Scott Tinker (00:00):

Next on Energy Switch, we'll look again at one of the most important questions in energy today: Could solar and wind power the world?

Robert Bryce (00:09):

If wind energy is so green, why are so many rural Americans protesting against it? Look at solar. The locals in these rural communities are saying, "No way."

Leah Guccione (00:17):

Well, I'm not saying that they should be ignored, but building infrastructure period, is hard. You're still going to have specific instances where people just disagree.

Robert Bryce (00:27):

I think it's more than just specific instances. It's all across the country.

Scott Tinker (00:32):

Coming up on Energy Switch, Part two of: Will solar and wind power our future?

Speaker (00:38):

Funding for Energy Switch was provided in part by Microsoft and by The University of Texas at Austin.

Scott Tinker (00:49):

I'm Scott Tinker, and I'm an energy scientist. I work in the field, lead research, speak around the world, write articles, and make films about energy. This show brings together leading experts on vital topics in energy and climate. They may have different perspectives, but my goal is to learn and illuminate and bring diverging views together, towards solutions.

Scott Tinker (01:16):

Welcome to the Energy Switch. In this episode, we'll cover the realities of scaling-up a mostly renewable system. How much new solar and wind generation would be required, and what timeframe? What metals and rare earths would be needed, and how much land? Where would we site these facilities? Finally, we'll talk about the cost.

Scott Tinker (01:39):

Our experts for this lively discussion are: Robert Bryce is an energy journalist, writing frequently for major publications. Author of six books on energy, a filmmaker, and host of the Power Hungry Podcast. Leah Guccione is the managing director for RMI's Carbon-Free Electricity Program, leading their research in distributed energy and batteries, and a former US Navy officer.

Scott Tinker (02:03):

On this episode of Energy Switch: Will solar and wind power our future? Part Two.

Scott Tinker (02:10):

How long would it take to get to a substantial solar and wind grid, if we were heading that way?

Leah Guccione (02:17):

One of the things that's very common right now is talking about how do we get to 80% by 2030? That's very much part of policy conversations.

Scott Tinker (02:24):

80% solar and wind in the next eight years?

Leah Guccione (02:27):

80% carbon-free by 2030.

Scott Tinker (02:32):

So, that includes hydro and other things?

Leah Guccione (02:32):

Mm-hmm (affirmative). It includes the sort of existing hydro, continued operation of existing nuclear, but much faster and more extensive deployment of wind and solar.

Scott Tinker (02:41):

Okay.

Leah Guccione (02:41):

Most estimates are pretty consistent that we do need to increase the deployment of those technologies between three to five times the current rate, the fastest we've ever done it, which, for reference, takes us to about at least 100 gigawatts of wind and solar a year. So I said we did 30 in 2020, and we need to at least get to 100 or more a year.

Scott Tinker (03:07):

Combined?

Leah Guccione (03:08):

Combined, if not more. If you look at a country like China, they're already deploying these technologies at that rate, and so, we know that it's technically feasible to deploy these technologies that fast. A lot of studies are showing that we need to get to at least one terawatt of renewables deployed by that 2030 timeframe, if not more.

Scott Tinker (03:33):

Okay.

Robert Bryce (03:33):

On these models and these ideas of, "Well, we're going to deploy it at this scale and this scale." Ignore the most fundamental challenge here, which is land use. I've been writing about this for a decade and rural America over and over and over again, rural communities are saying, "We don't want large scale renewable projects in our neighborhoods." Now, the response is, "Oh, those NIMBYs, they just don't know what's good for them." But why, then, have over 300 communities from Maine to Hawaii rejected

wind projects? This is data that's verifiable. I have the spreadsheets. You can find them on my website. You can't build large wind projects in California. You can't build them in Iowa. The backlash against big wind in New York is so strong that the state government in Albany is trying to override local zoning rules on wind projects.

Robert Bryce (04:18):

If wind energy is so green, why are so many rural Americans protesting against it? The answer is simple. They're concerned about their property values. They don't want to look at red blinking lights on top of 500 foot high wind turbines all night, every night, for the rest of their lives. So, that's wind. In the summer of 2021 alone, massive solar projects proposed in Nevada, Pennsylvania, and Montana were all rejected. Why? Because of local opposition. The project in north of Las Vegas was going to cover 14 square miles and the attitude is, "Oh, we'll just put it out there." Well, the locals in these rural communities are saying, "No way," because it ignores the most fundamental issue which is, where are you going to put it?

Leah Guccione (04:58):

Robert, I've taken a look at your own data and it actually shows that there has been a decreasing trend in the number of projects that are being contested or canceled. Part of why we're seeing a decreasing trend is that, one, we're still seeing overwhelming public enthusiasm and support for the idea of renewables in America, so there's still positive public opinion. But then also-

Robert Bryce (05:23):

But these are national level polls that don't consider local sentiment. I mean, those are not considering county level surveys, county level, city level, town level polls, and I don't believe that it's decreasing. I think what's happened is that the wind industry has found out that they can't put them in certain areas, so they quit pushing. But if you've got the two most democratic states in America, California, and New York, we have some of the most aggressive, renewable energy goals and you can't build renewable capacity there. What does that tell you? It tells you that the land use conflicts are the fundamental constraint here. They are the binding constraint. To ignore them, I think, is just unconscionable.

Leah Guccione (06:00):

Well, I'm not saying that they should be ignored, but part of what we're seeing is that wind and solar developers, as well as state and local governments have dramatically improved their citing practices. So, that is part of what's contributing to the reduced number and frequency of contested citing projects. The latest numbers show that there's between 800 and 900 gigawatts of renewable projects that are currently in interconnection queues in the United States today. So we already have close to 80% to 90% of what we need in this next decade, as actual proposed projects.

Leah Guccione (06:38):

But these companies are learning that you need to engage communities early, that communities need to be a key partner in designing and citing and other aspects of any new renewable project to mitigate concerns about citing, to mitigate the concerns about the shading issues, to mitigate concerns about environmental impact and noise. So, the project developers are learning and they're doing a better job, which is part of why you're seeing a reduction, and I'm not saying it's not 100%, you're still going to have specific instances where people just disagree.

Robert Bryce (07:18):

I think it's more than just specific instances. It's all across the country.

Scott Tinker (07:22):

Yeah.

Robert Bryce (07:22):

But let's talk about the scale issue, and in terms of both human costs and wildlife. Glad you mentioned the noise issue. This is an issue that the wind industry, again, has been very successful in ignoring and obscuring the truth. Here's the truth. The low frequency noise and infrasound admitted from wind turbines causes human health problems. I can point you to a dozen, two dozen studies that have been done by researchers all over the world, that have shown sleeplessness, sleep disruption, ringing of the ears, vestibular problems with noise from large scale wind projects. I've talked to dozens of people all over the country, all over the world, in fact, many of whom have moved out of their houses because they've had wind turbines built too close to their homes.

Robert Bryce (08:06):

Now let's talk about wildlife. I'm a bird watcher, been a bird watcher for more than 30 years. These wind turbines are taking a huge toll on American wildlife. Raptors, in particular, are being killed by wind projects and big wind doesn't have to report any of these wildlife kills. The bat kills by wind turbines have far exceeded the initial estimates. Bats are the only flying mammals. They're important insectivores and pollinators, and the wind projects are taking a terrific toll on bats. So, this idea that we should just cover the countryside with wind turbines with no concern for the humans, the wildlife, it's madness. It's just flat madness.

Scott Tinker (08:45):

Let me-

Robert Bryce (08:46):

I could go on, I'm sorry.

Scott Tinker (08:47):

... interject here. It's important to say energy doesn't seem to have much popularity when it needs to be built. It's just interesting remarkable fact that we don't want it near us. So, I think this is a big challenge, this land use, and it's been brought up many times before. The public opposition is such an important one.

Robert Bryce (09:13):

Can I just hit on one point because that public opposition as well on the land use, it's not just the projects themselves, and this is the other key limiting factor, and I think it will be for renewables, is the high voltage transmission. It's difficult to cite projects. Try building an interstate high voltage transmission projectm it's almost impossible. They take decades, not years.

Leah Guccione (09:33):

Absolutely. Absolutely. Robert, I completely agree with you on the transmission. Access to the right transmission interconnections is a bigger barrier to renewable deployment than any amount of public opposition, actually. Building infrastructure period, is hard. I mean, people don't want a transmission line. They don't want a new highway or a toll road or a rail line or a pipeline. One of the things that we need to scale up the most is energy efficiency, because perhaps the thing that has the least opposition is the energy you don't need in the first place.

Robert Bryce (10:09):

That's fair enough, but let me hit on the transmission point here, because again, it's a land use conflict. The Eastern Clean Line Energy Partners was trying to build a project across the state of Arkansas. The entire Arkansas delegation opposed it, and that project was killed and that's effectively stopped the development of large wind project in Oklahoma.

Scott Tinker (10:27):

Something that's bipartisan.

Robert Bryce (10:29):

Well, right. It's bipartisan. Well, exactly. But these are state level delegations, county level, and the same thing is happening in Missouri now where the grain belt express line has been fought over now for 10, 12 years and still, not an inch of it has been built. So, this idea of, "Well, let's just accelerate the building of transmission." Well,-

Scott Tinker (10:47):

What's the number?

Robert Bryce (10:48):

... it doesn't recognize the scale of opposition.

Scott Tinker (10:51):

I've heard like we'd have to double or triple the grid. What plus or minus are we talking about in terms of grid, the actual power lines?

Leah Guccione (11:00):

Yeah. Most of the studies that we've looked at as well as our own analysis is showing that you need at least 50% more, if not, two to two and a half times more transmission than what we have, relative to today.

Scott Tinker (11:16):

Okay. So, 150% to 250%. I guess I worry that that kind of infrastructure, we may hear it, but then when it comes time to do it, we see this huge public pushback on it, which costs a bunch of money, and now we're stalling deployment.

Robert Bryce (11:36):

Well, it's about time as well. So, you couldn't do it in decades. Yet, some of these studies are study put out by Princeton in December 2020. They're talking about a doubling or tripling of high voltage transmission. It's just not connected again to the facts on the ground. Where are you going to put it? How are you going to connect it? How are you going to pay for it? That's the fundamental issue.

Scott Tinker (11:56):

Let me jump to one scaling up big thing here, too. It's going to take a lot of stuff to capture lower density energy. The sun and the wind and the batteries to back them up, it's all mine, the sun and the wind are renewable, but the panels, turbines and batteries are not. The plastics and the chemicals and the metals and things, both the sourcing of them, and then the decommissioning and disposing of them. What's the vision there, as we scale this up?

Leah Guccione (12:25):

Yeah, absolutely.

Scott Tinker (12:26):

I don't mean to look at you every time. Robert, you could start, you can interrupt him.

Robert Bryce (12:33):

Well, sure, I'll go first. Here's the rule of thumb, the lower the power density, the higher the resource intensity.

Leah Guccione (12:39):

Yes.

Robert Bryce (12:39):

When you have a low power dense source, ethanol being the lowest, fractions of a watt per square meter in power density. Wind energy, I don't care where you put it, one watt per square meter. Solar, about 10 watts per square meter. Nuclear, 2,000 watts per square meter. When you have low power density, you have to counteract that with other material inputs, copper, concrete, polysilicon, steel, etc. When you start with such a low power density source, you have to bring in these other material inputs that then are costly.

Scott Tinker (13:12):

It takes a lot of stuff to collect it, to get the dense energy wind.

Robert Bryce (13:16):

To concentrate it to make it energy and power that's at scale, that is useful.

Scott Tinker (13:20):

Thoughts?

Leah Guccione (13:21):

So, one of the things that is a true attribute of these renewable technologies is that most of them, wind and solar in particular, are what we call capital intensive. You build them once with the materials that you need, and then the sun shines for free and the wind blows for free, and you don't need to pay for that resource. So, all of the material intensity and upfront cost is in the initial build. But then when you look at gas plants and coal plants, they have this resource intensity in their operations and maintenance because they're burning an extracted resource.

Robert Bryce (14:01):

Well, I'll take your point, but I think it's absolutely critical as well, that you understand where are these resources coming from? The Critical Minerals and the International Energy Agency in May 2021 issued a very good report on this. Who controls the global supply of rare earth elements, neodymium, praseodymium, lanthanum? The Chinese, on a scale of 90%. Where is roughly 40% to 50% of the world's copper refined? In China. Who controls the majority of the world's supply of cobalt? China. Who controls the majority of the world's supply of zinc, manganese? Critical minerals needed for alternative energy sources are dominated by the Chinese government. I'm not here to bash the Chinese, but you want to turn our supply chains over to the Chinese government so that we can have lower carbon technologies? That's not a trade that I think is worth making.

Leah Guccione (14:52):

I think your concerns are valid, but we need to have the same concerns for our coal, oil, and gas supply. So, other countries, other private sector entities that the U.S. has no control over, have a big influence on the availability of the supply, the cost of the supply. So these concerns that you have about the minerals, the metals that we're using in things like solar and battery technologies, the concerns also need to be considered when you look at oil, gas, and other energy sources that we're dependent on.

Robert Bryce (15:32):

I don't see how you make that point. We're effectively self-sufficient in oil, we're effectively self-sufficient in coal and in natural gas.

Leah Guccione (15:38):

But it's still a global market, and so, part of why we're seeing the incredibly high oil, gas, and coal prices that we're seeing right now is because of what's happening in the global supply chain for these resources. So we're not perfectly insulated from these problems.

Robert Bryce (15:55):

Well, fair enough. I guess, let me ask the question directly. So, are you okay with depending on China for rare earth elements? Because, really, it's obvious who controls the market.

Leah Guccione (16:03):

No, I don't think we want to become more dependent on China.

Robert Bryce (16:05):

I'm glad we agree.

Leah Guccione (16:06):

I don't think any country wants to become overly dependent on one supplier of anything.

Scott Tinker (16:11):

Yeah. One supplier, and as we talked about earlier, one source of energy.

Leah Guccione (16:16):

Exactly.

Scott Tinker (16:17):

I think optionality is important. So, we've talked about scaling up here and looked at the challenge, it's big numbers and timeframes that would take the land and the uses it would have to happen and impacts in public. It's hard to build these things in places that are passionate about them. The grid, building a bigger grid, we need to be ready for that. Moving energy is hard, no matter how we do it as electrons or molecules, it's hard. We started getting into the subject of cost. We know the levelized costs at the plant gate of wind and solar have come down remarkably, below coal and natural gas at the plant. We've just talked about a lot of things it takes to get it from there to us, and that adds cost. What are the cost trends for wind and solar? We'll talk about batteries next.

Leah Guccione (17:04):

So, for wind, if we're looking at roughly the last decade, 10 to 12 years, we've seen a 70% decrease in the cost, what is referred to as the levelized cost of wind and 90% decrease in solar. For wind, you're seeing project prices in what we call the $20 to $40, a megawatt hour range, and for solar it's in the $20 to mid $30s. We've seen projects come in as low as $14, $15 a megawatt hour, which is just staggeringly low cost. Part of what is driving these really low costs-

Scott Tinker (17:45):

That's like a penny and a half, a kilowatt hour.

Leah Guccione (17:47):

Exactly.

Scott Tinker (17:48):

Coal, maybe a dime, 6¢ to 10¢ or something.

Leah Guccione (17:52):

Exactly. Exactly. So, remarkably low costs. We saw a 90% reduction in the cost of battery technologies in roughly the same timeframe.

Scott Tinker (18:00):

Yeah. Is there any headroom? Are we reaching the limit? How much more can we get?

Leah Guccione (18:04):

It depends on who you ask. So, the estimates tend to be conservative and they tend to be conservative for two reasons. One, some people argue that some of the estimates are being made by incumbents

who have reasons why they don't want to see the cost come down any further. Then others, it's just a matter of conservatism. But the reality is, solar and wind are technologies that you mass produce, you make them in a controlled environment, you use repetitive processes, you can optimize the supply chain, you can do focused improvements on the design, making the technology more efficient and less resource intensive. You can see how increasing deployment will continue to drive down the cost of the technology.

Scott Tinker (18:51):

Yeah, interesting.

Leah Guccione (18:51):

So, there's the potential to see even further cost declines, I think, for all three of these technologies in particular.

Scott Tinker (18:57):

Okay.

Robert Bryce (18:58):

I think this laser focus on the watt hour cost is really just a head fake. When you look at the states that have deployed renewables at scale, California; their electric rates have gone up at a rate seven times that of the rest of the United States. They have some of the highest electricity prices in the continental U.S.

Scott Tinker (19:19):

I see that correlation in European countries and U.S. states, it's a correlation. How much of it is causative and what are the other things? What part of it would be the... It's not all because it's intermittent. What are the other parts?

Robert Bryce (19:34):

But it's the building the transmission, building new substations. Leah mentioned earlier how many megawatts? 100 megawatts of renewables are in the queue. I know for a fact, more than 100 gigawatts of that is in California.

Scott Tinker (19:48):

Yeah.

Robert Bryce (19:48):

So, they have to upgrade their entire system, high voltage transmission substations, distribution lines, that's all comes to the cost of the consumer. So now we've talk about economic costs. What about the other costs here? Ruined landscapes, ruined viewsheds in rural America. We're talking about impacts on human lives of people having to leave their homes. What about birds and bats? What about wildlife? What about these other costs that don't figure in onto that bottom line, on that balance sheet, but at a real cost in the system and on people and wildlife?

Leah Guccione (20:21):

Yeah. Robert, you are right. These externalities, as economists would call them, these things that tend to have a real cost, but those costs don't show up into the actual price that you're paying. Most of the studies around moving to a high renewable system show that the social and health benefits of that system are on the order of $3 trillion in benefits due to avoided premature deaths that currently happen from the pollution from burning fossil fuels. These projects tend to have tremendous net positive benefits when you take all of the externalities into account.

Scott Tinker (21:01):

Incentives or subsidies, whatever word you want to use, what roles do those play their important for things? Then I do want to ask you, how much do we need to spend to get to a mostly solar and wind system? So, first, what are the rules incentives and when should they stop?

Leah Guccione (21:17):

So, there's lots of opinions there, and I know Robert's going to have an opinion as well, but in some ways the industry has matured tremendously. I think the question is, if we're going to meet these deployment rates that we estimated that we need by 2030, you probably still need some tool. Now, whether that should be a carrot or a stick is a policy decision for policy makers and regulators to decide.

Scott Tinker (21:41):

Right. Set emissions targets or something else.

Leah Guccione (21:43):

Correct.

Scott Tinker (21:43):

Yeah. Short subsidy incentives?

Robert Bryce (21:47):

I'll keep it short. The production tax credit for the wind industry and the investment tax credit for the solar industry need to be eliminated now. These are industries that repeatedly said, "They're cheaper than conventional." Well, if they're cheaper, then let them stand on their own two legs. Yet they continue to lobby for the increased subsidies and extension of the subsidies, and it is distorting the wholesale market all across the country.

Leah Guccione (22:07):

I would just say that we need to consider that the other parts of our energy sector are also subsidized in different ways.

Robert Bryce (22:14):

At a tiny fraction of the rate given to solar and wind.

Leah Guccione (22:18):

Not necessarily.

Robert Bryce (22:19):

In 2018, according to Congressional Research Service data, on an energy produced basis, the solar industry got 250 times more federal tax love than the nuclear sector. The wind energy sector got 160 times more. So the idea that the hydrocarbon sector is getting unconscionable subsidies, it's just flat wrong. It's just not true.

Scott Tinker (22:39):

The subsidy comes in the form of not paying for the externality of CO2. So, let's come to this last piece, what's it going to take dollars-wise to get to a mostly renewable system?

Leah Guccione (22:53):

One of the studies I like to point too that's come out most recently was done by a group of researchers at Princeton. So, the cost estimates is that you need about $3.2 trillion of additional capital investment relative to the reference scenario. So, that comes out to something like less than 3% of GDP relative to business.

Scott Tinker (23:18):

That's $3.2 trillion on top of whatever we spend now?

Leah Guccione (23:21):

What we would spend normally.

Scott Tinker (23:23):

Okay. So let me do this. Let me have each of you give a little summary. We've talked about reliability, we've talked about scaling up, we've talked about cost. We framed the question, can solar and wind power the world? What's your summary on that?

Leah Guccione (23:39):

I think there's tremendous opportunity for solar and wind to power the world. We're seeing tremendous growth in the deployment of these technologies. Roughly, when you look at 2020, 90% of all generation that was added to global grid systems was clean energy. So we're already seeing a global shift towards wind and solar. When you look at the many studies looking at how do we move as cost efficiently and technically efficiently and socially responsibly to a net zero energy system. Even in scenarios that include carbon capture include a nuclear renaissance, you're still seeing tremendous growth in the deployment of wind and solar to provide the bulk of the energy we need in our future electricity systems.

Scott Tinker (24:28):

Robert?

Robert Bryce (24:29):

Jesse Ausubel is one of the great thinkers in terms of energy and power systems. He said solar and wind may be renewable, but they are not green and I think that's absolutely right. When we talk about the material inputs, polysilicon, all of the other rare earth elements, the land use, the other inputs that are required to make renewables at scale, they are not green. Full stop. This is the thing that I've been

talking about for more than a decade. If we're serious about reducing carbon emissions and providing more power and energy to the 3 billion people in the world today who are still living in dire energy poverty, we need to deploy nuclear and natural gas at scale, and we need to get on it and we need to get on it now.

Scott Tinker (25:07):

Studies suggest that getting to 80% carbon-free electricity in the U.S. by 2030 would require 1,000 gigawatts of new wind and solar capacity per year at a cost of $3 trillion over business as usual. That's three to five times the current deployment rate, but there are already 800 gigawatts of proposed projects in the U.S. pipeline, and China is deploying this fast. Still, there will be conflicts over land use. Rural communities are rejecting wind and solar projects because they harm property values and viewsheds. The noise from wind turbines affect sleep and hearing, and the blades kill birds and bats. Developers are working to smooth these issues. Even so, building new transmission lines for these projects will be extremely difficult. This may be a limiting factor, along with the environmental impacts of mining the required rare and metals now controlled by China. All energy at scale, faces challenges.

Scott Tinker (26:36):

Funding for Energy Switch was provided in part by Microsoft and by The University of Texas at Austin.