Tracey Peake ([00:00](https://www.rev.com/transcript-editor/Edit?token=4W1vgfgZvUwP-ejV3N1SpH1tAbbfDWuPAw9mWprYg1OHml-K9LKQ-3sPP6nDq_6m20s8xtpWBnzEQdHEXF_Bgqp2xBI&loadFrom=DocumentDeeplink&ts=0.51)):

Hello and welcome to NC State's Audio Abstract. I'm your host, Tracey Peake. Our power grid is in the news a lot lately, from how well it's handling or not handling our current needs to keeping it secure and preparing for a future that will only see increased demand. We're sPeakeing today with Jordan Kern, assistant professor of forestry and environmental research here at NC State, about what our power grid can handle and what it needs in order to meet our future power needs. Welcome, Jordan.

Jordan Kern ([00:31](https://www.rev.com/transcript-editor/Edit?token=TF1m6NqIj_mKttKX3vBWddVdZ1j-g1QNbm_RTya6o05ElAOJaZWIr-4KsyX-sMT7iZ9M65IV4wSTCXXsyztW1A0ahSU&loadFrom=DocumentDeeplink&ts=31.05)):

Thanks, Tracey.

Tracey Peake ([00:32](https://www.rev.com/transcript-editor/Edit?token=_JeS3MVB9hgQuG8v2kTeG9BmvgfKlmD6s4xNugIKACjyD2tM6SH1Qko8eHCJIIM9q2PRsQdaU5cPyG4XEB2AbOO4kYg&loadFrom=DocumentDeeplink&ts=32.31)):

I'm glad you're here. So, let's start about talking about a power grid generally. How are these things set up? How does a hydroelectric power plant end up turning the lights on at my house?

Jordan Kern ([00:43](https://www.rev.com/transcript-editor/Edit?token=KUJbq17m-P-BG6GHN42_XesIY3F-AA56CgQViA-yjMUUnapeyp2sFOtcq59WNHk8ZlP3bpWPnIj5WtzwNMZEk8Lm4Go&loadFrom=DocumentDeeplink&ts=43.32)):

Yeah. So, there are a lot of different components of the grid, and we can compartmentalize those into three different categories. So, generation, which should be power plants like the hydroelectric dam. Transmission, so high voltage transmission lines that are used to send electricity from where we generate it to roughly where it's consumed. And then, lower voltage distribution lines. And so, in between power plants and the distribution lines, we have substations that have also been in the news recently. And that's where electricity is ramped up and down in voltage. And so, we want to ramp it up in voltage right after it's produced and sent out over the transmission lines, in order to minimize losses of thermal, losses of electricity on the transmission lines. And then we ramp it down in voltage and send it out over lower voltage distribution lines. And then it's ramped down even one more time before it actually gets to your house.

Tracey Peake ([01:44](https://www.rev.com/transcript-editor/Edit?token=EYmYk4M00FmIDD8yNnolIGMHwa2REdHXubmXe6pwfyXNStOB4P15E7DrCQPtPZCL_OBf-pX3-Lou2jfhnkEMJcoGTPw&loadFrom=DocumentDeeplink&ts=104.34)):

Okay. So, that we don't flip a switch and explode?

Jordan Kern ([01:45](https://www.rev.com/transcript-editor/Edit?token=kgYJi7W3R4g-s77Fz0FfM63-UOzrzx7X281oPnNEwQYh-eTiDxLbhrsJjVKCWczbEIXmfJumCzsuDSMs9r-9dHEkDEY&loadFrom=DocumentDeeplink&ts=105.03)):

You got it.

Tracey Peake ([01:47](https://www.rev.com/transcript-editor/Edit?token=Ab6ESFc2ofqZXdo-SaVTiw5nWmJTT4w9KSvScelD59JAubpRoHbf5FKl54M-_-ZpVcpGxysHoI6t9LiBHA-GJgmbeCQ&loadFrom=DocumentDeeplink&ts=107.61)):

Okay, yeah. Excellent. So, with all of that said, traditionally we get most of our power from things like burning coal or fossil fuels, or we have been, and so we're trying now to transition to friendlier, environmentally friendlier energy. So, how is the grid adapting? Are we able to put out the same amount of electricity using solar, and wind, and hydroelectric, as we are just by burning fossil fuels? And if there is a mismatch, what does that look like?

Jordan Kern ([02:25](https://www.rev.com/transcript-editor/Edit?token=mj-zxJLtLj51MtiLGnot-Ogn22uzh6sMX8cdO82FOOwB75seatCUL_zZ_b9G7h5cOo0jf9xzwimAqXkFzYrsZfth0Pk&loadFrom=DocumentDeeplink&ts=145.41)):

Yes and no. So, in North Carolina, and I don't know the exact numbers, but we're now mostly natural gas, followed by nuclear, then coal, then solar, then hydro, and then some other stuff. And that mix looks a little bit different across the US. If you're in the Pacific Northwest, much more of your electricity's coming from hydro power, because that's where a lot of really big hydroelectric dams are. And if you're in Iowa, there's a ton of your electricity that's coming from wind. The difference between the more conventional power plants that we've used historically, like coal fired powered plants, natural gas plants, and something newer, cleaner, friendlier like wind and solar, is not necessarily how much you can build. And when we talk about the size of power plants, we talk about the capacity in megawatts, so how much electricity they could produce at any given moment.

([03:30](https://www.rev.com/transcript-editor/Edit?token=RfbnBCuCICcz3Jehldl0swNX_wwxtvPp_KeMvrxBXnc9REynB9EpSL8M8hmtOkYTi7A_njUe_rXqaPstKvlf4tng5z0&loadFrom=DocumentDeeplink&ts=210.84)):

So, you could have a 1,000 megawatts solar farm and you could have a 1,000 megawatt natural gas plant, but you're only going to be producing 1,000 megawatts of electricity from the solar farm when you have Peake solar radiance, when the sun is shining the most. And in all other parts of the day, it's going to be less than that. For a natural gas power plant or a coal-fired power plant, it's controllable. Meaning, humans, human operators are the ones who get to decide how much electricity is coming from that power plant. And so, that's really the rub with renewables, is that you can build as much as you want, but you don't always have control over how much electricity is actually coming out of a wind farm or a solar farm. And so, you can build as many of those as you want, but you still need something else that can provide electricity during the times when you don't have wind or you don't have solar.

([04:29](https://www.rev.com/transcript-editor/Edit?token=ROKqod79apdvRFq2SaA8gf5l-iMfuZqC_aEnesBhnkp95Lb0G_7XRK5XmtAiVpCrSrpQCGLYiEJUGThjuuUG5PZ4fZc&loadFrom=DocumentDeeplink&ts=269.7)):

Now, there are a range of different options for how you do that. One option would be some sort of energy storage, like a battery. So, you could take some of that extra electricity that's being produced by solar farms and wind farms during the middle of the day that you might not need and you could store it in a battery, and then you could keep it there until the sun goes down. And so, then you're just shifting when you're able to use that electricity that's ultimately produced by solar farms. The other option would be to use something like a natural gas plant. And instead of using it all day long, you would only use it during the periods of the day when the sun is not shining or the wind is not blowing. There's a difference there in cost. Batteries right now tend to be a bit more expensive than using the natural gas plant, but the trade-off there is with emissions. One of those scenarios gets us a lot closer to 100% renewable energy than the other one.

Tracey Peake ([05:33](https://www.rev.com/transcript-editor/Edit?token=FRt2NxCqOx0pggoap_vRokjQpDO4EeUy-9UBm1O5UGbiaamthMShO2mY_v4y5GLEmvNYs9bfvojpzyWntVpqhx_Yg5E&loadFrom=DocumentDeeplink&ts=333.63)):

Right. Okay. So, with that said, it sounds like it comes down to cost in terms of the shift, right?

Jordan Kern ([05:44](https://www.rev.com/transcript-editor/Edit?token=UnoN3OI1d2WO2w3yg3N5ZBfNbDyqGGlsiGhkxvQKVFvpsWWI4I5LAUKNEagSS-FkBgmoZODAtwO4seQFD4e4aGRYG3c&loadFrom=DocumentDeeplink&ts=344.49)):

Everything always comes down to cost.

Tracey Peake ([05:45](https://www.rev.com/transcript-editor/Edit?token=lEjt06KPfxRwUwWJi2qICpNotUSRHhR42N_BakIXDmvWw_xw441mRtMmG_mpjhQsJjoXwmxer58raZ5nvEu7qq8rbWQ&loadFrom=DocumentDeeplink&ts=345.87)):

Everything always comes down to cost.

Jordan Kern ([05:46](https://www.rev.com/transcript-editor/Edit?token=kjJmq09Ib9MvTEVD110KgMeEEF04Tt9CClfQMcB2Etpk4dsOXLuJlRQf_sc8nUroktcvX4pEOCvpHoudJJ8DLQ7dUHg&loadFrom=DocumentDeeplink&ts=346.77)):

How much are we really willing to pay to get to 80% renewable energy versus 90, versus 95, or closer to 100? And the closer you get to 100, the costs really start to balloon.

Tracey Peake ([06:00](https://www.rev.com/transcript-editor/Edit?token=fUaLWaZ_YFHB325GWFijFgeyEdUVXPG1cP4_HBsIZJa3FXzsPCKakB55i8UK8Kk1UKiQNmuNcmBWTQHTb836JDc_-Qg&loadFrom=DocumentDeeplink&ts=360.3)):

So, just for my edification here, with natural gas, obviously that's cleaner in terms of emission than coal, or is it?

Jordan Kern ([06:11](https://www.rev.com/transcript-editor/Edit?token=NKKAEs3M2-74YDJF08ieIrPDC-Gh4P6fdF0t_zMoQ8TJjS_KPhqRir1lp7-_c0w2TBsJTAqUDKlrae6a4qxd1wx1IHk&loadFrom=DocumentDeeplink&ts=371.46)):

The direct emissions of carbon dioxide from burning natural gas at a power plant is lower than the direct carbon dioxide emissions from burning coal. But methane, which is natural gas, is itself a very potent greenhouse gas. And there is some concern that increased use of natural gas across the US in a variety of different applications, but especially electric power plants, is contributing to what we would refer to as fugitive methane emissions. So, before the natural gas actually gets to the power plant, all these different pipelines it's going through in the process of getting it out of the ground is resulting inadvertent releases of methane into the atmosphere. And we don't actually know with a lot of certainty how much is escaping. And if it's enough that's escaping, it negates the benefits associated with switching from coal and natural gas. On paper, you're correct, coal is worse than natural gas. But there's some concern that just having any natural gas or switching from coal to natural gas might not be as beneficial as we think.

Tracey Peake ([07:32](https://www.rev.com/transcript-editor/Edit?token=yoWRDZX3lZHfeg_MITVCMnvhYBeHF4JW5RQDPEqL0ghuIfy36xP0wB7Ln75mlRLqdTVb1CUHQcPIP__1D6d85GLoV1E&loadFrom=DocumentDeeplink&ts=452.94)):

And then there's nuclear power, which I personally think is awesome because it's clean, but obviously I'd also grew up in the time of Three Mile Island and Chernobyl. What's happening in terms of promoting nuclear power as an alternative?

Jordan Kern ([07:54](https://www.rev.com/transcript-editor/Edit?token=kZWC_4s_ChgV0OgYq8amBr8r4Q7yM0mOACV38hpLWMCqotEnEBFpdOtQikTUteiW1JH1sFg7zAR6QwyMQ9c6EH69Ns4&loadFrom=DocumentDeeplink&ts=474.45)):

Well, I think there's a really important psychological barrier there for people. The perception of nuclear is that it's somehow unsafe. Now, there is a waste problem. So, when we use nuclear fuel for long enough, it degrades in essentially its potency. And when nuclear fuel is spent, meaning it's a little less potent for getting energy out of, it's taken out of the reactor and then it needs to go someplace. And it's still pretty radioactive, it's just not radioactive enough to use in a power plant. And we have not really solved the solution of what to do with spent nuclear fuel. Right now, the solution is you store it onsite at nuclear power plants. The efforts within the US at least, to either develop programs for long-term storage of nuclear fuel, which would be like Yucca Mountain, where they were going to essentially burrow deep, deep into the earth and store spent nuclear fuel below the water table in the middle of Nevada, didn't pan out.

([09:06](https://www.rev.com/transcript-editor/Edit?token=MlH-BeA-ZoJwB417Kp3-nED4MIjIlUN18DCqd9QSuYXZY3tvp_rLWi_Pa1Fs7__DJQ1jbanU_YNJWPGeRjq4LRV0v2k&loadFrom=DocumentDeeplink&ts=546.69)):

And then efforts to recycle nuclear fuel in the United States have also not panned out. And so, that is definitely an issue. The other part of it would be, and you brought up Chernobyl and Three Mile Island, and then there's the Fukushima Daiichi plant in Japan that was affected by an earthquake and a tsunami. Those are all examples of kind of worst case scenario, what happens if there's an accident at this power plant? And these power plants are incredibly complex, and failures do happen. The reality is that if you know compared the operations of nuclear power plants to the operations of basically any other type of power plant, they fail way, way, way less often. And part of that's because of the increased scrutiny and safety regulations that are in place. So, I agree, I'm a big fan. It's, relatively sPeakeing, incredibly safe and reliable, zero emissions electricity.

([10:10](https://www.rev.com/transcript-editor/Edit?token=WwL2z4pVrPZeATeJhYE_D3NrtDocJRxzgTwVjQiXxHt9diFuNHAJSOb4E0Ln8Nb977z_vhQWgvCYckmuOlwHrjoNfq8&loadFrom=DocumentDeeplink&ts=610.77)):

Once you build the power plant, the uphill battle for nuclear has been cost. The power plants we do have are really, really old, and so either we're going to need to retire them or pump more money into them to upgrade them and make sure they're operational over the next several decades. A lot of utilities don't want to do that, or maybe they do want to do it, but the costs outweigh the benefits. And so, they're for economic reasons, deciding to retire nuclear power plants. And building new nuclear power plants, partly because of the regulatory scrutiny, because there's this psychological barrier and everybody wants to make sure that they're basically failure proof, they're incredibly expensive to build. Especially when you compare it to something like wind and solar, where the cost has just been going down, and down, and down, and down for a variety of reasons. So, it just looks like, economically, a less viable alternative.

([11:18](https://www.rev.com/transcript-editor/Edit?token=XMA1PXk29xjFnIRKsJs-cds6oNbN0_s_JzWWim55vVdH0tD1xBMkEdIdNKfdZdGBTHEsKtBkmKP8TT2YCPuehcKGaIE&loadFrom=DocumentDeeplink&ts=678.45)):

That's starting to change. There's a movement away from building these gigantic nuclear power plants that we used to build in the '50s and '60s and '70s, towards smaller modular reactors that are kind of bite-size, that would allow us to make smaller bets about where nuclear is feasible or where it's not, without having to put all our eggs in one basket and building one gigantic nuclear power plant.

Tracey Peake ([11:44](https://www.rev.com/transcript-editor/Edit?token=Fj-TagTLejClabMwDTgnfhF8WBWQpwJ35kzSr6Jo0m-NUa1LM2tScNG-GF53yhHuvCnzlvy5fryjwrgVpRCAOg6_Nzs&loadFrom=DocumentDeeplink&ts=704.94)):

I had heard something about that. It sounded kind of interesting, like little mini nukes.

Jordan Kern ([11:48](https://www.rev.com/transcript-editor/Edit?token=QauO30CIJlZdG_RoxkMZIRBiTlvXQ2BD7D8A5GWqIy7sxoR00N6GfK98tn13xzQLQdfzVU0UeJYxE-2EObcV6KC8B2U&loadFrom=DocumentDeeplink&ts=708.9)):

Yeah. And I think we're going to see those come online in the next 10 years. And I'm hopeful that it will start this renaissance the nuclear power.

Tracey Peake ([12:11](https://www.rev.com/transcript-editor/Edit?token=Bh6sv_hKphzdfkzKyHUq8xo5MSOJrBvp0nPPOPLsqU7n8I6nWiKqoMV6lwkbpFJ9BHxSRFHMO3YVjB5ZPK0YnqJJS_k&loadFrom=DocumentDeeplink&ts=731.97)):

I'm also hearing a lot in the news about rolling blackouts or disruptions in service. I would like to know why. Is our demand increasing that much? Is it that we are not preparing for the population density that we end up having when we're building these plants? What's going on with that?

Jordan Kern ([12:32](https://www.rev.com/transcript-editor/Edit?token=pEq3sRA8gzmZG4X6UtLHTVN2i2CcYFQNwOOiuXBK8usbot_E1EJwljIj433tdNy6AcsETtf4iXJggVP3OqZbde4AVwc&loadFrom=DocumentDeeplink&ts=752.82)):

So, outages, interruptions in electricity service have increased over the last five to six years noticeably. My sense is that, overwhelmingly that's due to these sort of one-off exposures to extreme weather. Weather events are becoming, in some cases, extreme weather's becoming more extreme and more frequent as a result of climate change. And that can run the gamut. That can be more intense precipitation, more intense storms, higher temperatures in the summer, weirdly cold temperatures in the winter as a result of a polar vortex and a wavy jet stream. The connection there between more frequent or severe polar vortex events and climate change is uncertain, but some people speculate that that's could be what's behind it. So, I would say the first thing is weather, and the grid is old. It's ancient in terms of infrastructure.

([13:42](https://www.rev.com/transcript-editor/Edit?token=YHvCVUhTkwU1YVQArDXS8yCfYdc1uIZ5wZgtGCQ_44Gc8UyETpQTQE-1yHkg5P4Svkb6my6DeBMJ84ppCAeDdQYZJkQ&loadFrom=DocumentDeeplink&ts=822.39)):

And so, anytime you have this complicated, old system and you're hitting it with extreme events, it's going to break. And so, that would explain damage to infrastructure causing outages. You brought up increased demand. And so, that's a component of it as well. So, what happened over Christmas in North Carolina when they were rolling blackouts was that demand was really, really high because it was so cold. And more houses these days are using electric space heating in both residential and commercial properties. And so, that means that traditional utilities had to worry about the very hottest temperature of the year, because that's when everybody would turn on their air conditioning, and now they also have to worry about the very coldest temperature of the year as well. So, we had, I don't know if it was record, but very high electricity demand over Christmas or Christmas Eve, and then stuff broke unexpectedly.

([14:46](https://www.rev.com/transcript-editor/Edit?token=SZO_DyV3RMmX2uflzMCFgJqKS3a0fhxDVf8wsCv1ci8eXuNhvSdtLqPaiT-NV3KTIwGazW3RUpxciazzwpiqZwTRfJw&loadFrom=DocumentDeeplink&ts=886.71)):

There were two failures, at least two failures at natural gas plants that Duke Energy operates that were unexpected. And so, you had this combination of really high demand and less supply than they were expecting. And that's kind of similar, although less bad than what happened in Texas in 2021, which is another example of really high demand caused by extreme temperatures, coupled with physical failures at power plants that made it impossible for utilities to meet that higher demand. In general, and I think that companies like Duke Energy and regulators at the state government, the utility commission, who often work jointly to try to plan the future of the grid, do a good job at predicting how population and other dynamics are changing more slowly over time in North Carolina. And then responding to that by building new stuff, building new power plants, building new transmission lines to help meet that demand.

([15:56](https://www.rev.com/transcript-editor/Edit?token=iz11XY6j9uikfgmUhNooV51Eld233cIgcEIHs-apMKdiR0N2FRdmEdjDijhX4JvQN6F2GxDZSiW3vmpEwOWobvCix3Y&loadFrom=DocumentDeeplink&ts=956.52)):

But it's kind of inevitable that you're going to get it a little wrong or that you'll just get surprised by these extreme events where demand shoots up way higher than you thought it could. And if at the same time stuff breaks, that's rolling blackout. And rolling blackouts, I think it's different than a blackout that you would experience after an extreme storm, where trees fall on distribution lines. Rolling blackouts are instituted by utilities as a protective measure. So, they say, this part of Charlotte's going to go without power for 30 minutes or an hour, and then this part, and then this part. And the effort there is to try to keep the demand for electricity perfectly in balanced with supply, which they have to do every hour of every day of the year.

([16:50](https://www.rev.com/transcript-editor/Edit?token=2wssk7CLXHZfhF-V5Pfyo2Er4AmagjFm_Q7cpC_dt6bVjuJFOuP1tTc02Fd8gCsgHajtN6aDSlnRlqbOCKPpc2DNt6g&loadFrom=DocumentDeeplink&ts=1010.94)):

And if they produce too much relative to demand or produce too little, then it can cause instability in the grid that can cause widespread damage. So, it is their way of essentially making sure the grid continues to operate smoothly, even though it results in people temporarily losing electricity service in order to prevent more prolonged outages and damages to the grid that could really severely interrupt service.

Tracey Peake ([17:19](https://www.rev.com/transcript-editor/Edit?token=AUaVPXck3qJ57SMHDImVp-9bJXWrzoWkFI3Rg95Cu1cca0sCywQeixBs1dCooYMTi4S7-oRy9eSzVzmvPLVhOzcKe6w&loadFrom=DocumentDeeplink&ts=1039.05)):

And you mentioned as climate changes and we have more and more of these extreme weather events, are we planning ahead for that? And that also brings me to the question of EVs. Everyone's trying to encourage people, you're going to want to drive these electric vehicles. In California, they're actually introducing legislation to get rid of fossil fuel vehicles. They're also having rolling blackouts in California. So, this is my question. Demand is only going to go up if we're all charging our cars in addition to using all this electricity. And the summers are warmer for longer, for example. Or we're getting weird fluctuations in temperature where demand is off the charts one day and then not. How are we doing? It's 2023, I don't want to be in the dark cooking my food over a fire. I would like to have electricity.

Jordan Kern ([18:19](https://www.rev.com/transcript-editor/Edit?token=efmygIXKJdNpS_wKworz3ATWZdZNMj3fr2BdOgJ5t_pc-DgLZILGs-rZzS2u9ReGDID5liHXkykIMoUZRVpaZg6xmp0&loadFrom=DocumentDeeplink&ts=1099.41)):

I think it is a difficult job for utilities and for regulators and system planners that they haven't really had to deal with much in the past. I mean, the history of the power grid is mostly like this unmitigated success, just awesome. Like low cost for consumers, relatively sPeakeing, very high reliability. Now, when you start thinking about environmental impacts, the score is a lot worse. But in our attempts to address that, we are electrifying vehicles, electrifying other parts of our energy usage, including residential and commercial space heating, and then incorporating sources of electricity generation that are harder to predict on an hourly and daily basis, like wind and solar. So, what we're seeing is the growing pains of this. Now, the classic way to deal with uncertainty is to build more stuff. Redundancy is the best option for trying to minimize the occurrence of these failures.

([19:34](https://www.rev.com/transcript-editor/Edit?token=u6flAYl41yIz-I_d_8Pv7p-EOixgyEBEYnZiK1bftgY0BvWhS3RePG8Of9sVxJWgmUmGW35FPFArgvUFTEJ8k8WFtFw&loadFrom=DocumentDeeplink&ts=1174.38)):

You just build more stuff and you're less likely to run out of electricity, but that imposes a cost on consumers. There's this question of if you build too much stuff and you're increasing reliability from 99% to 99.95% or something like that, how much is that worth consumers, the average consumer? And that's a societal question that we have to answer. But it's companies like Duke Energy, organizations like the State Utility Commission, are trying to project forward. It's difficult because there's a lot of different possible scenarios that we could go down in terms of electrification of different sources of energy usage, combined with different pathways that the climate could take. And we don't know which of those paths we're on. So, it can be difficult to plan for those.

Tracey Peake ([20:36](https://www.rev.com/transcript-editor/Edit?token=oqpmJrXowQfuovJykNat9xBs9JRjuOMSRocNeEOqCmZHDryL5cy_ZK8GF8Jb7lNY9fSldaAts4uwnq3AJt_rdncmOBI&loadFrom=DocumentDeeplink&ts=1236.33)):

And that brings me to my final question, which is, in addition to all this other stuff, climate change, we've got old infrastructure, we're trying to shift to less predictable sources of power. Now we have weirdos shooting at transformer stations. What in the world? What is the risk to the grid as a whole from these things? And what can be done to, I guess, harden the infrastructure against human mischief in addition to mother nature?

Jordan Kern ([21:09](https://www.rev.com/transcript-editor/Edit?token=Twgy7PIaFpVIArRg9qk6KflcYYWItB3SovWBni0lewxDeK3WfQc-TqWlrCPNZeBzA2xoeQ7v_SMyLkKdEHYXe_cvMcc&loadFrom=DocumentDeeplink&ts=1269.36)):

Yeah. So, I think the risk for the grid associated with, as you said, weirdos shooting up substations, is relatively low for the wider grid. And I'll explain why. A substation, as I described earlier, is the place where electricity is either ramped up in voltage to be sent out to the wider grid, or it's the place where for your community, electricity would be coming in to your town or your city, or your part of your town or your city, from the wider grid. And in most places, if somebody shot up, well, in larger urban areas, I'll say if somebody shot up a substation, it's unlikely that that would significantly interrupt service, because there would be other substations that could draw power and send electricity probably to your house on distribution lines. So, there's redundancy.

([22:08](https://www.rev.com/transcript-editor/Edit?token=Np-bkJILK1XWuCJNGh_qOlt7ZCLin419J0RbLfwfHtKdhkMXF5QmZY7EXVALhfxxDHsxbKrT_nCxgDEILnFOa1jAMyM&loadFrom=DocumentDeeplink&ts=1328.52)):

And if you live in a really rural area, your town might just have one substation. And if somebody shot up your substation, you might be without power. But if it's a really rural area, it wouldn't affect that many people. Then there's this unfortunate Goldilock zone where you have pretty sizable towns that might have only a few substations and less redundancy, where if somebody shot up the substation, you could be without power, like tens of thousands of people could be without power for a prolonged period of time. And so, that can happen if somebody shoots up a substation or if it's damaged by flooding or other types of extreme weather. Or potentially if there are bad actors that are trying to hack the system from a cybersecurity standpoint.

([22:59](https://www.rev.com/transcript-editor/Edit?token=HZL3d0zWjBgegHGKn0Mya0lByu34ccR-kxS-BuHYjAx-no5sFbsAzuNt38D2c0xNmmMm1zSutSq_FF0zEEgiSzhKUhA&loadFrom=DocumentDeeplink&ts=1379.79)):

I think the cybersecurity issue is one that grid operators probably take more seriously than anything else. And that could be an issue with people in other countries trying to destabilize parts of the US grid on purpose. And it could be trying to physically damage infrastructure or doing the thing where they essentially hold you financially hostage, et cetera. So, I think those are all risks that are probably growing. And I think that's a hard thing for utilities to plan around again, because they probably have not been largely exposed to that in the past, and it's a new risk that they're having to wrap their heads around.

Tracey Peake ([23:44](https://www.rev.com/transcript-editor/Edit?token=6Zn0ZqeNzEGkS28DMdZSSpUu7Py92cbAcmZnZwIlYZ3Sd16hcTYep7_20prtObwSwDMh4KtrHORlgiTQQNiPJ9tsNnM&loadFrom=DocumentDeeplink&ts=1424.28)):

Yeah, it'll be interesting to see what happens in the future. Because you could just drive by a substation, so it's just out there, because who would think that you're going to mess with it?

Jordan Kern ([23:51](https://www.rev.com/transcript-editor/Edit?token=YnH486E7SmMGHeoRju1KEeZbTT_jp2VG3EsSprcySCmYyOI_Qg1OXTGfCTXmjxywgEkpaAg68qMwlAAkzh4-hiygWX8&loadFrom=DocumentDeeplink&ts=1431.99)):

They're everywhere. They're where everyone lives.

Tracey Peake ([23:55](https://www.rev.com/transcript-editor/Edit?token=LwLsAjwypf2To8dk_YVTjX1eceMoc_M6MTPr6t0dcU9Q5Pp1xH8s5sTyI51hNsoAB7pe_lNaiLhZx2I7lO6psY7xLyY&loadFrom=DocumentDeeplink&ts=1435.47)):

So, there you go. Well, thank you for being here today.

Jordan Kern ([23:58](https://www.rev.com/transcript-editor/Edit?token=9Coi2g1C12mLc61StQU1G1aXSNLQqvfNUYQVTXEDHEdoCZhf8oZhYJ2KX7-wxJBN_6XMJOnZDGlf6KDN3NdS71x9W_k&loadFrom=DocumentDeeplink&ts=1438.71)):

Sure.

Tracey Peake ([23:58](https://www.rev.com/transcript-editor/Edit?token=5RFm2aogeboncOqE_L0r_u5jOjz6aREa4y42OLmof2W3mrlwkhMOURXAj8FupoTil2r8exz77Lo5Y3A_gEVjmNR3w9E&loadFrom=DocumentDeeplink&ts=1438.83)):

This has been a very interesting conversation.

Jordan Kern ([24:00](https://www.rev.com/transcript-editor/Edit?token=mpYOwBoZ5tkOpP-Uk4yznEYtt-gBwzemQGFIrkOJSk2tI0kX3kvDN6ku8kRg9HxyhXMO4U8zfuPLQ0N2HMHBjgSU0EE&loadFrom=DocumentDeeplink&ts=1440.78)):

Thanks for having me.

Tracey Peake ([24:02](https://www.rev.com/transcript-editor/Edit?token=9BkEqd9dsLBtwaOS0wgEqixgoyobz6LRps0f0GBgrFCQwkyKYNkRHebgv-FRrx1ZS_8d6ZxHIgIl_uUQI-A5DGtjiBI&loadFrom=DocumentDeeplink&ts=1442.16)):

We've been sPeakeing today with Jordan Kern, assistant professor of forestry and environmental research here at NC State. This has been Audio Abstract. I'm your host, Tracey Peake. Thank you so much for listening.