Twenty-four countries in the European Commission are members, covering 90-percent of clean energy investment and 75-percent of the global greenhouse gas emissions.

This webinar is provided by the Clean Energy Solutions Center, which focuses on helping government policymakers design and adopt policies and programs that support the deployment of clean energy technologies. This is accomplished through the support and crafting and implementing policy related to energy access, no-cost expert policy assistance, and peer-to-peer learning and training tools, such as this webinar. The Clean Energy Solutions Center is co-sponsored by the governments of Australia, Sweden, the United States, with in-kind support of the government of Chile.

The Solutions Center provides several clean energy policy programs and services, including a team of over 60 global experts that can provide remote and in-person technical assistance to governments and government-supported institutions; no cost virtual webinar trainings on a variety of clean energy topics; partnership-building with development agencies and regional and global organizations to deliver support; an online library containing over 5,500 clean energy policy related publications, tools, videos, and other resources. Our primary audience is made up of clean energy policymakers and analysts from government and technical organizations in all countries. But we also strive to engage with private sector, NGOs, and civil society.

The Solutions Center is an international initiative that works with more than 35 international partners across its suite of different programs. Several of the partners are listed above and include resource organizations like IRENA and IEA and programs like SEforALL, and regional focused entities such as ECOWAS Center for Renewable Energy and Energy Efficiency.

A marquee feature of the Solutions Center provides as a no-cost expert policy assistance known as Ask-an-Expert. The Ask-an-Expert service matches policymakers with more than 60 global experts selected as authoritative leaders on specific clean energy, finance, and policy topics. For example, in the area of net metering we are very pleased to have Toby Couture, Founder and Director of E3 Analytics, serving as one of our experts. If you have a need for policy assistance in net metering and any other clean energy sector

we encourage you to use this valuable service. Again, this assistance is provided free of charge. If you have a question for our experts please submit it through our simple online format, cleanenergysolutions.org/expert. We also invite you to spread the word about this service to those in your networks and organizations.

Now I'd like to provide a brief introduction for today's presenter. Dr. David Jacobs, who is the Founder and CEO of the consulting firm Dr. David Jacobs is founder and managing director of the consulting firm IET, the International Energy Transition. David has an academic background in economics and languages and holds a PhD in political science. He has worked as a researcher and policy consultant for several governments and international organizations such as IRENA, IEA-RETD, World Bank, UNEP, UNDP, OSCE, IDB, and SEforAll. In addition to his research and consulting work in Europe and North America, he has worked in many emergency economies in developing countries.

And with that brief introduction I would like to welcome Dr. David Jacobs to the webinar. David.

David

Yes, hello. Good afternoon from Berlin. I hope everyone can hear me while I screen on _____, so you should be able to see it. So, today's webinar is going to be on net metering design. Normally I have three to four days of a seminar to really walk policymakers through each and every design options, so we are now trying to squeeze all of this into a 50 minute to one-hour presentation. So, I hope you can bear with me and at least 20 to 30 minutes of discussion for questions so we can clarify any further questions.

First of all, let's take a quick look at the framework conditions for prosumers. So, I was asked to be very precise on the definitions. Prosumer is someone who is consuming, but also producing electricity, and this is how the terminology prosumer actually was created. So, the framework of prosumer largely depends on two factors, and that is the cost for solar PV or distributed power generation technologies and of course the retail electricity price.

Here is a recent analysis from IRENA, which they published a couple of months ago, where they also analyzed the declining cost for roof-mounted solar PV in ten years and several countries around the world. So, the only thing you really need to see from this slide is that there's a decline in the cost of distributed solar PV in all of the countries around the world. There is of course decline [audio cuts out] degree; that depends of course also on the specific market conditions. Germany, for instance, which is the very mature market with high competition on all levels along the value chain, saw a very drastic cost decline. Same for California. We saw slower, but also existing cost decline. The major story from this slide is then of course that there is a cost decline in solar PV, and that's not only the case for distributed generation roof-mounted solar PV, but actually for solar PV in general.

On this slide you can see the cost decline for solar PV in general, distributed generation, and also large-scale systems. Over the last seven years 73-percent. What is also interesting is of course the decline of the battery costs, especially

in the last couple of years, but from 2010 to 2016 for electric vehicles we saw a decline of 73-percent, depending on the battery technology [audio cuts out] little bit, but overall we also see a dramatic cost decline in batteries, which of course is important for our prosumer discussion today for the combination of solar PV [audio cuts out] with batteries can of course further increase solar consumption levels and thus open new opportunities for different markets around the world.

Just a quick snapshot also of what we are expecting to see. This is a slide from Agora, an _____ vendor, they have done a study already back in 2015 where they have looked at the potential cost decline of solar PV. 2050, very conservative assumptions based on the learning curve concept. You probably know this, by each doubling of the installed capacity of solar PV over the last decade we saw a cost decline of around 21-22-percent. So if we assume that the global PV, the increase as we've seen it in the last years and of course the doubling of the installed capacity is now happening at a slower pace because the doubling of the installed capacity is now happening at a slower pace because it takes longer to double it from 1 gigawatt to 2 gigawatts than it takes from 1 megawatt to 2 megawatts.

But anyway, there is a clear tendency that we will see a further cost decline of solar PV in the next couple of decades. The analysis back in 2015 has shown that of all [audio cuts out] systems we'll probably see prices of 1.4 to 2.1 cents per kilowatt-hour in 2050. Some analysts say that these figures are actually very, very conservative, because already in the latest auctions that we saw around the world we saw cost of I think 1.79 cents in Saudi Arabia, 2 cents in other countries and 3 cents in Mexico. So, we're already there. In some countries where this study has assumed us to be in the year 2050. However, of course we all know that roof-mounted solar PVs systems are [audio cuts out]. But still we will see a rapid cost decline in the years to come.

And this of course opens up a lot of opportunities for prosumers, especially when we keep in mind that the wholesale and retail electricity prices in many countries around the world have been increasing, which is due to several [audio cuts out]. And first of all, we see subsidies being canceled in many countries so that we see more cost-reflective retail electricity prices. And of course, there's other factors which are higher fuel cost, but also depending on the wholesale electricity price development we saw quite significantly in cost increases.

So those two aspects are important in order to understand an important concept related to prosumerism and it's a concept of great parity. That means that once your electricity price is actually higher than the cost of producing solar PV on your rooftop or from any other renewable energy technology, then you reach this point of grid parity, and soon after grid parity one assumes that there will be an interest of these consumers to invest in self-consumption, either with solar PV or with other technologies. Of course, there are some limitations to this, because not everyone who pays a higher electricity price has a rooftop available in order to invest, and not everyone who has a rooftop

can actually—owns his rooftop as well. So, there's a few limitations. But anyway, it's a very basic concept.

So, moving on from here, let's now take a look at the very basic net metering definition. When we discussed this webinar with our colleagues from _____ _____ they asked me to start with a very basic definition of net metering because apparently there's also some policymakers which confuse the term net with Internet, which is of course not the case. Net actually refers to the net electricity consumption, so in contrast to the gross electricity consumption that you have, you're actually taking the gross electricity consumption minus the self-generated power and then you end up with your net consumption. And then metering, of course, refers to the electricity meter that you have, which manages how much electricity you consume and how much electricity you produce on your own.

So here a very basic illustration of how this works. So, you have a PV system on your rooftop with an inverter and then you have let's say we only have one meter in the [audio cuts out] graph, which is able to run forwards, but also backwards. So, in the case that you consume electricity and you get the electricity from the grids, of course the meter runs forward the usual [audio cuts out] kilowatt-hours that you consume. However, once you produce a true PV system, then this meter runs backwards because you start feeding in electricity into the grid, so you're reversing the power flows and by those means you're then, well, not only saving electricity, but you're feeding it back into [audio cuts out]. And this will then be calculated, the consumption that you have and the production that you have and you can actually match both of them over a certain period of time. So, a classic net metering scheme as we have seen it in many countries around the world in the 1980s. Actually, does not result in any cash payment; it only is an alternative way of measuring and then paying the electricity.

The standard design is as well, we'll come back to this later, at a later stage, that you can roll over the electricity for a 12-month period, so for one year you can then—your metering both your electricity generation from your rooftop, and by those means you can then say, okay, over this full year I have consumed this amount and produced this amount. This will be put together in your electricity bill and you will only have to pay the difference of it, so [audio cuts out] consumption that you have at the end of the year.

Of course, there's variations to this. This is just the very basic [audio cuts out] think this is a good starting point for you to learn about the general concept of net metering. So, what you're doing in a way is that you use the electricity grid as an electricity storage unit. So, while you're producing solar PV electricity at [audio cuts out] and then the sun goes down and you turn on your TV, you start cooking with electricity, then of course you are consuming electricity while you are not producing it on your own. So, you're using the grid as a storage unit, speaking of it in a very simplified way. And from a system perspective this makes a lot of sense that instead of having individual storage with an individual PV system in each—a battery system in each and every household. You can actually use the flexibility of the power system

altogether, which can provide flexibility, as we all know, much cheaper than individual battery storage units, and therefore this concept of net metering is very simple at start, taking advantage of the electricity grid as a very big storage unit.

So that is just the very basic definition. Now we will actually take a look at net metering diffusion worldwide and then take a closer look at the different net metering design options where we have to refine our very basic definition a little bit. So, let's first take a look at the diffusion of [audio cuts out] worldwide. As I mentioned before, it was actually first introduced in some states of the United States in the early 1980s, so it's a very old policy that exists for many, many decades already. There has been an increase, sharp increase of metering in the last, well, five to ten years, and this is of course due to the very beneficial background and [audio cuts out] work for consumerism—for prosumerism, sorry, because we see the sharp cost decline of solar PV and use of the retail electricity price.

And this is why we now see countries all over the world, this is just based on the REN 21 reports. It's just to show you that you really see now implemented in many, many, many countries around the world. I think this list is now even incomplete. I know for instance that Ghana is currently planning the implementation of a net metering scheme. Kenya has also implemented it and more countries are currently working on self-consumption schemes, either with net metering or with alternative schemes. We can further discuss these alternatives at the end of this webinar.

So, this was just a short view on the diffusion of net metering. Now let's look at the five major design options. And the first one is of course the eligible technologies. So, when we hear the term net metering we usually think about these systems and this is really the case I would say, well, in 95-percent of all policies, that there's a clear focus on roof-mounted solar PV. However, you can really open up the system also to other renewable energy technologies where there is a potential for distributed generation. Some countries have tried to work out with it, for instance for small-scale wind energy. But you can also open it up to other renewable energies, at least in theory. Even though, as I said before, really the major focus _____ is on roof-mounted and solar PV.

What is more interesting is the applicable sector. So, you have the three normal [audio cuts out] sector, the commercial sector, and the industrial sector. So, you can either open the net metering program to all of these sectors and just say, no, we have one net metering program which is very specific to our residential sector because they have a very specific rate structure and demand an alternative to net metering program or a different program altogether for our commercial and industrial customers. That's what you see in some countries around the world. Some jurisdictions also start with very specific consumers, for instance, schools, [audio cuts out] governments that you're really testing the net meterings on these very specific consumers and then you open it up to the other consumers as well. But the general design is really that you make it available to all types of sectors, however their need

of differentiating the net metering design for residential, commercial, and industrial consumers.

Now to some of the more complex net metering design options. Of course, the project and the program size limitations that you might face, first of all the program-size capsule limiting the net meter all together, this is sometimes done in countries due to several reasons. The most obvious reason is that the utility is normally not so much in favor of net metering programs because they feel that they lose customers to the prosumer part of the market, and therefore they normally try to limit the net metering in their first stages. Either you can do this by defining a percentage of the total peak demand of the utility in the country, for instance, 5-percent of peak demand. We saw this in several jurisdictions. What is probably the most common way of limiting net metering programs is that you define a maximum total capacity which can be contracted under net metering or which can participate—it's not really contracted—which can participate on the net metering. However, keep in mind that most of the net metering programs, when they start are unlimited because, well, it also has some significant benefits for the electricity system altogether and you usually only face [audio cuts out] of self-consumptions when you reach a certain share of renewables. So, for instance, Vietnam has recently implemented a net metering program, and this is not limited in size. This is also true for many other countries around the world.

What is even more differentiated sometimes is the system size caps or what is a maximum size of the solar PV systems that I can install on my rooftop. Of course, this also depends on whether I target the residential sector or whether I target the commercial sector. Most straightforward ways, of course, to say that there's a certain maximum size per PV system on each rooftop, for instance 10 kilowatt for the residential sector or 30 kilowatt for the commercial sector. What is also—looking at the third bullet point, what you also see in some jurisdictions around the world is that you have caps on the maximum allowable level of distributed generate [audio cuts out] in different circuits of the electricity and grid, because of course you're feeding back the electricity in a certain circuit of the electricity grid and the fear is that this circuit can only absorb a maximum amount of distributed generation, where it is hard to plan [audio cuts out] actually going to come into the system, where you might have difficulties feeding it back to the next higher [audio cuts out]high level of the distribution or [audio cuts out] for instance how wide they have said that pre-circuit a certain percentage of distributed generation is allowed because the grid is able to absorb this. However, no [audio cuts out] higher shares could be absorbed by the grid. I think they had recently also increased the size, because we are now a few technologies and also technical solutions at hand, which can help us to [audio cuts out] of this [audio cuts out] degeneration in the [audio cuts out] and which can also help us to better forecast and potentially load control the influx of operation in these systems.

Please also keep in mind here that the most prominent option is probably still that there is no size cap because you normally see an indirect limitation of the system size via the rollover provision. And this is what we're going to discuss in a few minutes.

Oh, here it comes already. So [audio cuts out] now it gets a little bit more tricky. This is really the question for what period can I actually [audio cuts out] my electricity generation with my own electricity consumption. So as I've mentioned before, the standard net metering design [audio cuts out] a lot in the 1990s and 2000 was that you had an annual period, which is of course also due to the fact that you did not have a lot of smart meters at that time and you were only measuring really—the utility was only measuring the electricity consumption of a household maybe once a year. So, this would then also be the period when you measure the electricity generation in case you have two meters. Of course, in case you only have one meter then it's done with this one meter by just turning it backwards.

But that was really the basic design and only in the last couple of years we saw countries opting for shorter periods. And this is of course, the main reason is that indirectly [audio cuts out] was this design options of having shorter [audio cuts out] that you want to limit the size of the systems and therefore also limit the influx of distributed generation into your electricity systems.

Maybe starting again from a yearly perspective, and this is also done in many countries because you have of course large variations in the solar PV generation between the summer and the winter in the parts of the world where you actually have four seasons. So, once you have a yearly rollover provision, then you can of course offset the amount of electricity that you consume in the winter, where your little solar PV consumption with your own self-produced electricity from solar PV that you have in the summer. So, this annual provision then allows you to really, well, use the electricity grid as a storage unit also for the seasonal variations that you have in solar PV generation.

Then some jurisdiction says, "No, we're not going to do it yearly. We're actually going to do it so you only can match the electricity production that you have with the electricity demand that you have on a monthly basis." And some jurisdictions also said that they want to do it on a daily basis or even on an hourly basis. So, the fact, as I mentioned before, is of course that you downsize your system so you only really—you want to avoid any excess that you have beyond demand, for instance, in order to lose this electricity. So, instead of installing let's say a three-kilowatt system on your rooftop, you decide that you only install a two-kilowatt system, because this will allow you to maximize your self-consumptions and to decrease as much as possible any influx of excess electricity grid.

We will further discuss this with the next and last design options, 'cause this is highly linked into the value of the excess electricity that you produce. And the excess electricity in this case means really what you have fed into the grid beyond the rollover period. So, let's imagine you have a monthly rollover period, as I said here, and you [audio cuts out] after one month you have still produced more electricity with your solar PV system than you have consumed. And then the question is with these kilowatt-hours that you have fed into the grid but which are actually exceeding your own electricity

consumption during these months, and this is on the question what is the value of the excess electricity.

So, in the worst case is that—well, maybe we start with a standard design again. As I said, the first net metering, the compensation rate is also your retail rate. So, for every excess electricity that you fed into the grid you were actually getting the retail rate that you were paying. And the retail rate, as we know, is usually relatively high, much higher than the wholesale electricity price, and this of course makes net metering quite attractive and it also incentivizes you to produce more electricity with your solar PV system than you actually consume yourself. So, you're actually delivering more electricity than you what you consume yourself.

What you also have to keep in mind is when you have the retail electricity prices benchmark, this of course is different consumer class. So, in many developing countries you have relatively high _____ prices for the commercial and for the industrial sector. So, what we saw in a lot of developing countries, of course, that the net metering program was this type of design first of all makes it most attractive for the commercial and for the industrial sector to invest in solar PV, because they can then offset the very high retail electricity prices with the self-consumption of solar PV that they have.

What is also interesting to note is that in many countries you have inclining block rates, so that for the first kilowatt-hours that are [audio cuts out] household consumes, you pay relatively little per kilowatt-hour. These so-called lifeline tariffs that you have, whereas once you get into the higher ranges of electricity consumptions, assuming that these are the richer households which consume more electricity and which can also afford paying more for their electricity, they have high incentives, again, to invest in self-consumption—to invest in the rooftop, to become a prosumer, because what they can do then with under the net metering scheme with the self-consumption is to really cap off the very—the kilowatt-hours that they would normally pay a very high price for because of the inclining block-rate structure.

So, this is sometimes criticized by analysts in developing countries, that net metering schemes, which are designed this way, actually incentivize first of all the rich households to benefit from this and then of course the whole discussion on the fairness of the net metering program as to other—how consumers becomes a very prominent role and becomes very political quickly. So, this always has to be [audio cuts out].

So, as I mentioned before, this retail—using the retail electricity price for the value of your excess electricity is the standard design; however, in the last five to ten years you saw important variation of this design. And what we can actually see in most jurisdictions now is that they are kind of moving away from paying the retail electricity price for this excess electricity and rather [audio cuts out] a lower value for the excess electricity because, well, you're actually competing with other power generators in the electricity system so that your excess electricity that you feed into the grid would have to compete

with them. So, what you see in many jurisdictions around the world is that they are now using the wholesale electricity price as a benchmark. So, every power generation unit which is participating in the wholesale market, the [audio cuts out] certain price, so you can then use either the annual average of the wholesale electricity price or something similar as a [audio cuts out] excess electricity that you feed into the grid that exceeds the consumption of the household or of the commercial sector.

What is also used in some jurisdictions, for instance in Malaysia, is an avoided-cost approach. So, you look at the avoided cost of the utility and then say, okay, for each [audio cuts out] kilowatt-hour that is fed into the grid which is in excess to my own [audio cuts out], I only receive [audio cuts out], which is in line with avoided cost of the utility. This of course makes the utility normally quite happy because they are no longer being penalized for operating this net metering system, but they can just integrate these additional kilowatt-hours that they get under the net metering scheme into their systems based on the general cost calculations that they have.

What we saw in the United States as well in the last, 2013 is the so-called value of solar [audio cuts out] discussion. So, you're not only looking at the wholesale electricity price, you're also looking at other important values that solar PV can bring to the systems. For instance, reduced amounts for distribution grid upgrades or additional grid services that they can provide additional ancillary services. So, you're adding all of these benefits and also the cost of the solar PV system together, you come up with a cost of solar PV and then you fix a value of solar, which can then serve as a benchmark for the payment of your [audio cuts out] the net metering scheme.

And the worst case, of course, and then also existing in some of your jurisdictions, you're not being compensated at all for your excess electricity. [Audio cuts out] a drastic measure in order to give the prosumers incentive not to feed any excess electricity into the grid after the rollover period. So, you're really trying to say, "Well, try to maximize your self-consumption. If you feed any excess electricity into the grid this is kind of a free gift to us as a system operator, as a utility, but you're not being compensated for this one." That still exists, but really the most prominent design options that we see in the last five years I would say is really the avoided cost or wholesale electricity price approach.

Last but not least, I also wanted to mention the FIT level approach. We had also feed-in tariffs around the world have been reduced quite considerable in many jurisdictions around the world and that the feed-in tariff level is now significantly below the retail electricity price in many countries. For instance, in Germany you now have a retail—a feed-in tariff price for solar PV which is about a third of the retail electricity price. So for each and every kilowatt-hour we don't have a net metering scheme, but actually the feed-in tariff scheme [audio cuts out] similar to an net metering scheme, because now you're feeding any excess that you have into the grid at a feed-in tariff price which is only one-third of the retail electricity price and we're still three times higher than the wholesale electricity price, between the wholesale and the

retail electricity price. And of course, under the feed-in tariff you don't have any limitation on the amount of electricity that you can feed into the grid and that you're then remunerated for.

So, these are the major design options for the pricing for the excess electricity. We could discuss them of course much further and spend a full day on this, but this is just a quick overview, so I suppose some more detailed questions on this once we get to our question-and-answer session in 20 minutes from now.

So, it was really just the four basic design options of net metering. Overall, it's a very simple support mechanism for our renewable energies. It just gets more complicated when you look at the facts of increasing share of consumption in different markets around the world. And this is where we're entering the interesting and also complex debate of net metering self-consumption electricity rate design.

So just to give you a short introduction into this, as I said before, with increasing shares of prosumers, they start to have an impact on the rate design and there's normally a common concern over potential cross subsidies for prosumers—from non-prosumers to prosumers, because the prosumers might benefit [audio cuts out] great as a storage unit, however, when you don't change the rate structure—this is a general line of argumentation—then non-prosumers would actually cross-subsidize [audio cuts out] because they're no longer paying the fair part in order to refinance the hardware, the grid of the electricity network.

So, the whole discussion is usually based on the notion of fair cost contribution. And as a disclaimer, I just want to tell you right from the start that this is of course an important discussion to have fair cost distribution in the electricity system between the different types of consumers in the electricity market. However, this is also very limited view and you should also keep in mind that there's other policy objectives that you might have in designing an electricity market, and I will come back to this in a few minutes, just to tell you at this stage the discussion that you will normally see, so you have the question isn't that [audio cuts out] residential consumers that do not participate in the program. In the worst case you see a death spiral.

This is the argument that what would then happen is that I have a prosumer, he no longer pays for [audio cuts out] the grid, he no longer pays grid usage fees, network tariffs. This of course in turn will then [audio cuts out] non-consumers. So, they will face higher costs, which again, is an incentive for them to invest in self-consumption and to also try to leave the electricity network as much as possible. So, in an extreme scenario, in a very theoretical scenario you would then say there's more and more people leaving the electricity network, no longer paying for it, and [audio cuts out] just benefiting from self-consumption and only using the electricity grid in cases of emergency, lead to a death spiral and no one will be left in order to pay for refinancing. This of course is a very drastic line of argumentation.

What we have seen, and this is probably very important for everyone who is confronted with this argument, is that even though there's no one increasing economic incentives to invest in self-consumption and prosumerism, the globe, the number of actors that actually do it is still quite limited. And as I told you before, this is due to several factors. First of all, many, many consumers don't have the money to invest in the solar PV systems, especially in developing countries. Then again, you have the limitation of having a rooftop or really owning the rooftop as well. And then we also saw this discussion in the case of energy efficiency, just because some investment makes sense on paper, by comparing the long-term benefits with the [audio cuts out] and there's—it does not mean that everyone—immediately starts to invest in solar PV, as we've seen as well, even though it is economically beneficial to invest in energy efficiency, people have not done this because you usually have rather long _____ and a relatively high _____ costs, so these are limiting factors. So, this death spiral argument is really a very extreme argument, and what we have seen is still a rather uptake of prosumers, even in markets where you have a significant difference between the retail electricity price and the solar PV cost.

So that just as a first disclaimer, then it also of course depends on the price structure that you have. This is especially a problem in markets where you have fully volume _____ charges for consumers. For instance, for the commercial and industrial sector, where they normally have fixed charges and maximum demand charges. Anyway, these effects are somehow limited and can be controlled for, but we're going to get to this in a few minutes.

So, what are usually utilities and regulators doing when they follow this line of argument that is usually brought forward by the utilities? First of all, you see a discussion on the increase of fixed charges that you might have, either for all consumers or just for the net metering customers. What you also see is the scale around introduction of demand charges, also for the residential sector. Some jurisdictions, especially in the US, have also minimum bills, so that even though you produce 80-percent of electricity on your own, with your own solar PV system, you would still have a minimum charge let's say of $15.00 per month with this fixed minimum bills. Even though you have not consumed this amount of electricity, you would still contribute with your fixed payment in a way to refinancing the hardware of the system. What you also see is some taxes or other payments on self-consumed electricity, other charges, standby charges, and as I mentioned before, probably the most frequent reaction was an adjustment of the [audio cuts out] provision so that they have _____ _____ in order to do restrict the bankability of the excess credits.

What is usually not discussed when you talk and discuss these issues with policy advisors or policymakers is the opportunity of doing anything, because as I mentioned before, the prosumer market is usually grown very slowly. So especially in the first years after introducing net metering you have very, very small effects on your rate structure altogether. So, you should really analyze whether an intervention is necessary or whether the effects are so limited on your overall electricity rate design that an intervention is not really necessary.

And you might also analyze whether the existing rate design that you have, depending on the electricity rate design for the different consumer types, whether this is actually quite adequate a risk allocation for them. And this might also be the case in your country. So, there's no silver bullet that you can use; I just wanted to point out that the vast options that I have listed here upfront might not be the best solution.

And this is also what I want to show in this slide. Again, first of all the arguments; you have like utility revenue losses because they're losing some part of the market to the prosumer. The other lack of fixed cost recovery, the stability of the grid might be affected. You have uncertainty over the utility's long-term investment planning because you never know how much of the— how many gigawatts, megawatts will be installed by distributing generation. You might also have impacts on existing power supply agreements, in case you sign fixed power purchase agreements for 20-year periods and you figure out that actually large parts of your market will then be served by prosumers. So, all of these arguments are normally brought forward in order to tighten and reduce your net metering policy to have tighter caps, to have more fixed charges, minimal bills, et cetera.

So, what I wanted to show you is that this might not be the best solution, that a long-term vision might be missing because you should not only look at the effects on the utility on certain stakeholders. Keep in mind what is actually your overall strategy and the long-term policy objectives for your power sector. And this is one I have tried to just quickly show in this slide. This is once again a subject where you could talk about for two days, I suppose. So, for instance, let's say you're targeting in electricity markets where you will have in the future as of wind and solar PV. So, what is really called for your systems is a lot of flexibility in the system, and that flexibility does not only have to come from the supply side, but also from the demand side.

So once I have a net metering scheme where I kind of limit the flexibility from my demand by [audio cuts out] demand charges or by introducing very high fixed charges, so that I no longer have any incentive to react on any prices, let them come from the wholesale market or from time-of-use rates, retail electricity price markets, then I kind of contradict my net metering design with my overall policy design of having a very flexible power market, which creates [audio cuts out] the supply and also on the demand side. So, this really has to be kept in mind.

What is also important to keep in mind is that you have an incentive or want to create incentives for energy efficiency. However, when I have very high fixed charges or minimum bills and the volumetric charge is really being more neglectable, then I also don't have a lot of incentives for energy efficient users of appliances anymore, so I'm also contradicting another overarching objective of my electricity market design. There [audio cuts out] also have climate and environmental objectives in our policy design, decarbonization of the power market, so the prosumers actually play an important role in this by also providing finance for renewable energy capacity additions to the systems in case you live in a developing country where access to finance is really a

problem, so you should really benefit from the thousands of potential [audio cuts out] which might want to become prosumers and thus are able to finance the renewable energy assistance.

And then last but not least, also prosumer engagement is an increasingly important policy objective that you're really trying to build an electricity system of actors involved, where you have a sort of democratization of the electricity of the energy market and therefore having thousands of prosumers [audio cuts out] achieve this target. And then of course you should also consider the arguments that we have just discussed before, but always keep in mind that this is just a sub-category of one of the considerations that you should have when designing a policy, but you should not lose sight of the overarching policy objectives that you have designed or that you have selected for your country.

To summarize this, I just introduced this graph again. This was a study with the [audio cuts out] back in 2014, analyzing residential prosumers. So once again, just to show you that by designing self-consumption policies such as net metering, you always have to [audio cuts out] and the cost and the risk for different factors into account and then balance also the different views and the different benefits and risk for the different consumers by an elaborate net [audio cuts out] design. I'm not going to go into every detail of these right now. I gave you a link as well to the study [audio cuts out] and you can take a quick look at it after the presentation.

At the end of my presentation I just wanted to take a look at some emerging business models. And once again, we could [audio cuts out] for one or two days, because there's a large variety of finance and business model for our prosumers emerging in different markets around the world. It always depends on, of course, on [audio cuts out] the market and also on the actors that are available, on the finance that is available. So, I'm really just highlighting three or four major business models that are normally associated with net metering and prosumerism, but you can easily [audio cuts out] for any more to this list.

First of all, third party, the ownership has become increasingly popular, keeping in mind that not each and every household might have the means to invest in a solar PV plus battery storage unit right from the start, because of the high upfront capital investment. So therefore, there have been quite a lot of firms specializing in this and then, well, buying the solar PV system, installing it on the rooftop and then sort of leasing it out to the residential customer, who is then here. You see these lease terms and then defer also from one country to the next, also depending on the general capital access conditions in your market, where in the US you usually have lease terms of 15 to 20 years; in developing countries such as Thailand you normally shorter lease terms also, because usually banks would be hesitant to hand out a longer-term financing for you.

A very similar but slightly different model is third-party PPAs, solar PPAs. We saw this also logic mostly in the United States and a little bit in the UK. And once you have someone who has a financial capability of buying and installing the solar PV system, but instead of leasing it to you, you actually

enter a power purchase agreement with them, and of course the bet is then that they offer you electricity for lower than the electricity you would usually pay for when you buy the electricity from your utility. So, let's say 80 to 90-percent lower than the retail market price. And then this way also you benefit from it as a customer, but also of course the third-party owner benefits from it because he will then cash in the additional revenues beyond the 80 to 90 percent.

An interesting feature that we see in different markets around the world is virtual net metering, and that means that you're not only able to offset your own power consumption with your self-generation on your rooftop, but you can, for instance, also offset [audio cuts out] consumption of your grandma, who is living 200 [audio cuts out] meters away from you via virtual net metering. So this of course then allows you to really scale up the solar PV system on your rooftop because you can either, well, ask your entire family to participate in this virtual net metering and then you can just add up the electricity generation of the entire family who lives in a state under certain jurisdictions and offset this with under the net metering scheme. Sometimes this is also limited that you can only do virtual net metering in a certain defined geographic area, which is then of course normally reflecting also some grid constraints, some grid congestion that you might have, so that you really just use electricity grid as a storage unit, where you don't have any congestions in the grid.

You can really make this virtual net metering as—well, as big and as complex as you want. Some people say this is really helpful for sizing up your solar PV systems, other people say instead of implementing virtual net metering just implement a feed-in tariff or just procure remunerance at a larger scale via other support mechanisms such as [audio cuts out] and stick to your general net metering design. But that's another discussion.

Another, last but not least, another model is on-bill financing, where once again the additional costs that you have for the system are actually integrated into your electricity bill. So, on the one hand you are kind of paying small parts of the upfront capital cost of your solar PV system via your electricity bill, and at the same time you're offsetting some of the electricity [audio cuts out] net metering scheme. So, this is actually quite a nice mechanism for the utility to still stay in the business by building and financing as a solar PV system, but then also allowing their customers to become prosumers and to be more active in the whole system.

Last but not least, I was asked to quickly highlight as well the potential of combining net metering with other support mechanisms. First of all, we saw it, especially in the early 2000s, not so much nowadays, is a combination of net metering with additional rebates or investment incentives for solar PV systems. This of course depends largely on the gaps that you have between the retail electricity price and the cost of solar PV. When this gap is very small or not yet existent, so just before you have reached grid parity, then additional investment incentives, let's say I give you an additional 500 euros for each kilowatt that you install on your rooftop, this might be necessary,

however, really keep in mind that this might no longer be necessary, so it really requires an analysis of your market, of the delta between the retail price and the cost for solar PV, and maybe it is necessary, but maybe it is also not necessary.

And as I already mentioned before, there is also, of course, the [audio cuts out] net metering, especially for a smaller scale. PV systems up to one megawatt, for instance, whereas using other support mechanisms or feed-in tariffs for larger scale systems.

So that was the content of Suite A seminar on net metering in just one hour. I gave you a list of some further reading, but for now I really—well, first of all want to thank you for your attention and I hope that you now have a lot of questions that we can discuss in the next 30 minutes. Thanks a lot for listening.

Katie Thank you so much, David, for that great presentation. I would just like to remind the audience as we shift to the Q&A please submit your questions using the question pane at any time. We are also keeping up several links throughout this question and answer session for a quick reference that point to where to find more information about other upcoming and previously held webinars and how to take advantage of the Ask-an-Expert program.

We have some great questions, so we'll use that remaining time to answer and discuss them with David.

The first question is, David, what is the major difference between net metering and feed-in tariffs?

David Well, I touched upon this already a little bit during my presentation. So, the major difference is really that under a feed-in tariff [audio cuts out] you install a solar PV system on your rooftop, you might use some of this electricity for self-consumption, but you just can also just feed in all the electricity into the grid and you're remunerated for this at a fixed rate. So, there is no limitation on the feed-in tariff of the electricity that you can feed into the grid. Whereas on a net metering scheme, as I explained before, depending on the rollover provision, but most of all depending on the payment for the excess electricity, you have certain disincentives to feed in excess electricity into the grid. So, you normally have an incentives under net metering to optimize self-consumption and to feed as little as possible of the electricity that you self-consume on your rooftop into the grid.

Katie Okay. Wonderful. Thank you for answering that. Our next question is how can small households with PV in capacities of 10 kilowatts be able to connect to the grid and how can they synchronize through the net metering system to achieve conditions for synchronization of same voltage frequency and phase angle?

David Well, grid connection is [audio cuts out] which needs attention from the policymakers. You should really have specific grid connection procedures for smaller scale systems. What you see in some emerging markets is that you

could be considered a power producer, having a very small-scale solar PV system on your rooftop. And in the worst case they have the same requirements for you with a three-kilowatt system on your rooftop than for a two-gigawatt coal fire plant which is connected a couple of miles away. So, what you really need is a streamlined and simplified grid connection process, which of course it involves as well the grid operator or the responsible utility. So, the process should be simple; it should have very clear deadlines for compliance. It should also have, if at all, a very reduced cost for grid integration studies that a utility might demand for. But this is a very important component, of course, and these administrative costs or grid-related costs really determine whether net metering is [audio cuts out] for you. Because if you have, for instance, grid connection costs, including the grid integration study of let's say 1,000 euros then this is a very strong disincentive for opting for the net metering scheme

And we've seen this in several markets around the world, that by having [audio cuts out]—just by having very high grid connection fees, then customers will still go for solar PV, but they will simply not register under the net metering scheme; they will just do it without being part of the regulation. I had the pleasure to advise a regulator in the Philippines, and there was rumors that 90-percent of the solar PV systems were actually not registered under the net metering scheme because the administrative process and the grid connection costs were so high that they just opted for just doing everything behind the meter and not being compensated [audio cuts out] electricity and not having the benefit of any rollover provision, so that they would just do it without the policy regulation. So, this is really something that we usually explain to policymakers, that having a bad net metering design actually incentivizes consumers to opt out of the electricity system or to go for so-called guerilla PV, where you just use it without telling anyone.

Or in the worst case, and this is also a long-term scenario that utilities should have in mind, they might completely cut the cords and disconnect from the grid. So, this is what we usually discuss under the grid defection. And this really could become in many [audio cuts out] as we see rapidly falling prices of solar PV and battery cost. So that the regulator should have an incentive to really minimize this grid connection and administrative costs.

The second part of your question was on [audio cuts out]. This is usually no longer a problem because the inverters that we have today are much smarter than the inverters that we had ten years ago. So, in line with the grid codes, in the case that you already have grid codes, very well-developed grid codes, you can just program the inverters accordingly and this way they should be in automatic synchronization [audio cuts out] quality that you have when transforming it from DC into AC. What we actually see in many countries, the modern inverters that we have are actually helping to stabilize the power system because they can provide certain _____ services to the power grid that just—while providing reactive power, so helping to have run-through capacity in the case of voltage dips. So, this is actually no longer a real big issue; it just depends on how to program the inverters.

Katie Thank you, David. Our next question from the audience is what is the relationship of net metering and peer-to-peer energy trading between prosumers and consumers?

David Well, net metering is really more or less a mechanism which involves either the utility of the agent who is operating and running the grid, because you're using the grid as a storage unit. When you have peer-to-peer sharing of electricity you're kind of trying to find arrangements within the close proximity of your power generation and of your solar PV unit. And by those means, while [audio cuts out] and demand so much in soft consumption, and PV generation will—this [audio cuts out] PV generation on a local basis. So of course, you can combine both and then bring this—then more like concept of virtual net metering, which I [audio cuts out] shortly touched on before. So, the [audio cuts out] allowing under the virtual net metering customers also—allowing to offset the self-consumption. There's the generation that you have with the self-consumption at different parts of the [audio cuts out] you have to [audio cuts out] on the virtual net metering.

Katie Can you explain the South African Netfit concept?

David Well, the Netfit concept is actually a modification of a classic feed-in tariff. So, as I explained before, previously the feed-in tariff rates that were paid were relatively high, normally also higher than the retail electricity price, so you had a strong incentive to really feed in all that you produced with your distributed generation unit into the grid. Now the Netfit program, which has been discussed in South Africa and which is also currently developed by municipalities, selected municipalities in South Africa, is really a feed-in tariff which incentivizes self-consumption by paying very low tariffs for any unit that's fed into the grid. So, I think they were talking about excess electricity fed into the grid at a rate of $0.08 or $0.09 per kilowatt-hour, so you really have an incentive to first of all optimize your self-consumptions, and then only the rest of it, the excess electricity that you have is then fed into the grid at a relatively low feed-in tariff.

So, it's very similar actually to many feed-in tariffs that we have in Europe, so that the feed-in tariff payment is significantly lower than the retail electricity price, but still higher than the wholesale electricity price. But by having this design actually the utility benefits from it,[audio cuts out] penalized by it by not having to pay the retail electricity price or even higher feed-in tariffs, and at the same time the consumer or the prosumer has an incentives to not limit the size of the solar PV system, but really make use of the entire roof space that is available within the house or the commercial unit, and this way you really will try to strike a balance between the interest of those two parties, I presume, and the utility.

Katie Thank you. Our next question from the audience is how can we motivate the utilization of net metering in developing countries?

David Well, I don't think you really have to motivate it. I think it is becoming really a standard policy also in developing countries. Because you have very rapidly falling PV costs, which of course are a global phenomenon, but also because

in many developing countries we do see a phase-out of the subsidies and an increase of the retailer of electricity prices. So net metering will certainly become [audio cuts out] it is more important to keep in mind is really the whole discussion on net metering 2.0 or net metering which is more restricted, that many of the discussion points that we have and that this discussion is mainly driven by developments in the United States, they are not so much applicable for many developing countries. Because you have to keep in mind that in the US and in Europe we are normally talking about markets where you have either stable or declining electricity demand, whereas in most developing countries we still have large [audio cuts out] sector and electricity demand.

So even though you are like taking away a certain segment of the market and give it to the prosumers, that does not mean that the share of the cake for the utility is shrinking, because you have still increasing electricity demands so that [audio cuts out] utility in many developing countries for meeting further electricity demand increases in the future. So, the whole framework, the whole background is a lot different, and therefore we should also discuss potential interventions, as I have mentioned them in my presentation, much differently and really highlight the benefits of prosumerism by adding new capacity, by stabilizing the electricity grid via modern inverters, et cetera. These benefits to the system and also triggering or mobilizing finance for renewable energy investments, these benefits are really much more important in the developing world than they are in the US and in Europe.

However, you also have to keep in mind that in developing countries you sometimes have a much smaller group—a much smaller basis of electricity consumers, and in many countries, you also have very sophisticated cross-subsidy schemes. For instance, between the residential and industrial sector, cross-subsidizing the residential sector. So keeping this in mind, self-consumption then can create very strong distortions to the existing cross-subsidy scheme, so let's imagine a country where the commercial sector is largely cross-subsidizing as a residential sector and all of a sudden all [audio cuts out] these commercial entities, which might not be allowed, maybe it's just 100 or 200 commercial units that you have [audio cuts out] for instance.

Imagine a situation where they suddenly opt for self-consumption, opt for net metering, and they start self-producing 50-percent of their electricity on their own. Then the utility quickly enters into a problem because they are no longer able to cross-subsidize the residential sector with the higher electricity rates for the commercial sector because they have partly opted out of the system. So for the developing countries it is the biggest challenge from what I see is really to combine self-consumption schemes, net metering mechanisms with the long-term strategies of readjusting the rate design, and that means of course phasing out these existing cross-subsidies, having more cost-reflected tariffs, and if possible, then allowing all the consumer groups to benefit from self-consumptions and to share those respectively.

Katie Thank you. Our next question is what are some initiative solutions regarding rate design in the pro-_____ world?

David Well, I had three or four slides on this. So, the rate design, as I just mentioned before, really depends on the overall structure of your power system and on the existing rate design that you have. If you have cost-reflected tariffs everywhere and very stringent distributions, let it be for the power generation or for the grids, in all sectors a net metering scheme has very limited effect and you can really just—you can continue to share the burden or to increase the burden for the prosumers and limit the burden for the non-prosumers. However, it is much more complex when you start from the premise that most power systems around the world don't have cost-reflective tariffs and they don't have any fair cost distribution between different consumer groups anyway.

So, when you start from this premise then of course the whole idea of just in the net metering scheme of having extremely fair cost distribution is somehow absurd, because you're starting from a system where this is not the case in the first place. So, then the question really is, is fair cost distribution really my overarching objective or do I have other policy objectives? And I mentioned them before, there's some incentives for energy efficiency, et cetera. Are these actually more important than making sure that each and every euro that has to be distributed is fairly allocated to the different consumer groups? So, I think the overall picture is much more important here than the very detailed nitty-gritty cost distribution just based on the very small perspective of only looking at the net metering scheme.

Katie Thank you. Our final question for the webinar is what comes after net metering? Is there a net metering 2.0?

David Well, what comes after net metering depends a little on your policy design. As I said before, we already have some markets around the world where the net metering regulation is too complicated, it's costly because you have very high administrative costs, very high grid connection costs, so that consumers simply say, "I'm just going to do it on my own and I don't need any of this. I don't need any net metering regulation, I just produce a certain amount of my electricity on my own." Of course, then the question is whether this is actually legal. But the potential enforcement of this not being legal is still another question, because when you have like several hundred thousands or millions of previous consumers doing this at once you probably have difficulties of getting a hold of this anymore. So, a potential future of net metering might just be consumers fully—just doing it on their own and not going into this.

Then of course a more elaborated design of net metering is also an option. That's what you normally call net metering 2.0. So, we discussed this before, that you have new regulation regarding the rollover period, that you maybe enter into virtual net metering, that you have an adjustment of the payment that you have x electricity moving away from retail pricing to wholesale pricing or to avoided cost pricing. So, all of these elements which are currently tested around the world are very, very interesting.

And I think we will probably have some net metering 3.0 coming in shortly when you really consider the options of net metering, of self-consumption

increasing, digitalization of the power system. So we already see quite a lot of net metering schemes allowing prosumers to combine with [audio cuts out] and then when you also allow them to combine it with real-time [audio cuts out] then you could potentially create very important benefits from the self-consumers to providing the flexibility of the system that we need in the future in power systems, including high shares of wind and solar PV.

Katie Great. Thank you, David, so much for that informative Q&A session. I would just like to provide you with any additional or closing remarks that you might have before we close the webinar today.

David Well, thank you very much for listening and of course feel free to contact me. You have the e-mail address on my last slide and also phone number. If you are a policymaker, then the Clean Energy Solutions Center can also provide assistance in the designing or reviewing net metering programs. So happy to stay in touch and thanks again for being so attentive and staying with me for so long.

Katie Wonderful. Thank you so much, David.

On behalf of the Clean Energy Solutions Center I would like to extend a thank you to all of our expert—or to David, and to our attendees for participating in today's webinar. We very much appreciate your time and hope in return that there were some valuable insights you could take back to your ministries, departments, or organizations. We also invite you to inform your colleagues and those in your networks about Solutions Center resources and services, including our no-cost policy support through our Ask-an-Expert service. I invite you to check the Solutions Center website if you'd like to view the slides and listen to the recording of today's presentation, as well as previously held webinars. Additionally, you'll find information on our upcoming webinars and other training events.

We're now posting the recordings to the Clean Energy Solutions Center YouTube channel. Please allow about a week for the audio recording to be posted. Finally, I'd like to kindly ask you to take a moment to complete our short survey that will appear when we conclude the webinar. Please enjoy the rest of your day and see you again at future Clean Energy Solutions Center events. This concludes our webinar.