MARTY ROSENBERG
November 6, 2023
GridTalk #406

MARY WERNER INTERVIEW

Welcome to GridTalk. Today we have with us Mary Werner who is the National Renewable Energy Lab's Solar Program Manager at NREL, the chief government laboratory for energy research.

A: Hi, Mary.

A: Hi, Marty.

Q: Thanks for joining us. There's a lot to talk about so let's get rolling. There's a lot of emphasis now with federal spending poised to facilitate a transformation of the grid and our energy infrastructure. We want to get a really close look at what's going on with solar and you're the perfect person to help us so why don't you tell a little bit about what you oversee at NREL and what is being done at NREL in the area of solar research. You privately confided to me a minute ago there's 700 scientists working on this. Tell us what they're up to.

A: Yeah, it's a very broad and expansive portfolio. We've got our flagship area which is our photovoltaic research and development area. Photovoltaics I will refer to as PV for the rest of the talk. We do research in the cells, the active layer. We do research in the modules looking at reliability, durability, performance, design, making them more efficient, more durable, reliable, and bringing down the costs as well as trying to increase manufacturer ability. In the grid space we have quite a portfolio of work in the grid integration space for solar looking at the distributed solar and both levels of the grid, the distribution level, and the transmission level for utility-scale solar. We have research in power electronics and inverters, controls, software, storage, cyber security, all of those different aspects of the grid and then we work in areas to reduce the non-hardware costs, so think of things like permits, interconnection, customer acquisition, financing, all of things we refer to as soft costs, and they're roughly half of the cost of solar installations, so we're working to reduce those costs and also reduce the amount of time it takes to do installations. And we also work in commercialization and manufacturing and so trying to de-risk technologies to help small businesses and industries move into the market faster and we also have a growing

body of work to capture the heat and that's looking at capturing the heat from the sun for industrial process heat usage or for thermal energy storage which can, when designed properly that thermal energy storage could then be turned into electricity later on to create 24/7 solar.

Q: So, Mary, I've got two sets of statistics to neatly bracket our conversation. One speaks to U.S. solar capacity. You, of course, NREL started back in the era of Jimmy Carter and solar research was a key component as I recall in your startup. According to the Federal Government's energy statistics agency (U.S. Energy Information Administration [EIA]), we had about 314 megawatts of solar way back in 1990 and as of last year, it reach 72,000 megawatts or 72 gigawatts. That's quite a sizeable increase but it is still just under four percent of the generation in this country. That's one set of stats. On the other end of the spectrum respected scientists are saying that the globe will need something like 20 to 70 times as much solar as currently is deployed to have a credible chance of dealing with climate change. First, I'd like to ask if you accept those figures as generally accurate and then, how do we get from where we're at today to that kind of ramp up?

A: Well, in terms of accepting the numbers, I accept most of them although I will add that the ramp up, amount of the ramp up

for the U.S. is a little bit different than the ramp up globally, so I don't know what to, to have the entire globe be climate-neutral, that we also have carbon sequestration and other things that are variables in here so it's tough to put a point to it. I do know that in our…

Q: But Mary, Mary, do you accept the notion that solar can and should significantly increase penetration in our generation portfolio?

A: Yes, absolutely, and I have a couple of numbers as well.

Q: Okay, go.

A: We did a Solar Futures Study in 2020 and in that report, we said that if you want to go to a decarbonized electric grid by 2035, we have to ramp up from our 2020 level by 9½X and so that's just in the United States. And then, by 2035, if we also plan on electrification which would then increase the amount of electricity needed, we would have to get to 12½X to accomplish that by 2035 so my numbers are a little bit different than yours but our study was focused on just the U.S. I'm sure they'd be much higher globally.

Q: I was looking to be as dramatic as possible and I think your numbers are very dramatic…

A: Mary *laughing*.

Q: So, how do we get there and tell us how hard NREL's working at it and what you think is going to be the low-hanging fruit? What's going to be harder? Where would you like to start on that?

A: Good question. Let's see: how do we get there? So, the Inflation Reduction Act has helped a tremendous amount with seeing new manufacturing in the United States. In a report last week that I saw, our quarterly Market Industry Report released says that there have been 240 gigawatts of solar manufacturing announced since the IRA passed August of 2022, so that kind of ramp up is what we need if all of that comes to fruition. Now, of course, we don't expect all of it to come to fruition but hopefully, a great deal of it will and we're not the only ones ramping up. Lots of other parts of the world are as well. So, we're looking at things like how do we make sure that any rare earth materials that are needed today, can we design the systems to not include those in the future? Otherwise, that could become a huge issue if everyone's ramping up at the same time so, for example, gold and silver are both used in some manufacturing for some PV and so, can we create a way to eliminate those so that we don't have those bottlenecks in supply chain? That's just one example. I think there's a huge amount on the deployment side that we're trying to address. One example's permitting. We created something called the SolarAPP+ tool that is being adopted

by hundreds of jurisdictions across the country and it's saving a lot of staff time and a lot of time to get a permit approved for in those jurisdictions so we're trying to speed up the process of installations as well.

Q: Well, let's start where the rubber hits the road, the solar photovoltaic itself. What kind of new technologies are being looked at, at NREL and when you answer this question, early on it's been said a lot of technology developed in America was taken over by others, a lot of our industrial competitors. Is there hope to keep this intellectual property better protected this time around?

A: To answer the last part first, it's very challenging. Not all countries in the world abide by the same rules and so it's very challenging to maintain and retain that IP. We are in a race-to-market right now in two areas: one is called perovskites and perovskites is a new active layer technology so the active layer in a PV panel is that part that creates the electrons and perovskites is solutions-based so you can, if you think of newspaper printing, you're printing ink on a piece of paper; you can do that with perovskites, you can paint it on a surface and so it has a lot of potential in terms of applications. It is not yet commercially available in panels or anything else but everyone is trying to ramp up to get there in U.S. and China and

in other parts of the world. And the other one that's another race-to-market is tandems and tandems are when you take two active layers and you put them together kind of like a sandwich and those two active layers are both producing electricity so you're increasing your output for your amount of square footage and so this can reduce land or space use and it can increase efficiency and the other benefit of it is that if you think of a panel, the active layer is a tiny amount of materials; there's a lot of glass, there's often a lot of metal, there's a lot of other materials there. If you ramp up by doubling those active layers, you can reduce the amount overall of raw metals and glass and other materials so, it has a lot of benefits. We're still working out how we get it to a competitive price point.

Q: So, if we're talking as you alluded to earlier, potentially a nine-fold or even a 12½-fold increase the amount of solar generation that's out there, is our current transmission and distribution grid capable of handling that or is that going to require a revolution in technology as well?

A: I personally think it's going to; the grid needs to evolve, there's just no question about it especially when you think about the old way, the old way the system was built was for gigawatt scale nuclear power plants, coal power plants, they're all utility-scale. There wasn't anything at the distribution level if

you go back 50 or so years ago. Now, solar has the ability to as we all know, be on a rooftop or power a stop sign or things along those lines, it can; it's very scalable so it behooves us to use the distributed capability of solar which then allows us to potentially do things like microgrids where you have a microgrid just as the name implies, that can disconnect from the central grid or work completely off of the central grid. And we're seeing more and more microgrids popping up in the United States. It can also help with extreme weather events so when the central grid goes down from an extreme weather event, if you have a microgrid, you can retain your power system in your area. So, there's a lot of benefits to the microgrid from the distribution system standpoint. We've got to learn how to operate a grid that has power going multiple directions versus just from a power plant to a building and that's going to take a lot of revolutionary change. And it' s happening, it's just I'm not sure just how quickly it will happen but it's definitely happening.

Q: Has the Renewable Energy Lab sitting in Golden, Colorado at the foot of the Rocky Mountains; how much of this lands on your campus? There are many other national labs. It's been said about the electrical utility industry as a whole that it has not spent quite a lot on R&D. Where are the answers coming from in the United States?

A: That's a great question as well and I'll talk about ARIES which I'll explain in a second. We started this initiative a few years ago and ARIES stands for Advanced Research on Integrated Energy Systems and it's focused on real-world hardware that can be connected with our assets and our research programs to have real-world answers to utility questions. Utilities don't want to try something on their grid. They want it validated; they want it reliable. They have to have it reliable and so doing simulations and modeling just doesn't give them the comfort level of taking an action off of that data so we're building out at our South Table Mountain Campus, we have the Energy Systems Integration Facility which can go up to two megawatts in terms of hardware the loop and testing in that building. Flatirons Campus which is about 20 miles north of our Golden Campus, the Flatirons Campus, we are building out to be able to have 20 megawatts of assets and hardware. We have things called the Controllable Grid Interface that can go up to 20 megawatts. We have our own substation. We can disconnect from the utility and run our own research. We can even do "black starts." We can do anything we want with this 20-megawatt system. And so, that creates a lot of opportunity to work with utilities to help them feel more comfortable with the integration of these different technologies. We've got PV up there; we've got wind, we've got an electrolyzer that's going in

to produce hydrogen. We're building out fast charging EV stations. It's intended to be an example of the entire ecosystem for our grid.

Q: So, what role will storage play as we do this? Is it going to be increasingly integrated in the development solar resources as you envision a more distributed grid? That's A, well, answer that, then I'll ask B.

A: Yes, in fact some states are already requiring if you put in solar you have to put in storage and so, we are seeing more and more systems are just becoming more and more naturally solar plus storage, not just solar alone. The grids have to have storage to be able to handle these variable generation sources.

Q: So, on that front, what kind of research can you point to? It's a little further afield from solar but will we be forever wed to lithium-ion or will there be other technologies come along?

A: There are a lot of other technologies in the works beyond lithium-ion. That's not my area or expertise. We are battery researches are led by the vehicles department but what we're doing in solar is we're looking at capturing the heat from the sun and storing that in thermal energy storage and we just started a new project on long-duration energy storage using thermal energy storage and that's looking at tank designs, tank

designs and trying to design those in such a way that we could retain the heat from things like molten salt and retain that heat for seven to 14 days. That doesn't get us to the seasonal storage that we're going to need for spring and fall but it does get us far past a four-hour battery so we need all of those different levels of storage and this is one potential application on the long-duration side.

Q: So, the big question I was going to ask was as solar is deployed and as storage technology evolves, might the shape and the whole deployment and strategy for grid design change to the extent that you need ship less percentage of power long distances and keep a closer to the end user?

A: Yes, that's, that's one of the benefits of solar is you can have it co-located with the load so you don't have to have it run through transmission lines a thousand miles to be used. We see transmission expansion as a real hurdle and so co-locating the generation with the load source could be a win-win all the way around.

Q: So, you mentioned a few minutes ago the excitement over the technology of painting solar resources as a liquid on a substrate. Talk about some of the bells and whistles that you have around you. Update us on where solar paint is, solar

highways, solar tiles. If you kick around the campus and wander into different labs, what are folks likely to see?

A: so, we have when I talk about painting, we actually have a visitor demo where visitors can paint their own solar cell using perovskite, a perovskite solution. And so, we have, it's in the laboratory in a safe environment but the person paints the solution on a surface and then we have a light that represents the sun and we see how well they did with painting their cell. We have solar windows; we have transparent solar where we are working with companies to rollout solar windows and we have been able to accomplish transparent solar.

Q: So, let me stop you on this for people who that might not be aware of this. Solar paint, do you think the south side of our houses could be one day be painted with solar capacity and these clear windows, I mean how far from primetime would you say it is to have these deployed?

A: It would be great if it were that simple but we all know electricity is dangerous, right? so you don't want it exposed to anyone that touches it, and so you have to be able to enclose it. You have to be able to wire it. You have to be able to have wires going through it so we' re not there in terms of simply painting a house but we have this potential with the solution-based material to apply it to things so you could potentially have a

layer of PV cells on your cell phone and you flip your cell phone over and it charges throughout the day. You could have it on; we already have it on street signs and things like that. You could put it on the sides of roads when there are 10-foot barriers on the highway to try to reduce noise; things along those lines. You could put PV on those surfaces, so we have a solar surfaces type of program looking at building integrated photovoltaics whether it's solar windows, solar shingles, solar siding. We are looking at vehicle-integrated photovoltaics where you integrate the PV cells into the vehicle surface. There are many car companies looking at doing this; I believe Toyota has in their Prius, has an option for a solar roof so you can have PV on your electric vehicle. We also are looking at floating PV which is not a solar surface but it's putting PV panels on a water surface. It's dual-purpose there in terms of generating electricity and reducing evaporation, so this would be for bodies of water that are not intended for recreational use or fishing or anything of that nature. We also have agricultural PV which is another dual-use PV where you co-locate PV panels along with livestock or crops and we actually have a solar farm on our South Table Mountain Campus in Golden and we're producing produce, hundreds if not maybe even tons of produce underneath our solar panels so there's a lot potential there with the dual-use and being able to co-locate

with other things to create more revenue streams for rural areas and farmers and folks in those situations.

Q: I realize you're not an economist but I know enough about NREL to know that you try to be very practically grounded to the extent that when you work on a technology, you're always looking on how to commercialize it and have agreements with parties in the private sector to bring stuff to market so that you're not working in a vacuum. Do you have any sense of what the overall social cost or the capital cost would be to get that 9½- or 12½-fold increase in solar and are there folks in the Department of Energy looking at how we get that kind of resources marshalled?

A: I don't have a figure for how to get to 9½X. I do know that the solar industry's been ramping up for several years now, growing by leaps and bounds each year, year-over-year. Solar is the largest, the largest technology area in terms of capacity added to the grid, solar has been the dominating one the last couple of years and so we're seeing huge deployment. In May of this year, the Department of Energy's International Energy Agency projected that we'll be spending globally, we'll be spending globally over $1 billion dollars a day on solar investments. They estimate the investments in 2023 to be over $380 billion so it is ramping up. It's definitely growing. Five years ago, it was I

think it was maybe a $5 billion dollar industry in the United States and now in 2022 it was over $35 billion in just the U.S.

Q: So, talk to me about you and your job. I mean, do you pinch yourself every morning that you get to go to work? What really excites you about what you're doing? You're in the middle of a massive transformation of the energy sector. You have a bird's eye view on some of the leading projects. How do you go about your job? How do you prioritize what you want, what you need to prioritize? How do you…what kind of moving parts are you dealing with? Give us a feel of what it's like to be doing what you're doing now at NREL.

A: A lot of moving parts. You know those 700 staff that work on solar is a challenge by itself. It's just a really…we are the largest program at the lab and a lot of people support solar. Out of those 700, 150 primarily work on solar but the other 550 are working on solar and wind and other areas. If you think about like grid and electrical engineers, they might be working on problems for solar and for wind and for other technologies at the same time so it's not that the 700 are just working on solar so there's a lot of collaboration and coordination trying to tap the right resources for each project and each problem, whether those resources are internal at NREL or whether they're at another lab or a contractor. Staffing has been a bit of a challenge the last

few years. We've really ramped up the amount of people at NREL; we're at about at 3,200 now I believe. When I started, it was a lot smaller but that was a long time ago. But I think we've doubled in the last five years and so seeing a lot of new people, ensuring that everyone understands the safety culture. We are working in laboratories making sure that everyone's kind of onboard with what's going on and understands the history behind the technology so we have a lot of our more senior people helping the junior people with understanding the history behind technology and ramping them up and mentoring them so those are a few examples of some of the things that we work with and try to address.

Q: So, if my figures are accurate, you started at NREL back in 1995, is that right?

A: I did.

Q: So, what was the flavor and excitement around solar research then versus now? What the biggest difference?

A: Well, NREL started 45 years ago as the Solar Energy Research Institute. Solar has always been the flagship area for NREL and originally for the first probably 20, 30 years, it was largely photovoltaic research and development and concentrated solar power research and development. There wasn't a lot involved; we didn't even know what soft cost was. We weren't talking about

installations; we were still trying to get a product to market and so, we were really focused on bringing down the costs so that it was not such a niche product. And so, once it started building in terms of installations, then we started realizing we needed to address grid issues. And then we realized we needed to address more than just the module and we need to address these soft costs and balance the systems and then it just kept growing over the last probably 15 years into all of these other areas so that we're looking at the whole picture of an installation and not just the module hardware itself, so I would say that's the biggest evolution.

Q: And as they say, the proof is in the pudding or in the solar? I think those figures you recently put out for residential PV at least, the installed cost for 2023 is $2.68 a watt which is down almost 16% from the year before. That's quite a sizeable cut.

A: It is, yeah. We're not doing this alone. There are lots of other entities doing research and industry is motivated. There's strong competition out there so costs are being driven down from both sides, the research side, and the competition side.

Q: So, Mary, it's an exciting space and we reserve the right to check back in with you down the road a bit to see how things are evolving.

A: Sure. Absolutely.

Q: Thank you for joining us.

A: You're very welcome. Thanks, Marty.

We've been talking with Mary Werner who's the Solar Program Manager at the National Renewable Energy Lab.

Thanks for listening to GridTalk a production of the U.S. Department of Energy's Office of Electricity. We regularly convene conversations and follow leaders in the fast-changing electric sector in America and around the world.

Please send us feedback or questions at GridTalk@NREL.gov and we encourage you to give the podcast a rating or review on your favorite podcast platform. For more information about the series, now on its fourth year, or to subscribe, please visit www.SmartGrid.gov.

END OF TAPE