PHOTOVOLTAICS

Guest Speakers: Robert Singh and Christopher Delp

Good evening. My name is Robert Singh. I work for WTEC, a renewable energy company. I'm just going to tell you very briefly about the company. WTEC, the acronym, really stands for Wind Turbine and Energy Cable. So you may ask, well, what are you doing in the other space and solar and stuff? We started out the business of providing cables into the wind energy market. And then the solar came about, and we saw the opportunity. Our name was well known out there, so took out the wind, turbine, and energy, and just stayed WTEC.

So we are wind and solar company. We supply a lot of stuff into the wind market and into the solar market. We also do construction and design. Our companies are under the WTEC that supplies a lot of the OEM stuff. RERC does a lot of engineering. And Alternative Energy Development does a lot of the construction.

All three entities here, they're headquartered in Fort Lee, New Jersey. We also have an office here in Tampa. The reason is that I didn't want to move to New Jersey, so opened up an office here. It's too cold there. 25 years in the business. We've started out from the onset of wind turbine when they were doing 250kW turbine to now when you're doing 3 megawatt turbines.

So based on your lecture that I have a little bit insight of what you did today, I just wanted to talk a little bit about what's in a solar plant, and what are the components of a solar plant. But before you even get into this phase here, you've got to identify where you're going to build this plan-- access transmission line? Who's going to buy your power? Who's going to finance your project? The PPA is one of the most important things. How much are you going to gather a utility or somebody to pay you for your power.

Today, you're ranging anywhere from $0.05 per kilowatt hour to $0.07 a kilowatt hour. The market is going down. Their pushing it down. It becomes more competitive. A year ago, you could get PPA for $0.08 to $0.10 a kilowatt hour. Now you can't. You're lucky if you get that. It's a really good project if you get it.

So the cost of material has to come down. The cost for labor-- you got to find innovative ways of doing things, so you can be able to sell your power for that and still make a profit. Of course, there's government subsidies in it, but those are going to go away. And you've got to find ways to keep your prices low, to keep your cost low, to keep the projects going.

So quickly on what's in a solar plan you? You've got a substation. You've got everything that generates within. The solar plans have to go to the substation. The substation steps it up from whether it's 12 kV or 35 kV to 138 kV or 230 kV, depending on transmission line. You need to build a substation. You got inverters in it. You got solar panels. You got the foundation, the tracker that it's on.

This is a project that we actually built in Austin, Texas. It's start 35 megawatts DC, 30 megawatts AC. We engineered and constructed this project. Quickly, the components of solar plants-- you have your PV panels in rows. You call them strings. You may have 20 modules. That goes in series. They get hooked up in series. And they call them a string. So every string from every row gets set into a combiner box. For the combiner boxes, though, they take all the power from each one of those strings, combine it.

So you may have 18 or 20, up to 24, sometimes 30 strings going into a combiner box. And then you got two cables coming out, the positive and the negative. This is all DC at a [INAUDIBLE] station. The inverter station then inverts from DC to AC. And so the inverters, they're all cascaded together. So you can look from one to the other and bring that into the substation.

So in that particular project, being 35 megawatts DC, 30 megawatts AC, we were able to combine them into two feeders and bring it into a substation. So if you can bring-- you can reduce that amount of feeders that you bring into a substation, you help to reduce the cost, because you've got less cost in the substation for the breaker. If you're putting in the [INAUDIBLE] breakers-- instead of putting them four or three, you've got to put two in. Those are very expensive items. So those are things that you've got to look at when you're designing the project to reduce costs.

Just to give you a flavor of some of these things, I've got a couple of pieces of the table. I don't know if you guys can pass these around. But these are what comes out of your PV panel and the PV string. And it's like a 10 gauge wire, and those get cascaded together to make a whole string. And then as you come into the substation from the inverters to-- I guess when you combine a box to your-- when you combine box, you go to the inverters. You have the larger cables. So you can see how those all collect up from smaller cables into the larger ones.

Call this kind of a collection system. And then, they go into the substation. From the substation-- from inverter to inverter. And then inverter to the substation, you've got that size of cable. That's a 35 kV cable, or 35,000 volts. It just gives you an idea of the tracking system, how it's built. There's 12 tubes across. There's steel I-beams that go into the ground. And the panels are all mounted like this. There's tracker modules along here. And this particular system pushes and pulls like that. So the modules are rotating from minus 45 degrees to plus 45 degrees. So this tracking system attracts the sun all day. So if you stand out in a solar field, it'll keep moving slowly like that. It's how you optimize your production-- by doing a tracker system.

The other option to this is doing a fixed tilt. Fixed tilt is less costly, but you get less production out of it. So if you do a tracker, you may get about to 20%, 25% more, depending on the geographic location where you're at. Temperature has something to do with it. Like if you were in a very hot climate, believe it or not, it's not always best for solar, because the cell temperature as that rises, the efficiency goes down, and you get less production. So sometimes in the cooler climates with the higher ratings, you get better production than you would get [INAUDIBLE].

So now this is just some pictures of how the initial stage of us putting the solar project together. So you go in and stage it. You drive the beams into the ground. And then you start putting your torque tubes, and the stuff across it. It's called a torque tube, because they have to rotate like that.

This is a picture of a combiner box-- what it looks like. This is it open. Now all the cables comes into it. And then, I think you see the larger conduit with the cable coming back. It all still goes underground. And this is how your PV panels are mounted with the cables all going from one panel to the other.

The reason you do about 19 to 20 modules in a string, because each module typically on the open circuit voltage basis has about 44 volts, 40 to 44. So 40 to 44 times 20 is usually about 800. And that's about where you want to be, because of the maximum power point tracking of your inverters. That has a lot to do with the maximum power that you can get out of an inverter.

A little bit more about the internals of a combiner box. You have the-- as the wire comes in there, they all go into 15 amp fuse holders. And then these 15 amp fuse holders go into box, but it goes into a main disconnect switch, and then your power cable that goes to the inverter would come out in here. Those are those-- the big table that I passed around-- not that one. The other one we're-- the next larger one. That one.

I don't know if you want to pass that around, but this is what the switch looks like that goes into the combiner box. That's I think it's the 400 amp switch if I'm not mistaken, or 250 amp. That's 250. And these are your 15 AMP fuse holders. And everything here has to be UL-approved.. This entire box here has to be approved by UL before you can actually put it out into the field to make sure it's safe. As far as inverter goes, this is what an inverter unit looks like. This is one that has different modules in it. And it all goes into a big container where there is a lot of cooling that has to happen, because the inverter, they generate a lot of heat, and you need to call them off with the fans. Now, there are some inverters that are built for outdoors. They don't have to go in a container or go into a house. They are an [INAUDIBLE] three or a [INAUDIBLE] 4 enclosure that you can just standalone outside.

This just shows you some of the equipment that we use in this business. There's a lot of people you employ when you're building these solar farms. The last one we built out in San Antonio, we peaked at 500 people on the job. It was 50 megawatts, but we had to get it done in a short period of time. It employs a lot of people, but on a short term basis, project by project. If you're building a lot of project, these trained people are going to go from one location to the next. And once you train, you don't want to lose them.

It's very equipment-intensive also. These are trenching machines that we have to use to put the cables in. So you have to dig the grounds to put the cables in. Not every time you put the cable that you would bury it underground. There are times when you put in a cable tray, depending on the soil conditions. If you have really hard soil out there or rocks, you don't want to bury the cable. It's more expensive. So you would put cable trays and put the cables inside of the cable tray. So you do an

economic analysis to see which one has the better low cost option. At the end of the day, how cheap you can build this project and still let it last for 20 to 25 years.

Still some pictures that are showing you some of the equipment that goes into a substation. This is a substation. That's a transformer. You need large cranes to be lifting that up to put it in place. I think this is one of the things that most engineers need to know. It's a PVSYST report.

And before you can build any project, you need to run this PVSYST report in order to see what your-- based on your geographic location-- using certain type of modules and the type of inverter that you used, what kind of production are you going to get out of it. And how that would range over the year, month by month. A lot of the developers need to take this to the bank.

These kind of reports that they use-- and PVSYST is one of the recognized software out there that you can utilize for banking purposes that they would put a lot of credibility into it. And then there's things like a performance ratio that you've got to be able to justify. Performance ratio meaning that whatever DC we're putting into it, there's a certain amount AC that's going to come out.

And you have to be able to guarantee that over a period of time, [INAUDIBLE] of the designer, and of the developer, and the EPC contractor. If you can guarantee that kind of power delivery, then you're going to be penalized for it. So that kind of keep anybody from going out there and saying, I'll build a solar farm, if you can't stand behind it.

I think this is where most of you guys want to know what's going to happen after you've finished with this class, right? So I'm going to let Chris tell you all about this on what to do, what not to do, the legal aspect, right?

Good evening. Yes, the solar job market is growing exponentially. You might ask, What is a solar job? A solar job is any job that 50% of the activity or more in that job is based on a solar project. So you might be installing solar. You might be a project developer. You might have maybe 55%, 60% of your job involves solar, the other is hydro, the other is some other form of energy, whatever. But basically, a solar job, that's what it is.

In 2013, it grew 10 times faster. The solar job market grew 10 times faster than the national job growth number. So it was 2% And they grew 10 times faster than 2% in 2013. 2014, the numbers just came in, and it's 20 times faster than the national average. So it's 174,000 jobs that are solar jobs today. And again, that's specifying just solars. That's not hydro. It's not wind. It's not all the others. It's just in the solar sector.

So what's driving that? We have plummeting costs. Robert mentioned that where you have your cost of your solar panels. There are all kinds of labor saving techniques, and so forth, and things of that nature that are bringing the cost of these facilities down. Their popularity is increasing. There are more solar installations therefore. And there are more jobs as a result.

So you know, what's a solar job again? So what a solar job is more specifically-- I've got a big long list here of things-- first and foremost, what you think of. You saw all those guys installing these things, basically doing construction work. And that's your basic construction work. Then you're managing construction crews. Maybe you're on the site, and you're an engineer.

And you're a project manager-- so project management. You could also be an offsite project manager where you're working in an office, and you're working from a computer, and you're basically working with the field the project managers. There's manufacturing and process management. All of the components that we just passed around. We actually have a factory in Pensacola, Florida, which I just visited this last week. It's a great place. I mean it's a factory, right? But I mean, it's really neat and impressive.

We actually have this really awesome machine that starts out with a five-story tower on the one side of the factory. And it starts out way up there, and it's this giant wheel thing. And I'm not an engineer. I'm a lawyer, by the way, so whenever I try to give you numbers or I try to talk engineering, this is what it sounds like, right? So but it's a giant wheel, and it's got this conductor that comes down. And it's super hot up there. And then they give it this colder waters as it goes down for a couple feet or something like that. 750 feet? All right. And it goes all way down there. And it is really amazing to see. It really is amazing to see.

Manufacturing, process management, research and development into new and innovative products, ways to modify products, ways to generate new components, equipment, things that go into the solar farm-- the efficiency of PV panels has gone through the roof over the years due to research and development. There's engineering and project design.

How many of you here are-- everyone here is a graduate student, right? OK everyone hear. OK. And how many of you your background is in the sciences? OK. About half. And how about the arts? OK. About half. Is there anything other than arts and sciences? Not that I'm aware of, right? So that is everybody. There were no absentia votes, right? But so in the sciences, engineering and project design.

I work with engineers all day long in our office, which is the headquarters of construction and engineering for our company. And they work hard, and they put out some amazing work product. They design these solar farms. They do all the work as far as the layout. And what you might think of when you think of the solar farm is how it's set out there, and where all the panels are, and how it's going to look on the ground. But then they also do all this electrical stuff as well where they're determining if interconnectivity with the grid, and all kinds of amazing things. So engineering and project design.

Project development, where basically this is a really interesting part, where there's really no barrier to entry in project development. Project development means I have this idea. I want to do a solar farm. And any one of you in this room can be a project developer like tomorrow. You say, I have this idea. I'm going to be a solar-- and there are people who do that.

Project developers we've worked with, right, where they-- that's what they've done. And they say, I want to have a solar farm. And they come up with a name for it. And then what do you have to do as a project developer? You have to find the land. You have to find a good site for it. You have to find a site that's going to be economically feasible, meaning it's going to be close to a substation or things of that nature.

You're going to be doing the environmental work, the permitting, and so forth, making sure that you're going to do environmental impact study and things of that nature. I'm sure various of you are right in that field where you'll be actually providing that expertise to the project developers. There's operations and maintenance, which when you saw the O&M a moment ago on the slide. I don't know if you remember that or not. That's what O&M stands for.

It's operations and maintenance. It means after you've built it, then you've got to keep it going. And you've got to do maintenance on it, and everything. And you've got to monitor the thing. You've got to make sure it's putting out the amount of power that you need. You've got to make sure it's financially meeting all of your goals and hopes and dreams, right. So that's what the operations and maintenance is.

Financing and accounting, obviously finance, your professor mentioned a moment ago, the project finance aspect of this where that is a whole rich world in and of itself. No pun intended, right? Just all these different players involved. You're going after debt financing. You're going after equity financing. You're going after private sources. You're going after-- maybe you're doing a publicly-traded source. Maybe you're looking at taking a bunch of projects and pooling them all together and then chopping them up into securities and sending them out that way as investment instruments.

How many of you have finance backgrounds. Couple of you? OK. Few of you. Finance is really where it's at. Then of course, accounting. Of course, making sure that the business in a general sense is running and healthy. And then of course also the project itself. There's the legal side of things where you basically get to put your hands into everything. And how many of you are thinking about becoming lawyers? And if anyone raised their hand-- which you did not-- and for the record, no one raised their hand-- and that means you're all much smarter than I am, so-- but if anyone had raised their hand, it'd be like, No, you obviously-- the only way it ever happens is that somebody who thinks, one night, I'm going to be a lawyer. And then the next day they go and do it, right?

But so the legal side of it, though, understanding the policy aspect of it is obviously very important. The policies change from state to state from market to market. If you're going to do international, then there's always the question of choice of law. There's question of how do you enforce a contract, if you're going to try to do a power purchase agreement, and it's going to be an international one, and how do you enforce that. Are you going to utilize the local courts? Are you going to do arbitration? What are you going to do there?

Whenever you build a solar farm, inevitably there's somebody does something wrong, and then nobody wants to own up to it, so they start pointing fingers. There's always some kind of litigation, right? The regulatory side of things-- and again, that goes to the policy. That goes to, maybe your work is a compliance personnel in a utility. So there's a lot of things there.

Marketing side of it-- I tend to moosh together legal and marketing side of things if you can't tell. But getting out there and, well, selling projects, and selling ideas, selling policies-- it's all part and parcel of it. And I've got on there software. The PVSYST that Robert mentioned to you a moment ago. That is obviously a very well respected program. Wouldn't it have been great to be the person who wrote that program, right?

Software is a very important aspect, not just for PVSYSTs, which tell you how a project will theoretically work. There's also software for operations and maintenance. Once you have it up and running, you have to gather all the data out of the data acquisition system and be able to analyze it and make sure it's doing what you want to do. I could go on and on and on, but every vendor imaginable, there are vendors whose main chunk of business is serving renewable energy companies, serving solar companies, being involved in human resources.

I put that at the bottom because if you want an exhaustive understanding of all the ways that you could have a job in the solar field, go be a part of human resources of the solar company, and then you'll have the full picture. So there are a lot of different ways. So it's not just the guys in the safety jackets out there installing the solar panels, it's a broad range of professions, a broad range of aspects. And so that's the US market I just referred.

And in the US market has been a tremendous beneficiary of this fact that the solar industry is truly truly global. Now when I went to law school, my purpose was to get into international law and international finance. And the place that I went right into was renewable energy. And the reason why is because it is a truly, truly global activity. I mean it's a truly global phenomenon.

So everywhere you want to go, I could just take just a quick moment. We're here obviously. This is in South America some of the most interesting projects are taking place. There's a place where-- obviously, we live in the sunshine state where we get a lot of sun. The place on the Western hemisphere that gets the most sun is right here, on the border between Peru and Chile. And so that's a hot bed-- no pun intended-- for all kinds of solar activity. They're building solar farms out there like crazy. And they-- I mean-- we're talking about companies from Spain, companies from France, companies from the United States, companies from all over the place. And that's the companies that are building it, but then you have all the finance partners. And before you know it, by the time you put together all the project development, the finance. And you put together the construction and all of those expertise. Before you know it, you have a truly international cross border situation on your hands. So it is a tremendously global way to go.

If you want to get into anything international, renewable energy is the way to go. Now that's just over here. You have the well established markets in Europe. You have a burgeoning interest here in

the Middle East in Dubai and Abu Dhabi where they have very aggressive goals for powering their cities and their societies there. And there's all kinds of activity believe it or not in countries that are economically disadvantaged where they have a need for power, and there's a market for that.

And you can do PPAs. You can do these deals and set up these projects to where you could provide power in places that really don't have it, places that really have like maybe four hours of power a day. And you go in with a solar photovoltaic system and all of a sudden, wow, the village has a reliable power source.

And then of course a lot of manufacturing going on over here in the Far East. And I mean I could mention India and the things that are going on the projects that are going on in Australia, but we just don't have that kind of time. But it is a truly, truly international field. So if you like international, you definitely need to do solar.

Now going back here to Home, which is Florida. We've talked about the United States. We've talked about the international scenario, but Florida is in the shadows, Even though it's the Sunshine State. And that's mainly because-- if you've noticed, I mean there's not a lot of solar panels on top of people's houses, not a lot of solar panels on top of businesses, factories, things like that. And the reason why is because, well, it costs a lot of money.

Even though the solar panels have come down, you look at it, and you say, You're a homeowner. And you say, Well, I've got to put a few thousand dollars into some units. Send a contractor to put it on my roof and everything. And if you got your priorities. You say, I'm probably not going to put the solar panels on if I got to pay for out of my pocket right now.

And so-- but a company like ours, WTEC, we can come in and say you know what, You don't have to pay a dime for your solar panels on your roof. You don't have to pay a dime for it. Let us come in. We'll finance it. We'll also install it on your roof, and then when we flip the switch and turn it on, then you just pay us for the price per kilowatt hour that produces just like you do with your regular utility, only it's cheaper. You think people would take that deal. Yes, they would. And that's why it's not legal in the state of Florida.

So absolutely. So absolutely. So what's happened is in the past week, a broad coalition called the Floridians for Solar Choice went to Tallahassee. And we had a press conference. And and it is a broad coalition. I mean, it's everybody from the far right to the far left. It is everybody from the Christian Coalition and the Tea Party. And then in the middle, there's business. There's the Federation of the Florida Retail Federation and companies like ourselves.

And companies represented within the floor Retail Federation like Walmart, and Publix, and companies like that, that would love to use their rooftops, would love to use their extra land space. And then over to the left, environmentalist groups that have been laboring long and hard for change in this area in this state. So everybody from the entire broad spectrum got up in front of the cameras last week and announced a petition to change the law in Florida to allow those sales. So

that's something here. And I wanted to put a plug-in for that, which is you can get that petition if you're interested in signing it at flsolarchoice.org.

So you're involvement with the renewable energy industry, if you're looking to go into renewable energy, if you're looking to go into solar in particular, there is no better place for you to be than right here. Not quite right now, maybe a year from now. But here pretty soon, we're going to see an explosion of solar activity, solar construction. And it's going to be in this state. And so the jobs are going to-- my prediction, of course-- is the jobs are going to flourish as a result. So the future looks bright, even though we're currently in the shadows in this state. So that's essentially everything that I had to share with you. I'm available for questions, and so forth. And I do want to thank Dr. Philippidis for having us here today.