

[SQUEAKING] [RUSTLING] [CLICKING]

**JEFFREY C.
GROSSMAN:**

This is the grid now. So we went from small to very big, right? The growth in solar and wind has been incredible over the last 10, 20 years. The problem, as I think I've shown you, is the variability.

And so this is like if you zoom in here, that's the load, the black line. And this is like what these two resources give you. And you can see that it doesn't match.

If you zoom in on a day, then you really can see it, right? There is the load. And there's what you would get from solar and wind. And so here's the question. You say, well, OK, how do you fix this?

You got to store it. There's no way to use renewables at large scales unless you store it. In fact, we're really at essentially the tipping point. Because if I look at the countries in the world and what their PV penetration is-- and this is a couple years old, but it's still pretty much the same-- Germany, Greece, Italy at the top. Sad frowny face here for the USA.

But you know, Germany is at 7.1% as of a few years ago. That's a huge penetration of PV. But here's the problem. If you look at-- this is Germany now-- huge penetration. These are these six years, right, seven years of adding PV. This is how much they had. They're now at 7%, 2016 was 7%.

This is how much the price of electricity was in Germany when they added. So notice that here is the sunlight electricity during the day. They can sell it for a lot of money. But as they add more and more of this renewable to the grid, its price goes down when it's available.

In fact, it's now not economical for them to add more PV unless they can add it with storage. Because actually, the price has gone down so much. And it's gone up here when they're not generating any PV electricity. So you can come up with-- and they did in this paper-- this sort of value factor, which when it goes below one means there's no economic outcome that's positive here. Right? You can't make money anymore.

And look at where that happens. It's right around where they are. It's at 5%. You can't solve renewables at the scale of the grid without storage and no option exists today. It might be batteries. It might be batteries. But there's nothing that actually does it today at the scales that we need. So that's a real challenge for chemistry.