

Checking in on solar power

A conversation with Bloomberg NEF's Jenny Chase.

November 29, 2023



David Roberts

Hello, hello there, everyone. This is Volts for November 29, 2023 "Checking in on solar power." I'm your host, David Roberts. Jenny Chase went to work for the London-based startup New Energy Finance in 2005, straight out of university in Cambridge. She founded its solar analysis team and helped establish some of the first reliable indexes of prices in the solar supply chain, as well as some of the first serious industry models and projections. The solar power industry barely existed then. The solar power industry barely existed then. Now solar is the cheapest source of new power in most markets and the International Energy Agency expects it to dominate global electricity by 2050.

Throughout that heady transition, Chase has run and grown the solar analysis team, even after the company was bought by Bloomberg and became Bloomberg NEF in 2009. It has become one of the most respected teams in the business and a widely cited arbiter of industry data. In 2019, Chase wrote a book summarizing what she learned over her years analyzing the industry. It is called "Solar Power Finance without the Jargon". But the title is somewhat misleading — it covers solar power finance, but also solar power history, technology, and policy. It is leavened here and there with droll bits of biography or advice from Chase and contains an incredible amount of information in a highly compact and readable package at just over 200 pages.

A heavily updated second edition was released this month. Also this month came Chase's yearly "opinions about solar" Twitter thread, which is highly anticipated among a certain sort of energy dork. Hi. I figured it would be fun to have Chase on the pod to talk about the current state of the solar industry, whether anything but standard-issue solar PV is ever going to flourish, and what the world needs to help balance out increasing penetrations of solar. Okay then. Jenny Chase from Bloomberg NEF. Welcome to Volts. Thank you so much for coming.

Jenny Chase

Thank you so much for inviting me, David.

David Roberts

I read your book over the past week and it's just delightful. I really recommend it to anyone. I feel like the title is a little well, I guess it does say without the jargon, but I just feel like the word finance is going to scare off some readers. But it's really just a nice, extremely approachable introduction to this whole thing of solar in the markets and how it's funded and how it's proceeded over the years. So I really was charmed by it. I noticed actually that it had a little bit of kind of autobiography in the first few chapters and I thought it was really kind of funny.

I had never really thought about it, but you and I have some parallels in our history. We sort of snuck into what was at the time a relative backwater in the world right around 2004, I think, both of us, and then just kind of hung around.

Jenny Chase

Absolutely. And I can't get another job, so I'm stuck doing solar at Bloomberg NEF now.

David Roberts

Same, we've been doing this for so long now that I couldn't really do anything else, but we just kind of planted ourselves and stuck around until the area we were in suddenly became huge around us.

Jenny Chase

It's a pretty good place to be planted, though. I mean, back in 2004, I was looking at this industry, and I started specializing in solar in late 2005. And I was like, "One day this might be 1% of global electricity supply, but, you know, that's worth working on. Even 1%, it's worth working on if we can make it clean." And last year, it was 5%, and it isn't done growing.

David Roberts

Same, I started covering climate change during the George W. Bush administration. I was like, maybe someday someone will do something about this. Maybe someday we'll pass legislation. And then here we are. PV dominates the world. People are targeting net zero. How things change.

Jenny Chase

Yes.

David Roberts

So I want to ask you, you have been following now the solar industry. I mean, honestly, one of the coolest, most fun, most sort of, like, optimistic of all the dark things happening in the world. I know so many people who basically are pinning, like, 98% of their hopes for the future of humanity on this market that you follow. So what a fun thing to be following. But here I'll start with a very big, broad question. A big part of the history of solar that you recount in your book, and I've written on this before, too, and there's been academic papers on it is a series of public supports.

Basically, you get the German feed-in tariffs. You get huge Chinese manufacturing subsidies. Spain had a little period of insane feed-in tariffs for a while. So it was definitely public policy that brought solar from obscurity, where it was when you first started following it, to borderline ubiquity now. And I just wonder, could solar survive now? Could solar PV would solar PV survive and thrive now without public supports?

Jenny Chase

Oh, absolutely. You couldn't stop solar if you wanted to stop solar, David, at this point. Those subsidies, yes, they were needed in the early years. They drove growth. They drove companies to actually make these things. But the thing about humans is that when they make things, they get better at making things. And that has been an incredibly powerful story. Solar modules cost over \$100 per watt in the 1970s, in today's money. By the time we started in 2004, they cost about — it was about \$4 a watt. Stayed that way for about four years because there was very strong demand, again, driven by subsidies, and then started falling again.

And, you know, last week they were 12.8 U.S. cents per watt. And I am super annoyed that didn't get into the book, because, of course, I had to lock down the book four or five months ago.

David Roberts

What was the cutoff price that you managed to squeak into the book?

Jenny Chase

I think it was 24 in the end. And I hope anyone reading the book realizes that I knew that was not the final price.

David Roberts

Well, this is the insane thing about this market, about this whole technology, is it's such a moving target. And the reason I started with that question is that I think to people in our industry at this point that has sunk in. It's clear that this is a juggernaut, that this is the cheapest thing going now and that you couldn't stop it if you want to. But I honestly don't know if that alone just that basic fact has penetrated this sort of general public consciousness. I feel like people generally still see solar as kind of a nice liberal extra whipped cream on top kind of treat you get with some extra subsidies.

But it really is the cheapest source of energy now, which is such a fundamental break from when we started, that I just feel the need to repeat it.

Jenny Chase

I mean, it is. I would slightly clarify that by saying it's the cheapest source of bulk electricity generation in many countries. There are some countries in northern Europe where it actually probably should be wind that's slightly cheaper. And also it is bulk electricity production. In 17 years of covering the solar sector, I have learned that the sun doesn't shine at night.

David Roberts

How many years into your career were you when this sank in, when you discovered this horrendous fact?

Jenny Chase

Not very many, but I have to admit that here in Switzerland, I only realized when I had a solar system installed in 2018, quite how bad it can be in the northern European winter.

David Roberts

Yeah, we'll discuss how to get around that. So, PV is now a juggernaut, is growing at crazy rates. Prices are falling at crazy rates. It seems like every week or two brings a new record low price of modules, some sort of record in deployment, some sort of wild new forecast. Just actually, right here, tell us, because you just came out with a forecast, did you not, for solar for next year?

Jenny Chase

Yeah. So annoyingly, it's my job, or my team's job, to keep our forecast to 2030 updated. And apparently, we're going to have to start doing 2035 soon, which is just great because we have not nailed 2030 yet, I can tell you. We haven't nailed 2023. So, this week I've been publishing our latest update of the forecast, and our estimate for 2023 rose 5% on last quarter. So, we're now thinking that 413 gigawatts of solar modules will get installed worldwide this year, and 240 gigawatts of that will be in China.

David Roberts

Wild. Have you ever in the 20, almost 20 years you've been doing this, forecasted too high? Like, have you ever overshot on PV?

Jenny Chase

Slightly, yes, actually.

David Roberts

You did?

Jenny Chase

We had a bit of a moment of over-enthusiasm in 2018, I think. And, like for specific markets, we get it wrong sometimes. I mean, I thought South Africa was going to be five gigawatts this year because of the rate they appeared to be going in May and June, but that has actually slowed down a bit and I dropped that from five gigawatts to 3.5 gigawatts. So you can be quite wrong in the granular sense. And of course, when you're covering the market quarterly, you have to cover that sort of thing. You can't just say, "oh, it all comes out in the wash," even though in the long run it kind of does.

David Roberts

Yes, it does all seem to be coming out in the wash in the long run. The line is only pointing in one direction, as they say. So I guess one of the things I'd like to talk about then is it seems like in terms of continued and accelerated growth in PV, the technology is in place, it's cheap enough now, the manufacturing is in place, the market is fairly robust, there's a lot of supportive public policy now. There's a lot of money, you know IRA being the notable example.

Jenny Chase

Yes, I mean, you Americans love throwing money at things.

David Roberts

Well, we can't do anything else. Our government is so broken that throwing money is literally the only public policy tool remaining to us that cannot be sort of mired in process. So everything's a nail. So yeah, we're throwing a lot of money at solar.

Jenny Chase

Creates a lot of green jobs.

David Roberts

Yes, that's a lot of wind at the back of solar. So let's talk about then, what are the restraints now on solar going forward? What are the constraining factors? I don't think it's any longer money and I don't think it's any longer policy, at least big picture climate policy, what's now holding it back?

Jenny Chase

So, at the moment, it's grid. If you're sitting there with a pot of money and you're trying to put it into solar projects that will generate and sell electricity and there are a lot of people who are in that position, many of whom are my clients. The problem actually is finding somewhere where you've got land, where you can get permission, and where you can get a grid connection, and it's mostly actually the grid connection we really need to build out the grid.

David Roberts

Is that true everywhere? Is that true in every market you look at? Or is the U.S. particularly bad on that for some reason?

Jenny Chase

No, it's everywhere. It's literally everywhere. If you were to go to a solar conference anywhere in the world, walk into the room and say, "oh, here in South Africa" or "here in Turkey, grid is the main constraint" and everyone will say "this person knows their stuff."

David Roberts

You can sound smart everywhere now. That's interesting. It sort of bespeaks, I think, something then maybe universal then, rather than some quirk of U.S. policy or something like that.

Jenny Chase

Exactly, I mean, basically, around the world, we've built grids for centralized power plants which made a certain amount of sense when we had centralized power plants. But to get all this cheap electricity from wind and solar to market, we are going to have to build some more wires.

David Roberts

Yeah. And is permitting just securing land in and of itself, is that also a universal thing, or is that somehow uniquely U.S.? Because we really do have a tangle.

Jenny Chase

You do, but challenges with land, they look different in every country, but it is quite universal that it's not easy to just grab a patch of land and have the rights to long term build a project on it.

David Roberts

Where are the markets where buildout is happening fastest? And is that —

Jenny Chase

China. It is China.

David Roberts

I guess China is always the answer to that question, it's kind of a cheat. Are they doing something with their grid that like — I mean, are they just building, is that the simple answer? They're just building a lot of it.

Jenny Chase

There's two things that China is doing. First of all, it's got a very coordinated rooftop program, so a lot of the provinces are building a lot of residential and commercial solar. And secondly, and separately, it's building energy megabases out in the desert and building ultra high voltage transmission lines out to them. So it's got this two pronged strategy. Plus it's got a bit of other utility scale being built as well. I mean, basically, China is just building everything it's got.

David Roberts

Who's building fastest? The answer is China, on more or less everything.

Jenny Chase

Always is. I mean, 240 gigawatts, we think will be built this year in China and the entire world market last year was 252.

David Roberts

Yeah, that's wild. You look at these models that say we need X amount of PV to hit our targets, to hit net zero by 2050 or 1.5 or whatever it is, and they look so big and eye-popping, they look to the naked eye sort of like impossible, especially when you break them down. Like, we have to build a utility scale solar plant every five minutes from now till the end of time and they seem impossible. But China is moving at that pace. It is moving at the crazy pace we need to. It's possible.

Jenny Chase

It absolutely is. Yes, China is moving at that crazy pace. And to be honest, solar modules are super cheap and solar is actually quite easy to build compared with everything else we've built.

David Roberts

Yeah, well, it's just Legos, right? I mean, it's more like Legos than a nuclear plant, for instance.

Jenny Chase

Very much more like Legos than a nuclear plant. I mean, I think that the engineers working on solar plants would probably say that there is a certain amount of skill to doing it properly. And there is, of course, but I think you can build a decent solar plant with relatively limited technology.

David Roberts

In terms of all the constraints or headwinds that you mention in the book, let's talk about these trade disputes and trade barriers, because we're hearing now about tariffs. Talk about tariffs as flying everywhere. Trump put a bunch of tariffs in place.

Jenny Chase

Actually, it was Obama that put the first tariffs in place.

David Roberts

On solar?

Jenny Chase

On solar, yes. 2012.

David Roberts

Interesting. And they've been in place ever since. And I'm just wondering, on the macro level, is this just going to change where the panels go and when? Or is this going to be a constraint on absolute growth, do you think?

Jenny Chase

So, trade barriers are the reason that we generally regard the U.S. as this weird little market, not really a proper one. The U.S. would definitely be installing more solar if it hadn't been for constraints, particularly last year. First of all, modules do cost two to three times as much in the U.S. as in Europe and other markets.

David Roberts

That's just because we're not buying the super cheap Chinese ones. Is that so?

Jenny Chase

You're not buying Chinese. But also, last year there was the Uyghur Forced Labor Prevention Act, which means that anything coming into the U.S. has to have a pretty strong verification chain showing that every part of the value chain was made outside the province of Xinjiang in China. And functionally, it seems to have stopped a lot of Chinese brands getting in at all, although Indian brands possibly using the same wafers don't have so much trouble.

David Roberts

Do you think? Because you know IRA, and recent Democratic legislation in the U.S. puts a big emphasis on trying to onshore or friendshore things, not just solar panels, but also the materials that go into them, EVs, batteries, etc. Do you think that these trade barriers, which are more I think the U.S. probably has the most of them around solar at this point, or at least as much as anybody else, are going to — like, is that price differential going to settle out? Is it possible, I guess what I'm asking is, do you think it's likely that the U.S. is going to bulk up its own manufacturing or the manufacturing of its friend countries, whoever those turn out to be, that that price will even out relatively quickly, or is it going to take a while?

Jenny Chase

I think that the U.S. will probably have a lot of its own manufacturing, maybe even for the more complex parts of the value chain, because most of the solar capacity announced in the U.S. so far has just been for the module stage. And you can make a solar module in a garage if you have to. That's not the high tech bit of the chain. I don't think that the price differential will even out. I don't think that the U.S. will get to the scale and the integration of manufacturing bases that China has anytime soon. I mean, China is genuinely good at this.

This is not a matter of cheap labor. It's not a matter of not even cheap energy. It's that it does the whole thing there. And they've got very, very good at it.

David Roberts

Oh, so this is not just a matter of their stuff is cheaper because they have I mean, I think that's the sort of popular perception, right, is that they just have cheap labor and lower standards, etc., etc. But there's genuine technological expertise that's difficult for us to replicate.

Jenny Chase

Absolutely. I mean, China is the reason why solar is not a cottage industry anymore. The Chinese manufacturing industry is a juggernaut. It's viciously competitive within itself. The companies hate each other. If you're imagining some kind of monolith, that is not the case.

David Roberts

Well, China is very big. There's plenty of room inside it for competition.

Jenny Chase

There certainly is. So now the skill to ring out final tenths of a cent out of the cost of making a module, it's high tech engineering, it's very careful, but it's also something you've just got to have done a lot of and know exactly how it works.

David Roberts

Is this something you lose sleep about? Do you think the U.S. energy balance in 2030 is going to be substantially changed by the presence of these tariffs?

Jenny Chase

I think that the one reason the U.S. isn't having as much of a boom as other countries in solar is the tariffs. So I hope the IRA can shift it. I mean, from an external perspective, the IRA looks like pushing down the accelerator really hard on a car that has the handbrake on.

David Roberts

Yes, the handbrake being the trade barrier and the permitting.

Jenny Chase

And the permitting. And the grid. To be fair, there's stuff in the IRA about the grid as well, about building that out, and I know Jay Gashar(sic.) is working on it.

David Roberts

And the final question about trade barriers: Are these more or less consensus — is there any prospect of these going away? Or do you think these are more or less kind of a permanent feature at this point? This is how we're going to do it?

Jenny Chase

I think, in the U.S. and India — that's the other weird little market — they are not going away anytime soon. These are two countries that are quite committed to building a domestic manufacturing industry, even if it costs more.

David Roberts

And you think it'll be a long time before either of those are at the level of cost and technical expertise of Chinese companies?

Jenny Chase

It'll be a long time. I mean, you could say that at this point, even just making modules as good as China was making three years ago is actually all right. You could say that's good enough.

David Roberts

One other constraining factor which I have been interested in for a long time and think is controversial, at least in my little corner of the world, is this notion of renewables in general, but especially solar, eating its own lunch, as they say. Price cannibalization, as you call it, in the book, which is a simple — I don't think there's anything particularly technical about — it's, just that all the solar is producing at the same time when the sun's out. So the next solar plant you build is going to be directly competing with the existing solar plant, producing solar at the exact same time and thus mildly bringing down the price. The more you build, the more the price comes down.

I feel like the conventional wisdom, call it like five years ago or ten years ago, was that this phenomenon of renewables eating their own lunch is going to kick in at a lower level than has turned out to be the case. And I just wonder if you agree with that — if you agree that this is maybe less severe of a problem than we thought a while back?

Jenny Chase

I think what we've realized is that most grids actually have a fair amount of flexible capacity. So you can turn down gas plants in the daytime and of course you want to because it's good if you can turn down the gas plants and burn less gas. It is starting to be a problem though we do have zero or negative power pricing events quite regularly on sunny weekends in Europe. Now California has them, bits of Australia have them. There are times of the day when power on the spot power market doesn't cost anything and you could say, well, what's the problem?

And like, as a first approximation, there isn't actually really a problem.

David Roberts

Yeah, free power doesn't seem like the worst thing that could happen to you.

Jenny Chase

But it does, of course, mean that if you want to build another power plant that's the same, you are competing with free power a lot of the time. And you can do it to an extent, because while solar is getting cheaper, you still build for those — they call them shoulder periods when solar is not at maximum and the power price is not zero. But it is still a concern. And, to be honest, that's what keeps me up at night. The fact that we will get stronger negative feedback mechanisms kicking in, particularly in places that don't have a lot of flexible capacity, who are maybe doing coal and nuclear rather than gas and hydro.

On the other hand, one big update between the first edition of my book and the second is that batteries are just a thing now.

David Roberts

Yeah. Which is newish in the world, I think. New enough that we don't totally know how it's going to affect things.

Jenny Chase

Yeah. And batteries have to be built and obviously they have to be manufactured, they have to be built. They are actually really expensive. I mean, when we try and calculate the economics of batteries, I'm not entirely sure why most people in Europe are building them, but they are.

David Roberts

Yeah, you seem skeptical of the economics of residential batteries too.

Jenny Chase

I am very skeptical. I attempted to calculate the payback period on my parents' battery system in the UK, and it's more than 20 years. I'm like, "Mum, did you know this was that bad when you bought it?"

David Roberts

And yet you also say that you've underestimated batteries. What do you mean by that? What are they doing more than anticipated?

Jenny Chase

Getting bought. No, I mean over 70% of residential solar systems in Germany and Italy added this year now have batteries attached. And that does make a huge difference to this power price cannibalization problem because it does mean that you can shift your output to the evening and the night. And then what keeps me up at night is the seasonality thing.

David Roberts

Yeah, so you feel "okay" then about the, sort of, sun going down problem, the diurnal problem, smoothing out, like Jesse Jenkins and I did this a few weeks ago about the sort of timing of intermittency of solar and there's second by second swings, there's minute by minute swings, there's hour to hour swings. And it sounds like you think and I think he thinks that batteries are going to sop up most of the sort of short term variability. You're more confident than that than you used to be, let's say.

Jenny Chase

I certainly am, yes.

David Roberts

Well, this is another question I have about this. And maybe as someone who's watched markets grow and develop, you have some insight into this naively. I would think if we have this problem in a capitalist society, in a market where during certain periods of the day, we're producing this valuable commodity for free. And so it's just sitting there. It seems to me naively, that you're going to get a stampede of people finding ways to use that power, finding ways to use that excess solar power. Not just you could shift demand under those periods of high sunlight and just use it directly, or you can find new ways to store it or shift it or move it around or something.

But this seems like the kind of problem that markets ought to be very good at solving. So why should I worry rather than just thinking like this will solve itself? You say high prices are the solution to high prices. It seems like free power ought to be the solution to free power also.

Jenny Chase

So I think it is. But historically, people have not always responded to power price signals. I mean, certainly on the residential level, people have not always responded to power price signals quite the way you would expect them to. And on the commercial and industrial level, you often have to spend a lot of capex to take advantage of these low prices. Like for making hydrogen, for example. You can make hydrogen with electricity, but the electrolyzer, which is the equipment that makes the hydrogen, is really expensive. So you don't want to buy all that equipment and run it for like 1000 hours a year.

You want to be running it at least 50% to 80% of the year. And there's a lot that we can probably do with stuff we already have, like flexible charging of electric vehicles is an obvious thing that we should all be doing.

David Roberts

Water heaters, hot water heaters.

Jenny Chase

Water heaters are good. Yes, heat pumps. Although again, in northern Europe, the issue with heat pumps and heat pumps are brilliant, and I have one, but the issue is that they do run a lot more in the winter, and that is when we do not always have the sun.

David Roberts

Yes, this is back to balancing out solar, which we'll return to later. So I want to ask about — it's funny, normal people, when they get excited about solar, there are a bunch of call them sort of exotic forms of solar that people love to get excited about. And at some point in your book or Tweet threads, you have poured cold water on all of the following: thin film solar, thermal electricity, floating solar on water, agrivoltaics (i.e., solar on the farm building), integrated solar, perovskite solar. And I guess I'm just wondering, do you think that standard PV built in the standard way is such a juggernaut that all of these things are going to turn out to be more or less kind of like frivolous extras?

Are any of those going to be real? Because you've broken a lot of hearts. There's a lot of people who love — in each of those categories there's a lot of fans whose feelings are hurt when you come along and say, "It's just solar PV on a boat, don't get so excited." Are any of those worth getting excited about?

Jenny Chase

No, I wouldn't get excited about any of those, sorry. I mean, some of them are worse than others. I think the best thing I could say about solar thermal electricity generation is it's not quite dead yet and floating — so the big thing about floating solar is that you could put it on water and sometimes it's really easy to get the grid and the use of the site on water. So, for example, our hydroelectric dams, the water is usually already zoned as electricity production and there's a grid connection and there's generally anticorrelation between the output from the hydro dam and the solar panels.

So, like in summer, the solar panels are going into the grid so you can save some water. So it's good, but it is still solar on a boat. And agrivoltaics, I'm worried that people are a little bit overexcited about that because, if you

do it wrong, it is bad solar subsidizing bad farming. There are some crops, like berries, maybe berries you can grow under things with shading, but how many berries do we want to eat as a civilization?

David Roberts

But thin film, more energy dense, but higher cost.

Jenny Chase

Less energy dense, I would say.

David Roberts

Oh, wait, is that —

Jenny Chase

First Solar is — So the only thin film player of any significance left is First Solar.

David Roberts

Oh, right. Less energy dense, but allegedly cheaper to crank out because you can do it on a sheet.

Jenny Chase

No, it's more expensive now.

David Roberts

Well, then what the hell?

Jenny Chase

The reason First Solar is having a great time now is because plants in the U.S. are going to get 17 U.S. cents per watt under the IRA as a production tax credit.

David Roberts

Good grief.

Jenny Chase

And because the U.S. has trade barriers on imports.

So does thin film – I mean, if it's less energy dense and more expensive, then it's hard for me to think of an obvious application for it. What's left for it to do?

Lower embodied carbon, actually. But when we talk about thin film, we really are talking about First Solar at this point because everyone else has failed. And to do credit to First Solar, it's a company that has met its milestones, scaled up meticulously, has a great recycling program, and has a pretty plausible claim to having lower embodied carbon per watt than crystalline silicon.

David Roberts

Who's using that?

Jenny Chase

Americans. Nobody else would buy them. They're more expensive and less efficient.

David Roberts

But on their roof or where – ?

Jenny Chase

It's ground mounted mainly. There's no reason why you couldn't put them on the roof, but because they're less efficient, you would tend to go for the crystalline silicon option.

David Roberts

And then the one that really hurt my feelings was this about — I used to get so excited about all these ways of integrating solar into building materials, right. Like, they say you can put solar cells in windows so that they're sort of ambiently generating all the time. They say they can put it in concrete. Like you can put them on fabrics now. Like if you read the lab stuff, the MIT press release world, there's all kinds of cool stuff you can do. Integrating solar into other materials. You just poo-poo all that — is there nothing to any of that?

Jenny Chase

Don't put them on fabrics. You know the really great thing about glass, it's one of the oldest materials we've got and it doesn't degrade, it doesn't flex. It's pretty hard, it stays transparent. It's a really great material to encapsulate your modules on. Every attempt to make flexible solar has ended up with worse encapsulants that will almost certainly degrade after a few years.

David Roberts

So you haven't seen anything in the building integrated world that you think even on the long term has a chance of surviving.

Jenny Chase

People say it's pretty. I mean, if you want to pay more for pretty. Personally, I'm interested in electricity generation. But like most of these solar windows, they are just bad. They are just bad PV that is being sold as a gimmick and it's barely worth wiring up, in all probability.

David Roberts

Well, that's just a bummer. I love this sort of Sci-Fi vision of your entire infrastructure sort of ambiently generating power all the time because it's all sort of got solar cells in it.

Jenny Chase

But just put proper solar panels on the roof, it's the same thing, except it probably works better and it certainly costs a lot less.

David Roberts

Fine. Ruin my Sci-Fi vision. And perovskites, the other great white hope of this whole world at this point are competing with SMRs to be the perpetual next big thing. The next big thing in a few years, forever? Is that going to happen? Is it happening? Is it getting closer? Are we closer now than we were three years ago? Or is it still at the pure hype level?

Jenny Chase

Well, I was walking around the world's biggest solar conference in Shanghai in May, and I was having a little bit of a panic because I thought I'd more or less finalized the book saying some relatively uncharitable things about perovskites. And every single company was like, "perovskites!" I actually saw my first perovskite, and then the Chinese manufacturers were like, "oh, our research arm has got perovskites." "Oh," Hanwha Qcells was like, "oh, we've made an investment." First Solar was like, "we've made an investment." I was like, "oh, god, is this going to make my book look stupid in six months?"

But to be honest, nothing has come of that. Which doesn't mean that nothing will, because it was relatively recently. But personally, I think they were just having a little moment of, "oh, everyone's saying this. We have to seem like we're ahead of the curve." And they all have a skunk works

where they're investigating this sort of thing, and so they basically release some of the lab results. And I think it's at least five years away.

David Roberts

And also, one thing I've come to appreciate more looking at this stuff over time is even if the perovskite tech proves out faster and better than we expect, it's just like you're so far behind the eight ball at this point trying to catch up with PV or squeeze in past PV anywhere. That the tech thing is not even the main problem. It's just your scale wise. Like, where do you start? Where do you find a foothold?

Jenny Chase

No, really, the tech thing is the problem. The problem is that this stuff does not have a lifetime of years.

David Roberts

Oh, it degrades quickly?

Jenny Chase

Exactly. I mean, the problem with perovskite is it degrades really quickly. And I don't think anyone is claiming that they have a completely stable product that's ready for commercialization at any price. But the other thing is that if perovskite does succeed, it won't be as a standalone product. It will be as a second layer on top of crystalline silicon. So it will backpack.

David Roberts

Oh, interesting. So it will be like an improvement to existing panels.

Jenny Chase

Exactly. And it will make a lot of money for the company that figures it out.

David Roberts

Again, sort of from the outside, it looks like your basic PV panel, your basic solar photovoltaic panel looks a lot today like it did ten years ago or 20 years ago, to my eye. But one of the things you describe in your book is that there's actually lots of micro improvements happening. There's lots of improvements happening within these PV products. So maybe just talk a little bit about sort of like what tech improvement looks like within the PV category and how much headroom is left for just the standard PV panel to get better.

Jenny Chase

So the first thing I would say is that the layperson doesn't need to know anything about exactly how a solar panel works.

David Roberts

Thank goodness.

Jenny Chase

That said, obviously, there are incredibly talented engineers who are working really hard to make that panel more efficient and produce the same output or more output with fewer materials. And so the big improvements over the last 15 years have been wafers have got thinner, so there's much less polysilicon used per watt. It used to be about 10 grams per watt in 2008, and today it's 2.6 grams per watt.

David Roberts

And that's just a cost-saving.

Jenny Chase

It's a cost-saving. It's also an embodied carbon saving, if you care about that, because polysilicon is a very energy-intensive step of the value chain. The wafers have got bigger, so you can make them out of bigger ingots and then they're easier to handle and they have a lower ratio of the gaps between them. So the standard wafer used to be what we call 156 mm, which is the side length, and now the standard one is 182 mm. So that saves all kinds of costs. There's been a move in cell architecture, first of all, from aluminium back surface field to passivated emitter rear contact (PERC), which is currently the standard.

But we're just moving to TOPCon (tunnel oxidated, passivated contact).

David Roberts

Okay.

Jenny Chase

And to be honest, I can barely remember what that stands for. I never know what the difference is.

David Roberts

But from the layperson's point of view, the upshot here is that they're getting cheaper and they're working a little better.

Jenny Chase

And more efficient. And there are theoretical limits to how efficient they are.

David Roberts

And where are we at now? Like 20 – state of the art is like 22%. Is that right?

Jenny Chase

State of the art is probably 24 or 25% of commercial production. Obviously, most modules are a bit worse than that. I think it's about 22% for the typical module this year. And it will be a bit better next year because next year the typical one will be TOPCon, not PERC.

David Roberts

And that 25 could get to – ?

Jenny Chase

34, perhaps. I think we've got a roadmap to 34%.

David Roberts

No kidding. That's not a small amount.

Jenny Chase

I think we hit that by 2050. It's not a small amount.

David Roberts

That's a third more power coming out of our panels.

Jenny Chase

The same space, yes.

David Roberts

That's more room for improvement than I thought. And that's just with polysilicon PV?

Jenny Chase

Just with crystalline silicon? No, that involves a heterojunction that does involve a second junction on top of that. So another layer of another sort of semiconductor, whether that is perovskites or something else. Because when you stack your layers of semiconductor, you absorb different wavelengths of light with different semiconductors and so you get a higher efficiency.

David Roberts

Interesting. I didn't know there was that much headroom left. And whatever happened to concentrating? I always thought that it was very clever the concentrating solar panels, where you just use a cheap plastic lens to concentrate the light, and then you get more intense light and you can get more sort of, comparatively more power out of the light with a special kind of solar cell. Did that come to anything?

Jenny Chase

Cells got cheap and lenses stayed expensive. Also, if you're doing that, you've got to make sure that the angle that your panel is mounted at is correct, because otherwise it's focusing the light on the wrong place and it turns out to be way cheaper to use ordinary solar cells. And it doesn't matter that much if they're oriented right, rather than have a super duper lens thing that has to point the exact right direction. So, CPV is dead.

David Roberts

Another clever tech, RIP. And what about — these are you know, we're mostly talking about improvements to the panel and the cell. What about, you know, I saw a company that is using steel for framing instead of aluminum. I think I could be getting that wrong, but I think that was it. The stuff around the panel, the brackets, and the frames and the mounts, is there a lot of headroom for improvement in that stuff?

Jenny Chase

I think there probably is. So steel is heavier than aluminium, so I think this is for the frame of the module. And module frames used about 2.8% of world aluminium production last year, so it's not actually small. Now, steel is lower carbon than aluminium, but it is heavier. So I suspect the maths on that might be a little bit complicated. But if you don't have to transport them very far, that's good. And of course, when you've got solar sitting in a field held up on steel structures, then there are improvements to be made to the design of that.

So it catches the wind less, so it's more sturdy with the same amount of materials.

David Roberts

And just in terms of mounting and tracking the sun, what's the state of the art? I always wondered, is it going to end up being cheaper to just make the cheapest possible panels with the cheapest possible installation? Or is it worth spending the extra money to get fiddly precise tracking of the sun throughout the day?

Jenny Chase

So modern trackers are not particularly precise, actually. They just more or less follow it from east to west, because, unlike concentrated photovoltaics, they don't have to be precise. So the really rough rule of thumb we have is that tracking costs about 4 cents per watt more in Capex and gives you 25% more output, which does mean that you put tracking in in sunny places, because 25% more output is more powerful in sunny places.

David Roberts

Right.

Jenny Chase

So we reckon that you don't really use tracking anywhere, like further from the equator than France, and you use tracking in sunnier places. Tracking also takes more land, but it also gives you a nicer output profile. It gives you like a table of output profile throughout the day, because you start generating first thing in the morning, whereas if you just make them south facing, you get this peak.

David Roberts

You get more into those shoulder periods.

Jenny Chase

Exactly.

David Roberts

And what about people who think that AI and machine learning is going to revolutionize anything? Is AI or machine learning any help at all in PV, in tracking or anything like that? Or is dumb and simple better?

Jenny Chase

This is machinery tracking moves. It's stuff that's got to be reliable, it's got to be rugged. I'm sort of inclined to say that AI can't revolutionize it, but maybe machine learning can do a little bit around the edges.

David Roberts

In terms of markets, one of the things you say in the book is that while the sort of macro growth has been relatively steady and predictable, there's been some surprises on where this happens. And it's funny, I thought in your forecast now you have this category "rest of the world," outside of the major markets, which you are sort of using as kind of a buffer. You're just sort of like adding a bunch of capacity in the rest of the world category just as a buffer because you keep underestimating; everyone keeps underestimating how fast things are going to go. And I know you said —

Jenny Chase

We don't do that anymore. Now we call it buffer/unknown. And then people ask me, "what's buffer/unknown?" And I'm like, "we don't know."

David Roberts

Exactly.

Jenny Chase

They go away after that.

David Roberts

This to me is funny as we've been underestimating growth in PV so long that at this point we're just like, "Here's our forecast... plus some. We don't know where or why, but there's probably going to be more."

Jenny Chase

Exactly. And we need it as well. Even within a single year, we tend to find it gets taken up by existing markets being more than anyone thought.

David Roberts

Oh, funny.

Jenny Chase

But my clients do tend to get mad at me if that's more than about like 30% of world demand.

David Roberts

Wow, 30% is a substantial amount of like, "we don't know" buffer.

Jenny Chase

I mean, that is by 2030. So, there's a lot of "we don't know" by 2030.

David Roberts

Yes, true. I wonder, I was going to ask about this later, but this seems like a good opportunity: Why is it, and this, I guess, is kind of a sociological or maybe even like a psychological question, why is it that it is so much easier and safer to make a conservative forecast that ends up being wrong on the downside, which is like 99% of solar forecasts to date, than it is to try to be as optimistic as reality? Like the one thing I come back to over and over again, and you mentioned it in the book, is like the one solar forecast that's been even close to reality was Greenpeace's sort of wild forecast early in the 2000s, where all they did — it was viewed as wildly optimistic — but all they did is just say, "Well, here's the improvement rate, here's the learning rate. What if that just keeps happening?"

Jenny Chase

No, they just took the growth rate of build and extrapolated that. Oh, it was simpler than that. They don't know what a learning rate is. And yes, it was the best mainly because it was the highest. I'm just going to say it's also not particularly useful if you're trying to decide what world markets to go into or sort of adjust your expansion strategy if someone's just telling you, well, it will be 40% growth per year forever.

David Roberts

Right. Well, you want something more granular than that, I guess, if you're in the business —

Jenny Chase

And more regularly updated and where someone is actually sitting behind it, being somewhat responsible for being wrong.

David Roberts

Right. But why is it, why do we always under predict? And why is there no like, people seem to feel safe under predicting, whereas clearly there's a much greater fear of overestimating such that everyone's underestimated every time forever. What explains that?

Jenny Chase

I mean, you can't predict complete transformation and the more you know about a market, the less you can predict that it will totally change, I think. So obviously, if you are an expert on the energy market, you can't predict it. You don't want to predict that everything becomes totally different. Also, like if you go around with wild numbers, everyone just calls you boosters and says that you're just selling something which is not entirely untrue. But mostly what I've been trying to sell is accuracy.

David Roberts

Yeah, it's a little crazy. People would almost rather be inaccurate than risk that than risk being viewed as a booster. It seems like in a biz where you're literally predicting and projecting seems like the social penalty for inaccuracy ought to be maybe higher than the social penalty for being optimistic.

Jenny Chase

The thing is that there are no prizes for just coming up with the biggest number. I mean, you can do it, but it's not particularly helpful. I mean, throw a pin at the dartboard and if you happen to be the closest, it doesn't give you any real insight. And also, solar is weird. It's the first form of bulk electricity we ever have had that doesn't involve turning something, turning a generator. So it is a little bit unique. It's the first ever semiconductor form of electricity, so it is unique. But it's also you cannot extrapolate a growth rate forever because you end up with the whole world covered in solar panels."

So you do have to recognize that there are limits to this and there are negative feedback mechanisms. And on the local level, we already see some of those negative feedback mechanisms.

David Roberts

I get all that, but just at a certain point, like the IEA, if I'm wildly under predicting solar again and again and again and again and again and again, eventually those arguments have to lose some of their power, don't they? Like whatever limit you're worried about or trying to predict, it's not happening statistically on the odds it's probably not going to happen next year either. There will be limits, obviously, like the learning rate and the growth rate and all that can't project out to the future the way they are forever.

Jenny Chase

The learning rate, you can actually, because it's an exponential decay, so you can double capacity as many times as you like. You're never going to get the price to zero. So the learning rate, you can theoretically go out forever. Don't ask me what's happening to my experience curve this quarter because the price is way below the experience curve, and this is causing some real construction difficulties.

David Roberts

Really?

Jenny Chase

Yeah, so I feel some sympathy for the IEA as well, because what they were trying to do was not make a prediction of solar. What they were trying to do was model world energy supply in a sort of continuous way that had worked when the world electricity, worldwide energy supply was fossil fuels and nuclear. And then they were trying to tweak the sensitivities of that model and bring it to the future. It was not a model that was designed for transformative change, and they have changed that around, and they have got whatever their equivalent to the net zero scenario is called, and they have changed that, to be fair.

David Roberts

Yeah, people do seem to be trying to catch up, but even the people running faster and getting more optimistic are still, as far as I know, undershooting.

Jenny Chase

It's more complicated, though, than just drawing a line on the chart. At least, I mean, for my team, it isn't actually that much more complicated, but when you've got to put things together and make sense of it, be like, "okay, what is power price volatility in California in 2030 if we project this out?" Then you do get some very strange-looking effects. And you can either spend your life analyzing those strange-looking effects and trying to figure out where you should put your money in that, or you could be a little bit on the conservative side.

And, I mean, we've been talking like it's all people in developed countries. And the biggest problem my team has is that analysts who have become experts on the energy of, say, Indonesia or Brazil find it very difficult to imagine this strange thing coming here and knocking it all over. And I don't feel like I can go into emerging markets and say, "guys, you're all wrong, it's going to look like this." At least not as forcibly as I maybe would like to.

David Roberts

Yeah, there's something to that. Like, psychologically, the more you know about a particular thing, the more sort of skeptical you are about radical change happening to it, the more reasons that change won't happen that you can cite. So when someone just comes in and says, like, "I don't know, I just got a gut feeling that miracles are going to happen and it's going to be more than that," I can understand why they're greeted with skepticism. But again, if that goofball turns out to be right over and over again, repeatedly for 20 years, at a certain point you have to accept that miracles are going to happen.

They keep happening. Speaking of that, where are the markets? Like you mentioned that some markets have sort of like taken you by surprise. And that's one of the things that's kind of skewed your forecast in the past, is that things take off where you don't necessarily expect. What are some

examples of that? Where is solar taking off now that people might not popularly know that it's happening and where might be next?

Jenny Chase

So, I have no idea what's happening in Pakistan, but it is importing a load of modules from China, four gigawatts a year. Something's going on in Pakistan, and I have not spent enough time, but I've spent a little bit of time looking at the licensing website. It looks like there's a lot of commercial scale going in there. I am still super excited about South Africa because this is a major medium income economy that has been having crippling blackouts and one of the best solutions is just to buy a solar system and a battery.

David Roberts

Is this distributed that's happening there?

Jenny Chase

Mostly, but there's also a bunch of commercial and probably mining scale because there is actually no limit now on how big a system you can put in and have it feed into the grid. So there will be some big stuff, but so far it's been mostly rooftop, I think. So, South Africa is exciting. I'm quite excited about Nigeria because Nigeria removed its fossil fuel subsidies earlier this year, and Nigeria has about 15 gigawatts of on-grid power capacity and about 50 gigawatts, very roughly, of generators that run on diesel and gasoline.

David Roberts

Whoa, wait, they have more than twice the amount of personal generators than they do actual grid-connected power generation.

Jenny Chase

So the sources are not great, but it's probably more like three times.

David Roberts

That's wild.

Jenny Chase

It's called "I Better Pass My Neighbour," and basically, the idea is that you've got a generator when your neighbor doesn't. And running those generators became extremely expensive when the subsidy was removed. So there has been an upswing in small solar and small batteries.

David Roberts

Interesting. Yeah, I was going to ask I don't know that we have time to get into it much, but I was going to ask what your sort of general temperature is on the whole enthusiasm around kind of like distributed off-grid for people in severe poverty. This idea that you can get distributed PV to people before you can get the grid to them, practically speaking. Do you put a lot of stock in that?

Jenny Chase

I've been excited about that for the last 18 years. And if we're honest, the growth has not been —

David Roberts

Yeah.

Jenny Chase

It's grown, but it's been steady and it's still pretty small. And I'm really the only member of the team that spends a lot of time on it because most people have better things to do. It is one to watch, though, and I deeply hope that what does happen with this latest fall in prices is that simple module battery systems and things that can just power a house become so affordable that just a wave of them goes in across Africa and Southeast Asia.

David Roberts

So you think there's still the possibility that we could hit the S curve on that that could substantially tick up?

Jenny Chase

Yes, I do. I think there's still the possibility that things get so cheap that we can leapfrog over the need to build a centralized fossil fuel infrastructure to bring power to Africa.

David Roberts

Interesting. As a way of wrapping up the main experience, you've had everybody who's watched this market, but I assume it's more visceral for you being so close to it. The main experience you've had is just headlong growth and PV crashing through purported limits on PV, PV crashing through forecasts, crashing through markets, just crashing through things, doing things people said it couldn't do, being bigger, selling more, getting cheaper, et cetera, et cetera. It's really a wild success story. So, I mean, one of the things you address is actually, I'm going to quote your tweet here because I thought it was interesting.

"When you tell an energy future model to optimize a power portfolio for clean power adequacy, it will give you more wind and less solar than when you tell it to optimize for a least cost electricity sector development." In

other words, if you just want your model to do the cheapest thing possible to get you as much power as possible, it's going to do a lot of solar. If you want sort of adequacy and backup and resilience, you put more wind in. First, just to say why that is.

Jenny Chase

So wind blows at night and in the winter. And it's not just better system adequacy, it's that the wind pathway is actually better if you want to get to net zero.

David Roberts

Better literally for reaching the goal itself?

Jenny Chase

And for economics like it's probably cheaper to reach net zero building a mix of solar and wind in nearly all of the world. I mean, there may be a few countries that have so low seasonality that you could just do it with solar, but for most of the world, the lower cost scenario will be at least 50% wind, 50% solar. And if you let the solar get built first, it will cannibalize the daytime and summer revenues of the wind, and the wind might not get built.

David Roberts

Oh, interesting. And then you'll be stuck — you'll whatever, get up to 80% and get stuck. Is that the —

Jenny Chase

And then you're stuck on a solar pathway. Yes.

David Roberts

Interesting. Yeah. So that was my next question. What do we make of the fact that – because as Bloomberg NEF, their latest big forecast shows that – we're actually on track to build as much PV as we need under a net zero by 2050 scenario. We're actually on track ahead of schedule, even mildly on PV, but behind on wind. And I sort of have been wondering, there's two ways you could interpret that. One is we've overshot on public policy supporting solar, we're overdoing solar, we're making a mistake basically, and we will regret this later. The other way to look at it is just solar is doing what it keeps doing over and over again, which is doing more than we think it can do and solving more than we think it can solve.

And eventually, just like sheer bulk, sheer low cost is going to overwhelm these intermittency problems. And in the end, solar will just be a bigger role in the final mix than we have forecast. That solar is going to beat our forecasts again, that solar is telling us that it can do it, rather than we're making a mistake. Do you see what I mean? Which of those do you come down on there?

Jenny Chase

I'm going to be really disappointing and say it's a regional story. I think we're underestimating the impact of solar in sunny places. I think solar in sunny places can absolutely go along with it. Build some transmission, build some batteries, it'll all be good. I think for places like Northern Europe, we really should be building some wind and probably, to be honest, and nuclear as well.

David Roberts

Why aren't we, why are we out of balance in those places? Why is PV doing so well and those other things aren't?

Jenny Chase

So nuclear is hard. It's not popular, it's big projects. Nobody really wants to take the risk. It's not cheap. There are many reasons why it's hard to build nuclear and it will really require government determination to get nuclear built and probably not be particularly popular, but that may be changing a little bit.

David Roberts

That I get. Wind is a little bit more of a mystery to me though. Why that's — ?

Jenny Chase

Yeah, wind is more difficult than solar, especially offshore wind, because you've got to do a more difficult thing than building a solar plant and you've got to do it out in the ocean and it's got moving parts and things. Also, because the individual projects are so big and things like the cost of steel impact it. So, I think a lot of the issues recently have been that someone's agreed to build a wind project and then found that they couldn't do it at the cost expected and that has caused the contracts to be canceled, companies to pull out. It's all been a bit rough lately. And then for onshore wind, there's just often a permitting issue that some of the, they're called easements,

the amount of space you've got to leave between the wind turbine and something else is probably further than it needs to be.

David Roberts

Would you take that to mean if you were talking to national policymakers, that they should dial back on support for PV or just dial up support for wind?

Jenny Chase

I mean, if I was a policymaker, I would probably be dialing back support for PV.

David Roberts

Would you? Interesting.

Jenny Chase

I mean, depending on which one I was, if I had none, I might not be, but I'm not sure I would bring in extra support for PV right now. But also it saved our bacon. I mean, last year, in 2022, in the energy crisis, PV and wind, but also new PV, saved our bacon.

David Roberts

Yeah, it's a really underappreciated story, too. I feel like somehow out of that episode, the powers that be somehow took the lesson "we need more gas from different places." But that doesn't seem to be like what the lesson they should have learned?

Jenny Chase

Well, last year we did because there were so many uncertainties and last year could have 2022, the energy crisis could have gone so much worse for Europe if we'd had bad weather. Bad weather is a big one because if it gets cold, then gas demand would have gone right up. And of course, what Europe does is buys gas all summer to fill up its reserves for the winter. So you have to be making accurate projections some way in advance. And in the end, demand destruction was much more than expected as well. So high prices meant lower demand apparently.

David Roberts

That's another lesson I feel like we learn over and over again and can't seem to make it stick in our heads, is that demand is much more – I've seen academic papers on this – you can get much more out of demand in emergency situations than people think.

Jenny Chase

Sometimes you can and sometimes you can't. That's the frustrating thing. And sometimes it takes an emergency situation to get that out. I mean, I think maybe Europeans are maybe a bit fatigued now with the whole saving electricity thing.

David Roberts

I've kept you long enough. As a final sort of looking ahead, if I read your book and I take just what you've said here today into account, I'm going to guess when I think about what's next for solar, it's not going to be any weird exotic offshoot, or twist, or brand new use, or brand new placement, or brand new technology. It's just going to be more and more and more of what we've got. Is there anything when you look ahead to the next five years of solar, do you just see more, more and more? Are there potential surprises?

I mean, obviously them being surprises you don't know in advance.

Jenny Chase

But that's the problem. Everyone's like, "what are the things you've not predicted?" I don't know if I could predict them, I would predict them. But I think higher volumes, lower prices, more or less the same tech.

David Roberts

Same thing that's been happening then?

Jenny Chase

Wave of bankruptcy is probably coming.

David Roberts

And that's in manufacturers or installers or residential installers.

Jenny Chase

Manufacturing, installers. Installers tend to go bankrupt after a boom. And there's been a bit of a boom in Europe. I think there's a little bit of a hangover in some markets and maybe some – nobody ever notices when installers go bankrupt, though, it's one of the problems with a very fragmented sector.

David Roberts

If it's really been commoditized, which is, I think, sort of kind of the theme coming out of this whole area for years now. If we've really settled on a commoditized, basically standardized form of PV, isn't it the case that most commodity markets consolidate over time? There's going to be a few big players? Do you expect that to happen?

Jenny Chase

I don't know. The installation end is more like plumbing. And if you have a good plumber, then keep their number and give it to your friends. I think that locally skilled work people will never quite be a commodity.

David Roberts

Right. But in the manufacturing, on the manufacturing side.

Jenny Chase

On the manufacturing, that's a commodity, and that is vicious.

David Roberts

Yeah. It doesn't sound like after reading your book, I'm like, "why would anyone want to go into this business?"

Jenny Chase

I know. I mean the U.S. is like, "oh, we should make our own modules." And I'm thinking, why? Horrible business.

David Roberts

There's low margin, frequent bankruptcies. Yeah, well, we'll see how it plays out. Thank you so much, Jenny. And I will just say again that the book was so approachable and readable and interesting, and even I learned I mean, this is like, as you say at the beginning of the book, this is the book I wish I'd had at the beginning. I agree with that completely. Like, if you're just getting into this whole area, it's just such a nice plain language introduction to the various aspects of it, all of which I think are less — they seem complex and daunting because of the terminology and jargon that surrounds them.

But I think your book makes plain, like, there's nothing in here that you need a PhD in engineering to understand. These are all relatively simple concepts if someone just lays them out for you. So I appreciate your book and your threads.

Jenny Chase

Thank you so much. And I appreciate the work you do on your podcast explaining a wide variety of things I had no idea about.

David Roberts

All right. All right, have a good one, Jenny. Thanks so much.

Jenny Chase

Have a good one. Bye. Thank you.

David Roberts

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