CLEAN ENERGY SOLUTIONS CENTER
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Peer to Peer and Blockchain

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Webinar Presenter

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Toby Couture Welcome to the International Solar Alliance Expert Training Course. This is Session 17 focusing on peer to peer energy trading and blockchain. I'm Toby Couture from E3 Analytics and I'll be giving this training session.

This training is supported by the International Solar Alliance in partnership with the Clean Energy Solutions Center. This training is part of Module 3 which looks specifically at the issue of the future of solar policy. This segment focuses on a wide range of topics relating to the future of the industry, trends in policy, and where things are going in different markets in the world. We will try to look forward at some of the innovations, some of the developments that are shaking up, and that have the potential to reshape the solar market in the years ahead.

So this training focuses specifically on the issue of peer to peer energy trading and blockchain. So here's a quick overview of some of the topics we'll be covering. We'll look at what peer to peer trading is, what blockchain is and means. No doubt you've heard the word before. This presentation will try to provide a brief overview of what blockchain is, how it works, and how it's relevant for and being used in electricity markets in particular. We'll look at some of the benefits, some of the challenges, as well as a few case studies before wrapping up. And at the end there will be a knowledge check with a few skill testing questions.

So the main goals of the presentation are to understand how peer to peer energy trading and blockchain technologies work, to understand their benefits, to understand their challenges, and to learn from case studies of where peer to peer energy trading and block chain are being used around the world in different markets.

So let's dive in. What is peer to peer electricity trading, or energy trading? Traditional electricity trading is mostly done between companies trading with one another or utilities who have trading desks to buy electricity on the market. And that can either mean in real time. That can mean on the day ahead market, on the forward market, in the range of different products, in the range of different platforms. And the trading of electricity typically happens between people who are specialized in trading. So there's a focus on certain skills.

It's a specialized service that's delivered specifically to utilities, to companies who are active in the electricity market, and who stand to gain from trading electricity, either by securing lower cost power, either by diversifying their portfolio further, or simply to make sure that they have enough power in the system in the days ahead to keep the lights on. So trading is a very central part of current electricity markets in most jurisdictions around the world. The exception is in markets that are either islands where there is no trading between companies or trading between utilities because it's all nationally owned and controlled.

Or simply in jurisdictions where maybe it's not an island but it's still nationally controlled without any export ties to other neighboring countries. In that case there isn't really an active platform. It's more internal to that electricity market. And one national company dispatches its generation suite, whether natural gas plants, nuclear plants, coal plants, and hydro dams in function or in relation to its needs. So electricity providers can be partnered with organizations that own and operate generation equipment. And typically there's a profit margin. A profit margin of trading is the difference between the price at which the electricity is purchased and the price at which the company can sell it on for.

Now if we look at distributed generation and how this plays out on a smaller scale we start to see a new dynamic emerging. Microgeneration or distributed generation is the production of small quantities of electricity by individual households and businesses, using technologies such as solar PV. We've seen rapid uptake of microgeneration in markets around the world and distributed PV remains a very central part of the electricity market in a growing number of countries.

So in markets like Germany there are over 1.7 million individual solar PV systems. In countries like Australia they've recently passed the 2 million mark with over 2 million solar installations nationwide. And in other markets like Bangladesh there is even more—mostly standalone household systems designed for predominantly rural and peri-urban areas where Bangladesh has somewhere on the order of 5 million systems installed. So microgeneration, small scale, household specific PV installations are increasingly common parts of the electricity market.

Now if you're a household that has solar on the roof typically your only buyer—the only person who can take your excess generation—in other words the generation you yourself can't use in real time from the sun—is the utility, the utility you buy your power from. And that's typically done via some kind

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of net metering policy. You can see a separate training that was done as part of this Clean Energy Solutions Center training series on net metering specifically. And that's worth looking at more closely if you want to better understand the mechanisms at play there.

So traditionally you really only have one option, namely the utility from whom you purchase your electricity, to sell your electricity to. But now what's starting to happen is households and businesses are starting to say, "Hey, well if technology enables it why don't we trade power with each other without needing to sell it or have it be compensated by the utility? In most net metering policies you don't get a cash payment for your net excess generation. You just get a bill credit. That means it progressively erases your electricity bill for each kilowatt hour that you inject back into the system.

So there's no cash payment. It just helps reduce your bill. Now a number of customers who are part of net metering programs naturally started to wonder, "Why can't I get a cash payment for this? This electricity it worth something. My neighbor buys his electricity from his utility or her utility. Why can't I sell my power to them instead? It's directly next door. The electricity can follow on the same wires. Why do we always need to buy our power from upstream?"

In other words from another within a neighborhood, within a community, within a further up in the distribution and transmission network. Why can't we supply power to one business district, and in a sense cut out the middle man, which in this equation becomes the utility? Now the utility provides the wires without which peer to peer power trading would not be possible. So unless you were to build and install a dedicated wire, a dedicated cable, connecting your house or business with a neighboring house or business and essentially developing your own microgrid—

Short of doing that in most cases you're going to be using the utility's wires. So the utility needs to be in a sense part of the conversation insofar as they ultimately own the asset. They own the distribution wires. So even though you're trading peer to peer, in most cases thus far you're still using the utility wires to do so.

This whole discussion of peer to peer is also connected to a much broader conversation around what's called the sharing economy. You've no doubt heart of house sharing platforms like AIRBNB and car sharing platforms like DriveNow which has recently been rebranded ShareNow and a range of bicycle sharing programs, as well as even peer to peer lending where loans can actually be issued between groups of people instead of from a traditional bank. So we are seeing in many ways a revolution sweeping through a number of different markets using peer to peer sharing based concepts to do so.

So in that sense electricity and the focus of this presentation on peer to peer electricity trading is a microcosm of a much broader trend, a much broader conversation. So in the case of a household or business that installs solar power on its roof or from its property, they generate excess electricity and

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as such are known as prosumers. They both produce and consume their electricity. So a portion of their electricity is self-consumed, and a portion of it which can't be kept self-consumed in real time, is injected into the grid. And virtually every household that uses solar power or business has some time during the day or during the year when they are not able to self-consume all of their onsite generation.

And that's because of holidays, weekends, and the sunny Sunday phenomenon when you have a beautiful sunny day. Everybody is outside and there is very little electricity load in the house. The solar panel is in most cases going to—Or the solar system is in most cases going to produce more power generation than the household is consuming. So you have a dynamic situation in which the balance between supply and demand is constantly changing. And you are a net importer of power when your power demand needs go up. And the next moment you can be a net exporter of electricity to the grid because you are producing more than you consume.

So it's a constant dynamically changing reality when you look at it from the perspective of the power meter and from the perspective of what's being exported back to the grid. So there's an opportunity. And a growing number of households and businesses have realized, "Wait a minute. I'm exporting this power. My utility is not giving me what I consider to be a fair deal for that. Why don't I look for another buyer?" And previously this would've been very difficult to operationalize and costly to implement. In many cases it would've also been illegal.

The market however—partly driven by technological change, partly driven by new business models and new platforms and new services like blockchain—are making it possible, as we'll see in a moment, to unlock that and enable households, businesses to trade power with one another in real time and actually do so on cash payment terms. So you're no longer just getting a bill credit, thereby offsetting your power bill. You can actually trade power and receive money for it. So you can get cash payment which makes it more attractive to become a prosumer, more attractive to invest in solar power, and ultimately it creates, or creates at least the potential for a much more engaged and much more active electricity market than what we have known previously.

Compared to traditional net metering this is a much more active, hands on approach. Traditional net metering, just like a traditional feed-in-tariff project, you are effectively passive. You connect your system. You connect to the grid. And it's essentially plug and play. The utility will net out the difference or will buy it from you. But you're not an active—Your active engagement is not necessary to keep the whole thing ticking along. The possibility here with this peer to peer trading is that the household or business or individual can become a more active participant.

They can potentially create or adjust their settings within their platform so that they can buy and sell to specific people, buy and sell of specific products. So for example only buying renewable electricity rather than just buying the gray or blended power that you get from the electricity mix in your region.

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So it allows a much greater degree of control, much greater degree of customizability than was previously by and large in most cases, in most regions, possible. So it remains to be seen how far this trend develops towards peer to peer sharing and ultimately how big of a part a future of electricity markets it can be or become. But it certainly remains an area of very activity innovation at the moment.

So let's connect this to blockchain and try to better understand what blockchain has to do with peer to peer energy trading. The traditional energy market you buy and sell power by drafting different forms of contracts and by communicating with each other directly. This can obviously get very complicated and is time consuming and costly. For businesses who invest in power trading platforms—You can see here a picture of the trading desk with multiple different screens. You have staff whose job it is to ultimately trade power and trade different products on the power market on a minute by minute, hour by hour basis in order to keep—ultimately to keep the lights on and to optimize cost and performance of the utility.

But because of this cost intensive—Because of the fact that it's cost intensive and that there are so many nodes in the network, and that it's done largely behind closed doors so to speak in trading desks, it's challenging to make the system fully transparent. Companies only have disclosure requirements around certain aspects of their business. So for auditing, accounting, financial market purposes—there is only so much transparency that utilities need to share around their trading behavior and around where and from whom and for what they're buying power.

So the possibility of injecting or making use of technologies like blockchain is that the potential is there, as we'll see, for much greater transparency across the energy market. Peer to peer energy trading involves a large number of transactions being done between different prosumers and consumers. And in order to do that—because we're talking not only about hundreds of consumers, or hundreds of households and businesses—not even thousands. We are really talking about millions of individual microgeneration units and solar PV projects that are injecting power in real time into the system.

So the market in a way is screaming out for a low cost simple authentication and validation mechanism that allows that power that's injected to be validated and settled while protecting people's privacy. This is where blockchain enters into the equation. Blockchain's best known product or application is bitcoin, which is often referred to as a crypto currency. This application of blockchain is somewhat different in electricity markets and we'll see how it's different and what that means and how it can connect to the bigger conversation around the future of electricity markets.

So how does it work? Blockchain can be thought of as a shared database that has unique properties. Instead of there being a single entity or company that manages that databased and makes data available—Think of the World Bank's data or the OECD's data. Data in a blockchain is controlled by everyone on the network. And as such a history of all transactions that have

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ever occurred within a particular network is retained. So the system in that sense is fully in a sense almost radically transparent.

Every transaction, every occurrence is monitored, is validated by everyone else in the network, and therefore cannot be erased or modified after the fact by anybody else in the network—by any other single individual node. As we'll see in a moment the moment a blockchain enters into the chain it, by being validated instantaneously by all the other nodes on the network, is locked in and can no longer be modified. And it's that key mechanism that gives blockchain its power in terms of validating and settling transactions.

The history is there. The record is there. It's auditable. It's trackable, and thereby giving users the confidence that the product that they've bought or sold has actually been transacted per the platform. So blockchain offers what's called a cryptographically secure, distributed ledger that can track where electricity was generated, from what technology it was generated, where it traveled, and ultimately who consumed it—to whom it was delivered. And that's a powerful asset. In most electricity markets in the world—in most utilities around the world—it's still very difficult to know where power outages originate in the network for example.

Utilities will wait until customers call them still today and try to figure out roughly where the power line went down, and then send staff to visually inspect the site, and visually inspect the wires and the distribution poles and the substations to make sure that they can identify exactly where on the network the power outage occurred. The potential of having smarter, more distributed ledger based technologies like this embedded within the network is that it could also provide utilities with a fairly low cost way of instantly identifying where problems on the network occur, and particularly where power outages originate. So a number of utilities are starting to look at this to see how using this kind of network intelligence can further improve the efficiency of their own operations.

So this diagram provides an overview of how blockchain itself works. Let's say A wants to send money or electricity in our case to B. The transaction is represented online as a block which you see here as a bit of a puzzle piece. The block is broadcast upon entry to every part in the network. So it enters into the system. All other nodes within the system acknowledge the entry of this new block into the system. Those in the network approve the transaction. They say, "Yes this is in fact a kilowatt hour entering the network from Jim's or Suzie's solar panel." although their names wouldn't be known because it's private.

That blockchain enters into the system, gets validated by everybody else, and then the block is added into the chain which provides an indelible, i.e. nonerasable, record of that transaction. And then once approved and entered into the blockchain the money can then be transferred. Or the electricity in this case can be transferred from A to B. So this end to end encrypted cryptographically tight network enables even things as ephemeral as kilowatt hours to be monitored, to be tracked, to be entered into a system and to be distributed and transferred between parties.

This is partly what makes it possible for households to trade even tiny amounts of electricity in a very low cost, very transparent, and efficient way. If it were not low cost and if it were not efficient—if there were a lot of losses or a lot of additional transaction costs—it would not make sense because for most households we're talking about very small amounts of electricity. And businesses may be a bit more, but then the economics still need to cancel out. The benefit of this is that the ultimate losses in the sense of transaction costs and others are kept to effectively nil, other than your kickoff costs.

And that makes it possible to have again this transparent validation network that makes sure that when you inject power into the network it can be delivered to your neighbor or to any other active taker, active buyer on the network. Similarly once you're within the system you can also buy kilowatt hours. And you can set your parameters such that you only buy from say solar projects. So your daytime electricity demand could be constituted of snatching up or buying all of these individual kilowatt hours from different household producers in your area with their own PV systems. So you can have a higher degree of control over your actual electricity supply in a way that was simply not possible before.

So what makes blockchain relevant for this whole peer to peer power trading? As we've discussed the transparency of it is a powerful asset. Data is stored and is visible to anyone. The technology is transparent and secure. It does not require a central entity like a company to store or manage the data. It is fully auditable. So the data, once it's entered, is indelible. It stays and transactions can be confirmed or disputed by anyone. And there's no ambiguity about where a kilowatt hour came from and how it was produced, because as it enters into the network those characteristics are validated and need to be validated ex-ante—so before the fact.

And that means that the network itself is secure which brings us to the third point here which is trust. In principle the interactions between individuals or between companies can be direct with no third party getting in the way or interfering or controlling transactions. So the potential there to get to again a much more direct, much more personal, much more engaged energy or electricity platform is there. Now there is the question—and you may be thinking, "Well maybe most power users, maybe most households and businesses don't really care or don't really have the time to get involved in this level of consumer engagement."

And I think there are still some important concerns even within the industry about the extent to which customers are actually going to want to do so. I think the advantage is that it can be customized and you only need to be as engaged as you would like to be. So you can essentially plug and play and let the system do the rest just by establishing your settings and letting it run. Or if you want to be more actively involved and you want to be doing this via app you know in a real time way deciding what kilowatt hours to buy and what to sell at which price then you can do so.

So there's a spectrum obviously of users and it doesn't entail that everybody needs to be hyperactive user of the trading platform. You can still plug and

play, which may be enough to overcome initial concerns from some around whether this is worth the time and effort. Again the benefit for consumers at the end of this, if you're a household with solar, is that you can potentially start to earn money rather than just bill credits on your electricity sale. And that you can actually know in a way that that electricity is being used locally and that you can have greater control over again where it comes from and to whom it goes.

Blockchain has several different applications. And you see here everything from the use in microgrids or mini-grids which has been talked about quite a lot, peer to peer energy trading which we're focusing on now—the possibility of scaling it up in the adoption of electric cars where batteries of electric cars could participate in blockchain and feed kilowatt hours into the network and take them back depending on price signals. So if it's attractive during peak hours for the battery of the car to discharge a little bit of electricity into the network then the network could configure itself that way. Or the user could configure their car that way to start participating in this way, and again earn money in the process.

So again we are potentially moving to a future via technologies like blockchain where power sharing and power—the level of engagement and participation is greater than ever before. But also where in a sense the revenues generated from the sale and trade of electricity themselves start to become much more distributed. So it's no longer large owners, or no longer strictly large owners of power plants who are benefitting from electricity sales and trading, individual households and businesses can as well.

You see here different applications as well in reducing carbon emissions, rewarding renewable energy adoption—so tracking renewable energy production. Tokenizing energy—we'll discuss that a bit more in one of the case studies. And there have even been discussions of using blockchain for completely other things like rainforest protection and environmental conservation. So there are a range of different applications. We are really focusing on one part of the ecosystem.

Now let's look at some of the benefits of peer to peer electricity trading with blockchain. As we've seen there's no middle man or middle person. Therefore customers can get a higher price—Sorry, producers can get a lower price and customers can lock in a lower price than for example what they're getting from the utility. So let's run a scenario. Let's imagine you are a household in an electricity market where you would buy electricity for $.20 per kilowatt hour from your utility. Now that $.20 includes the energy charges—so the actual electricity generation charges—as well as fixed demand type charges.

It could be also billing charges, et cetera, meter reading charges, a range of different things that utilities pack on. So maybe half of it is energy and the other half is all of these other fixed miscellaneous charges, plus tax. Now if you're buying for $.20 and you're connected to a net metering application—so you're essentially getting bill credits for every kilowatt hour you inject back into the network. You may want—You may prefer to get a cash payment for that. Similarly your neighbor who is paying $.20 to their utility—to the same

utility—may be prepared, may be quite keen to pay a bit less than $.20 and actually pay your cash for that.

So you could then sell to your neighbor for say $.15, get a cash payment, and your neighbor is able to lock in cheaper power because it's delivered to you, to them directly on the network. So in that sense you substitute your bill credit in this case or your feed-in-tariff which may be well below $.20 a kilowatt hour. You may be able to substitute that for a higher price. So let's refine that a little bit. Under net metering if you're allowed you would get a bill credit which would typically be valued at the full retail rate. In a growing number of jurisdictions you're getting less than the retail rate now.

So you would get only for example the energy charges—so only $.10 let's say per kilowatt hour for that. And if you're participating in your feed-in-tariff program or policy you may get even less than that. In the UK for example the feed-in-tariff you'd get is well below $.10 pence per kilowatt hour. And it may be attractive if you can find a buyer who's again willing to pay more than say the $.06 you get for the feed-in-tariff. He's willing to pay maybe $.12.

Then you could strike an agreement and make it both economically attractive for the household or business and for the buyer. And that's really the main market that's unlocked here is between customers on a small scale or even on a large scale potentially who can more cost effectively trade power with each other than buying it from the utility. So again you can see here how if this were to take off like wildfire it could potentially be quite disruptive to many utility's business models. And this is one reason why a number of utilities are starting to get in on the action and starting to develop their own peer to peer trading pilots and pilot programs. So we'll see a little bit more on that in the examples to follow.

The transparency is obviously an advantage which we've touched on a number of times—the fact that you can have greater customer choice, consumer choice over your supplier and over the energy source you're buying is very appealing to a number of people and is also something that gives people again more flexibility in terms of determining their overall environmental impact and their overall consumption choices. So just like when you go to the supermarket you can choose to buy different products of different quality. You go to buy a new car or a new vehicle. You can buy different products at different quality.

The electricity market in this more radically decentralized way with peer to peer trading would enable you in a similar way to go to a bazaar, to go to the supermarket of electricity trading and buy different products from different producers and different suppliers. So again the potential there—We aren't there yet but the potential there is potentially quite exciting and also again quite disruptive. You can choose to buy as much energy as you need from whichever technology you would like to buy it from as long as there is available power supply from that supplier, that technology on the network at that time.

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So there are also some broader advantages for society. In a way producers produce their own electricity. They sell it or store it using batteries. This can reduce congestion on distribution lines and even help improve grid stability. So if you are buying your kilowatt hour from your neighbor instead of buying it from a power plant that may be located hundreds of kilometers away owned by the utility, that power doesn't have to travel as far. So that electricity that's going from the power plan all the way to your home through transmission lines, through distribution substations, through distribution wires, all the way to your house entails a lot of losses.

The further electricity travels on a wire there's resistance. And the more resistance there is over distances the greater the losses. So if you can consume power closer to where it's produced you reduce the total networks on the network. And that makes this peer to peer trading also potentially quite attractive because it can reduce losses quite significantly on the grid. In a number of countries around the world and not only in developing countries power losses can be quite high. There are many markets in Africa where power losses are well over 25 per cent.

There are markets even in Southeast Europe where power losses in the system are over 30 per cent, both technical and non-technical losses. So the potential to minimize that or reduce that by using more direct peer to peer trading, peer to peer sharing within distribution networks, is quite attractive and could help significantly reduce losses in the years ahead. It's also enabling again a greater degree of transparency and smartness, a greater degree of intelligence within a grid, within a network because utilities can then have greater transparency of what's happening within their network.

So if again there's an issue within the network—if there's a bottleneck, greater congestion, if there's a downed wire because of a storm and a branch broke over a power line this kind of distributed intelligence in the network will help make those kinds of things easier to localize. And therefore utilities won't need to spend as many resources, identifying the precise location of and magnitude of outages because they'll have more direct control, more direct visibility.

And there are further advantages for the broader power system. So in theory by being able to shift demand and supply around, by being able to reduce for example the amount of power needed from far away power plants during the day time, you can reduce demand during the sunny hours of the day. You can also potentially flatten peaks and valleys by bringing into play distributed storage which can start playing again on the blockchain peer to peer trading concept where you have a battery starting to play a more active role in supporting supply and demand.

Energy efficiency can also be increased by reducing overall energy demand in the network. Because more of it is supplied locally the overall net load that needs to be met within a given distribution feeder goes down which can make it—again can reduce overall load in the system and thereby also reducing the losses. Electricity grids tend to lose more—tend to have higher losses—when they're overloaded. So when there's too much power trying to flow through.

And finally it can help also reduce peak demand by enabling a smarter and more dynamic pricing mechanism.

So for example if you were a household and you wanted to inject—you had a battery system let's say connected to your solar system. And you wanted to tap into and help meet peak demand. If you were given peak pricing for that you could feed in more electricity from your stored battery energy into the network and get basically via the blockchain higher pricing because it can be more dynamic, more real time. And that kilowatt hour is worth more if it's entered into the system at those peak hours. And that can be remunerated. So you could have—By having more customer participation and engagement with the supply and infrastructure you could potentially have also an additional way to mitigate peak demands.

Now we've heard a lot about the good things and all the advantages and all the up sides of peer to peer and blockchain in electricity markets. What about some of the challenges. So peer to peer trading is not yet mainstream, nor is it yet fully commercialized. So there are certainly still growing pains within the industry, within the market, and there are—The market for technology solutions is also still relatively immature. The amount of competition is not yet where it could be. And ultimately there are still other stakeholders that need to be convinced of the business case—in particular electricity retailers and utility distribution companies.

So there are a lot of conversations that need to happen around how best to balance these different stakeholder interests and it's likely that the path is not going to be a linear one. We can expect additional regulation. In today's electricity markets there is often a lack of enabling regulation. The risk however as you start to introduce enabling regulation is that you also start to strangle innovation. And you also start to limit some of the potential that the technologies can unlock. So there's a delicate balance there.

And finally there are issues around perception and trust. So ultimately these technologies still—Despite the fact that they are again transparent, verifiable, auditable, there is still a public awareness challenge around getting everybody to understand the technology, how it works, and ultimately to trust it. And that's the case with any new technology entering the market.

A further challenge is related to network charges. Electricity is normally transported through the distribution network or the transmission network and utilities will charge a fee for this use. Network charges can be up to 50 per cent of the traditional energy bill. So if you constantly have to be paying these network charges just to distribute power from your household to your neighbor's household. And if those charges are not proportionate, if they're not reasonable and backed up by the actual cost of the system then it could discourage a lot of this peer to peer trading activity from happening.

And utilities obviously would rather be the ones selling you that power, not your neighbor. So they have a built in interest in making those charges disproportionately high in order to discourage that behavior from happening. So there is a clear need for public interest, focused regulation, to come in and

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introduce regulation either—in whichever form to insure that utilities aren't strangling these developments through disproportionate network charges.

There are efforts for example in Australia. See here the example in Sydney to introduce local generation network credits which would help reduce network charges specifically for prosumers that are using peer to peer energy sharing, so different ways to try to carve out a niche and try to again not undue burden this fledging market with onerous pricing or counterproductive regulation. From a consumer interest, consumer standpoint if it can reduce costs then there is a strong case for again making—allowing this to continue to happen. So there's an ongoing—We can anticipate more regulatory battles over this in the years ahead.

Now let's take a quick look at some case studies and examples in the real world before wrapping up. Progress thus far with peer to peer energy trading has been relatively slow. There are some interesting examples starting to emerge as we'll see. There are some in the UK. There are some in Germany and Australia as well as in emerging markets like Thailand where different concepts along these lines are being piloted. Now let's dive into some of these examples. One of the most well-known is Power Ledger based in Australia. It's a blockchain based peer to peer energy trading platform.

They've recently raised funding successfully to trial out their technologies. So this suggests investors who've looked at this carefully have come to the conclusion that there is a business case here and that this is something that can scale. The aim of Power Ledger is to create a power system that is low cost, zero carbon, and that allows customers more choice over their energy options, so all of the things that we discussed around the ability to customize your technology, customize from whom you buy, from what sources you buy. In a transparent world it's all there. And the aim of Power Ledger is again to try to unlock this market, try to make this easier for people to do so.

The platform they've developed enables interoperability between different market pricing mechanisms and different units of electricity by way of pre-purchased tokens. So this comes back to the point about tokenization of energy we talked about earlier. We don't have time to get into all the details here. You can look at their website, their model, more carefully online. The tokens are pegged to the local currency and they can be traded on the platform within defined trading groups that interface with smart meters.

So the ledger system tracks generation, consumption of all participants on the network, and settles energy trades on predetermined terms with different customers in nearly real time. So basically it takes the blockchain principle, the blockchain mechanism, and uses it to settle micro trades between households and businesses. You can see a bit of a visual there of how it works out in practice.

Now another example led by a utility in this case—ADF of France has been piloting a project in the UK in a housing estate in London. The power will be used by residents of the estate and stored in batteries for trading. There's a consumer facing app that is used to facilitate trading and allow people again

to be more active and engaged. Transactions will rely on blockchain for tracking, and the project now from early-2019 until October in an 8 month trial.

Now regulations in the UK currently permit customers to purchase electricity only from a single party which effectively prohibits peer to peer energy trading. However the energy authority—the regulator—is considering changes to these regulations in order to allow this to unfold. So again you see how existing regulation because it was developed and designed before these technologies, before this possibility even existed, often by default excludes it. There are no doubt going to be cases where the law because of the way it was written does not explicitly exclude it.

But in cases like the UK the regulations will need to be changed. So there's again the need for creating an enabling environment to allow this to happen. And sometimes that requires changes in laws, changes in regulations to make it happen. And finally the third example here is Sonnen, a battery storage company in Germany. A quick note here: Sonnen was recently acquired by Shell as part of its efforts to diversify away from oil and get into the electricity market more actively and also get into the battery storage market.

Sonnen continues with its brand and with its product offering in pushing the battery market and electricity delivery model forward in both Germany and now expanding into other markets across Europe and I believe Australia if I'm not mistaken. The program relies on controlling energy from its customers to create something like a virtual power plant. So by connecting households with battery storage in real time they can start to operate all of those as a virtual power plant which we touched on in the other training as part of this training series on virtual net metering and wheeling.

So essentially it enables these customers to participate as part of this network and to customize again their settings accordingly—according to their preferences. So the so called NEMoGrid is exploring the economic and technical impact of using blockchain between households within a given region to allow people again to trade power between their solar systems and their battery banks and potentially even also their electric cars. They're creating an integrated network of electricity supply and demand sources.

The project aims to provide insights into how flexible electricity price is—So real time dynamic pricing and grid stability can best be combined at the local level. The project is now currently ongoing and it'll be interesting to see how all of this continues to unfold in the years ahead. There are many other examples. As I mentioned there are some even from emerging markets like Thailand happening and this is—You know we potentially are at the beginning of something quite substantial in the electricity market. And we'll see.

It's important to keep in mind that residential electricity demand is only in most markets somewhere between 20 and 30 per cent of total electricity demand. And that in a sense limits the potential for the residential sector to fully and completely shake up the sector. But if you start getting visitors

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involved, you add commercial and industrial customers; you start to get to a much wider share of the electricity mix and could really start to shake things up.

So a few concluding remarks as we wrap up. Peer to peer electricity trading with blockchain offers a new solution to electricity trading between micro generators and consumers and offers a number of different benefits as we saw throughout the presentation. Key among these benefits are increased choice but also reduced cost for consumers. So consumers can have more control over where their power comes from, but they can also potentially lock in that power at a lower price, thereby saving consumers money and freeing up resources that can be spent in other ways.

And as things move in this more networked Internet of Things way we could see the potential of this to connect to a much broader set of electricity appliances, much broader set of electricity supply and demand technologies. And with again fairly significant potential to disrupt and change the way things unfold. So exciting times. I hope this has helped—this presentation has helped you understand a bit more about blockchain and how this connects to the peer to peer energy trading, has opened your eyes to a new facet in the electricity market and a new area where innovation and new business models are starting to be developed.

A bit of further reading, a couple of quick articles: *Power of Blockchain*, *Blockchain Beginners Guide*, as well a *Peer to Peer Energy—a Threat or an Opportunity for Traditional Suppliers*. So with that I'd like to thank you very much for your time and for paying attention. I'm Toby Couture from E3 Analytics. I'd like to thank the International Solar Alliance as well as the Clean Energy Solutions Center for support with this—in funding this training series, and would like to invite you now to stick around for a few moments longer for the knowledge checkpoint and a few multiple choice questions.

Thank you very much. I'm wishing you all a great day.

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