

The Great Simplification

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[00:00:00] **Meredith Angwin:** A good situation has a very simple issue, and that is there's nobody responsible. The buck doesn't stop anywhere. For example, in Texas in 2021, they had a blackout for about 24 hours for a large part of Texas, and the fundamental reasons for that blackout was they didn't have enough power plants that could be brought online.

[00:00:23] That was partially due to poor planning, partially due to not good enough winterization and so forth. But the thing is now, who do you blame the power plants? Do you blame the public Utilities Commission? Who do I call if this doesn't go right?

[00:00:42] **Nate Hagens:** Today I am joined by Energy Analyst Meredith Angwin, to discuss the fraying state of the United States electrical grid and the policy decisions behind this unfolding situation. As a working chemist, Meredith Angwin headed projects that lowered pollution and increased reliability on the electrical grid.

[00:01:03] She's an inventor with several patents and was one of the first women to be a project manager at the Electric Power Research Institute where she led projects in renewable and nuclear energy. Meredith also served on the coordinating committee for the consumer liaison group associated with her local grid operator ISO, new England.

[00:01:25] Uh, I-S-O-N-E. I'm not sure if that's New England or Northeast. She continues to study and take part in grid oversight, governance and education, and is the author of the book Shorting the Grid, the Hidden Fragility of our Electric Grid. As many of you know, energy is a foundational topic of The Great

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Simplification Podcast, but this is the first episode where we explore the effects of our policy and governance decisions on the reliability of the electric grids on which so many of us depend and take for granted.

[00:02:01] Um, Meredith also unpacks the consequences of rising renewable penetration and natural gas electricity generation in the United States, and what that means for grid stability. Ultimately, it's my belief that these issues will become only more pressing as resource pressures intensify in coming decades.

[00:02:21] Before we get into the episode, if you enjoy this podcast and would like to connect with other listeners, I invite you to join our new online community on hilo.com, which we just launched in place of our Discord Hilo, HYLO serves as the digital comments for TGS listeners and is designed for pro-social and meaningful discussion where viewers from all over the world can connect online.

[00:02:46] You can find the link to join Hilo in the description of this episode. We hope to see you there. With that, please welcome Meredith Angwin. Meredith Angwin, welcome to the program.

[00:03:00] **Meredith Angwin:** I'm so happy to be here, Nate.

[00:03:01] **Nate Hagens:** You're welcome. I have long been aware of you and your work, um, and I have a PhD in energy, specifically net energy analysis.

[00:03:12] Uh, but I actually know a fraction of what you know about what an electrical grid is and the stability and the reliability and all the details. And so I invited you to give us a electricity grid 101 primer, uh, for our viewers and what that can tell us about the broader future of electricity in the United States and and beyond.

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[00:03:43] Um, so let's start with. What, what exactly is the US electricity grid and how old is it? And, uh, where is it located and how's it responsible for, for providing, uh, energy services throughout the United States? Give us a broad arc overview.

[00:04:01] **Meredith Angwin:** Different parts of it are different ages. I mean, part of it started in like the, uh, uh, 1890s and 1910 era era.

[00:04:11] But, um, most of the grid really got put into place in the fifties and forties because before that it was not everybody had electricity. And as a matter of fact, um, uh, LBJ Leonard Johnson, uh, campaigned in, in, uh, Texas on bringing electricity to the, uh, farm women so that they wouldn't have to work so very hard.

[00:04:36] And they could be as pretty as their sisters in the towns.

[00:04:40] **Nate Hagens:** When was that? The fifties?

[00:04:42] **Meredith Angwin:** No, no. That was, that was a, that was a long time ago. He was just campaigning for, um, being in the Congress or the, the Senate. He wasn't campaigning for president.

[00:04:52] **Nate Hagens:** Well, the, the, the point being is that we just assumed that.

[00:04:56] We've always had 24 7 electricity for all citizens. And that is not the case.

[00:05:02] **Meredith Angwin:** No, it isn't the case. I mean, I remember, uh, I, I met a man here who's a, a, uh, an engineer and he's actually a, an engineer who builds, uh, dams and other parts of infrastructure, and he talked about how he was growing up in rural Vermont without electricity.

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[00:05:19] Yeah. I mean, and so, you know, obviously he's older than me and I'm, I'm older, but I'm, I'm 80 and he was older, but I mean, in living memory, people didn't have electricity. Yeah.

[00:05:31] **Nate Hagens:** Yeah, it's really, I mean, just that is something that we take for granted. The, i I read somewhere there are 60 devices. The, in the average American home that are plugged in 24 7 drawing on electricity.

[00:05:47] We take that stuff for granted. Um, and one, one of my core themes is energy blindness. And, uh, you're here today to dispel energy grid blindness. So keep going, uh, about the grid.

[00:06:00] **Meredith Angwin:** Okay, so the grid, uh, grew and, and, and, and, and one of the big ways it grew was in, in the early days, was building dams, which were mostly done, uh, uh, with government, uh, assistance and money.

[00:06:13] And so you had public power. So the West Coast still has more public power, especially the northwest. And then of course you have the TVA. And anyway, then, um, it, it really gets very complicated what, how it actually grew. So I'm gonna just skip that because I, I just want you to know that it's not that hard to meet somebody who grew up in the United States and didn't have electricity if they lived in a rural area.

[00:06:45] **Nate Hagens:** Yeah. So in, in your book, uh, shorting the Grid, uh, you compare the management of US power grids in the past few decades to the Big Short, the Wall Street movie. Um, oh yeah. And can you explain what, what you mean by this and what your main thesis is?

[00:07:03] **Meredith Angwin:** Okay. I, it, it'll take a moment here, but basically what happens is that there is a physical grid out there and it, it, it, you can see some of it out your window.

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[00:07:12] There's wires. There might be a substation there. You might be able to see a, uh, um, where I used to live, I could see a DA dam on the, um, on the Connecticut River if I stood in a certain part of the window and looked. But anyway, that's the physical grid. And then there's the policy grid, which is, uh, how power plants get paid, how they get permitted and so forth and so on.

[00:07:36] Now, what is going on? Uh. Currently is that we have, uh, sort of forgotten that there is a physical grid and we're busy, uh, uh, tweaking the policy grid all the time. So let me look at, uh, the policy grid for a moment. Uh, the way it used to be and the way it is now, um, the way it used to be is that, um, let's say you had a company, um, let's say it was, uh, uh, consolidated Edison, okay?

[00:08:05] And it was responsible for, uh, power plants transmission, uh, in its area. Um. And it was responsible for distribution and sending bills and having guys who came out and repaired your wires. I mean, your, your, if after a storm it was, it was the whole ball of wax. And since it was the whole ball of wax, it couldn't be it competing with somebody else.

[00:08:34] I mean, you're not gonna have. Uh, two sets of wires to your house, you're not gonna, so it was what's called an integrated utility, integrated that is soup to nuts, uh, generation making the power to, uh, the wire that leads to your house and, and whether it's intact or not, uh, distribution wires, that's everything.

[00:08:55] And so it, it isn't going to be in competition. So what it was, was it had a rate of return. That is, if it invested money in building something, then the, uh, public utilities commission for that area would say, okay, you have. 4% rate of return on the money you've invested. So it became a very good widow's and orphan stock because it had a rate of return.

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[00:09:20] And also there was no particular reason not to invest. As a matter of fact, uh, people would say, you know, they're gold plating the grid because everything they bill, they make more money on it. You know, they build more than they need. They, they build fancier than they need. And so there was a feeling that this was inefficient.

[00:09:40] And so then it became this idea that we would have to bring in the, um, invisible hand of the market. And, uh, you know, this invisible hand would, would fix this problem. So that is when we went from, um, cost of service, which is the pay, pay for what we have to do and pay us a, a reasonable, uh, uh, profit on it to, um, RTOs regional transmission organizations where, uh, the.

[00:10:11] People who, the, the companies that own the power plants are not the companies that bring it to your, uh, uh, not, usually not the companies that bring the power to your, uh, house. So the power plant companies, um, they are competing with each other to be the one that brings it to your house. Well, the, these competitions are taken care of by auctions.

[00:10:39] They run every five minutes. And the rule is that the, the general rule is that. The lowest price, uh, per kilowatt hour plant is the first one to be dispatched on the grid. And you, you keep having, you add more expensive plants as the demand goes up so that, that the overall grid cost would be low. But there's always this one thing.

[00:11:09] It, it doesn't matter that the overall good cost is low, because what happens is that when the most expensive plant goes online, all the other plants get the same. Uh, payment. So the, that the expensive plant goes online and that quote sets the clearing price. And the clearing price is what everybody else gets, including the most expensive plant.

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[00:11:34] **Nate Hagens:** So, um, I know you're just at the beginning of, of this story, but I have to interrupt with some questions. Uh oh, please. 'cause usually if I have questions, my viewers have them as well. How much of the cost of electricity, either in your region or the United States, what percentage roughly is the generation, like the coal or natural gas or renewables, and how much is the transmission and all the other things, getting it to where it, where it is, uh, consumed.

[00:12:06] **Meredith Angwin:** Generation is generally less than half of the cost. Okay. Uh, and, uh, but you know, it depends on where you are and how expensive your generation is. So I, I don't wanna get further into that,

[00:12:20] **Nate Hagens:** but half or less than half roughly as a, yeah, it's not 90% or something like that. Not 90%.

[00:12:26] **Meredith Angwin:** I mean, think about it.

[00:12:27] Somebody is running a power plant and they're buying fuel for it, and they've got a staff on, on site. Okay, fine. Right. Meanwhile, there are a linemen, there are tra substations, there are billing, there are, there are customer service representatives there. I mean, you know, you've got this whole infrastructure that's separate from that power plant.

[00:12:47] **Nate Hagens:** Yeah, no, that makes sense. So, um, back in the day, the, uh, priority was to. Give energy services to citizens. And then what you're saying is, um, this kind of switched to a profit objective where, uh, reliability to humans was no longer the primary objective. It was, there was a profit motive embedded in the intermediary steps.

[00:13:18] **Meredith Angwin:** Yes. And there was always a profit motive in the following sense. And that is that if a, a, um. If a utility, an integrated utility messed

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up big time, you know, and, and, and there was a, a major outage and they didn't get it fixed right or whatever, uh, then they would be ex, the, the, the, the local PUC uh, public utilities commission for the state would find them.

[00:13:46] Mm-hmm. And, or, or they would say, well that was nice. We used to give you 4%, uh, uh, profitability, but the rate you're going, we don't wanna give you that, you're gonna have three and a half percent. So they wanted reliability for, uh, several reasons. First of all, they made a profit on what they built for reliability, and secondly, because the reliability put them in good withstanding with their public utility commission who set their rate of return.

[00:14:16] **Nate Hagens:** Yeah. So why is this, uh, um, dichotomy that you explain a, a risk, why is this important?

[00:14:26] **Meredith Angwin:** In my opinion, the good situation has a very simple issue, and that is there's nobody responsible. The buck doesn't stop anywhere. And, uh, I, I consider that that is typical of many things that are happening in our country, where, uh, there layers and layers of, of rules and, and exceptions to the rules and, uh, so forth get piled on each other.

[00:14:51] And at the end, you don't know well. Who do I call if this doesn't go right? Oh, well, you know, that's a complicated question there.

[00:14:59] **Nate Hagens:** Who are the, let's talk about either, uh, you recently, you've moved from Vermont to New Jersey, I believe. Yes. But we could talk about Vermont, just 'cause you're familiar with it.

[00:15:08] Yes. If there's, uh, super cold winter and there's some energy flows that don't happen. Uh, I got my PhD in Burlington, so I know that that community, uh, well, if all of a sudden there's a brownout or a blackout in the middle of winter in

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Vermont, like who is, who, who is to blame and who, like what are the, what's the hierarchy of, of the buck doesn't stop here.

[00:15:33] Let's kick it up to a higher level. Does the national government get involved at some point or who are the players?

[00:15:39] **Meredith Angwin:** Uh, that's a good question. Well, let's start with the local, uh, players. If, uh, there's, uh, it depends on why the blackout happens. So, for example, if there's an ice storm, then, uh, the, uh, local utilities are, are cons are the ones who are running the distribution system, and they're, they're the ones who are, uh, responsible for getting the power back to the houses.

[00:16:05] In that sense, there is a clear, uh, demarcation of what it, what happened. The, the question is in, for example, in Texas, in 2021, in the, uh, February, um, they, they had a blackout for about 24 hours for a large part of Texas. And the fundamental reasons for that blackout was they didn't have enough, uh. Power plants that could be brought online now that, that was partially due to poor planning, partially due to winter, not good enough, winterization and so forth.

[00:16:44] But the thing is now who do you blame, uh, the power plants? Do you blame the public utilities commission? You see, the thing is, let's say I, I own a power, I own a bunch of power plants. Nobody can force me to build another power plant just because, uh, the state might need it.

[00:17:01] **Nate Hagens:** So the only reason you would build one is if you were economically incentivized to do so?

[00:17:06] Exactly. And the right, exactly, exactly. The profit opportunity was large enough.

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[00:17:09] **Meredith Angwin:** Right. That's right. And so basically, um, one of the other things is that I didn't talk much about the auctions, but let's, let's, uh, remember there's this clearing price and, uh, power plants in general, and it's a lot of questions about this.

[00:17:26] They get paid the clearing price. Now, one of the things that happens is that, uh, uh, you have, uh, renewables, uh, and renewables get outside of market funding. In other words, they get subsidies. So a renewable, most of the renewable subsidies go on the basis of how many kilowatt hours they put on the grid.

[00:17:49] So they really want to put kilowatt hours on the grid. I mean, which is good. I mean, that, that's a great incentive. The trouble is that they're so willing to put kilowatt hours on the grids that they don't need to be paid for them. Because they get the subsidies when they put the kilowatt hours on the grid.

[00:18:08] So they, they don't need, they, they obviously, they need to be paid. Everybody has to be paid. But the, the thing is that in general, if I have a, uh, coal fire plant say, um, my main income will be from selling kilowatt hours to the grid. But if I have a wind turbine, part of my income will be selling kilowatt hours to grid.

[00:18:30] Another part will be selling renewable energy certificates to utilities. Another part will be subsidies like production tax credits. So pretty soon, uh, you know, I can look at all this and say, well, I still get. Two of these things. That is the production tax credits and the renewable energy certificate payments.

[00:18:52] Even if I don't get paid by the grid, okay, I'm bidding in at zero, I'll be chosen because the, the, the auction doesn't care about your other sources of funding, it just cares what you're bidding in.

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[00:19:04] **Nate Hagens:** I actually did write one of my PhD papers on, on this topic, um, that the more we add intermittent renewable sources, the, uh, higher the standard deviation of, uh, return is, and what ends up happening is.

[00:19:22] Base load companies like coal or nuclear or, or natural gas get penalized because they had a pro forma when they were built that they would be running at 70% capacity over 20 years or whatever. But if all of a sudden the, the, the, uh, market is flooded with renewable and they have to turn their plant off or, you know, mothball it for a little time or whatever, that ends up making them not profitable.

[00:19:49] What, what do you have to say about that?

[00:19:51] **Meredith Angwin:** Oh, that is absolutely the case. It is absolutely the case. The running a base load plant intermittently. Makes it less profitable because after all, a base load plant is usually a heavy investment in, in the capital to build the plant. And, and, and so not running it, you still have to pay for whatever, uh, you need to pay for, for the capital.

[00:20:18] You have to pay maintenance, you have to pay interest, you have to pay taxes on the fact you've got a big in you, you're the biggest thing in town. And, and, and so when the school board wants more money, you are gonna be ending up, coming up with the bulk of it, you know? Uh, that's kind of what happens.

[00:20:35] **Nate Hagens:** So what, what are the, like big risks here and we'll, we'll backfill some of the things on auctions and other, other points, but like, what should be we be concerned about?

[00:20:47] Uh, quite, quite a lot I can think of, but I, I want you to give us a, a couple, three points of what should people be concerned about with the current, uh, electrical grid situation. Let's just talk about the United States for now.

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[00:21:02] **Meredith Angwin:** Okay? You should be concerned about the term resource adequacy. In other words, are there, are there enough reliable plants online to meet the demand on a cold day

[00:21:15] **Nate Hagens:** or a, or a hot day?

[00:21:16] **Meredith Angwin:** Or a hot day. Yeah. But in, in, i, l, a hot day can be bad too, but when the hot day is bad, things are really bad. Because basically one of the things that happens on a coal day is the power plants that run on natural gas are competing with homes for natural gas. So basically the power plants are actually lower in the L line, uh, than the homes are.

[00:21:43] **Nate Hagens:** Why, why is that? Is that a government restriction or policy or something?

[00:21:47] **Meredith Angwin:** It's sort of a restriction, but it's also, part of it is that. People don't want people freezing to death in their houses, right? And they figure a big power plant can take care of itself. It can, okay? It can buy some, uh, uh, diesel oil and, and, and many plants, uh, are dual fuel.

[00:22:03] They can use natural gas or, or, or diesel. Once you, uh, atomize it and shut it, uh, send it into the, the combustion turbine, it, it, you know, you can use that. So that's one thing. The other thing is power plants are competing on, um, on price. If you're buying natural gas, you can make one of two kinds of contracts.

[00:22:26] Now you understand I'm not personally buying natural gas. If I bought natural gas, I would buy it through a natural gas distributor who would buy it from the big pipelines. Okay. So the, there's two kinds of contracts. The natural gas distributor are homes. His business depends on reliably giving electricity to the homes.

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[00:22:49] So he's gonna make a firm purchase contract. Meanwhile, the power plant depends, their business depends on being, um, uh, the, one of the less expensive things on the grid. And so they're going to make a, um, interruptible contract. So there's, and, and the interoperable contract will be cheaper per whatever unit of gas, you know, than, than the firm contract.

[00:23:18] So as a rule, then the power plants end up being last in line unless they've made firm contracts. Now you say, well, wouldn't the gas companies want them to make firm contracts? And, and to some extent no, because, um, you've got a gas pipeline which can carry a certain amount of gas, and before a cold snap, the gas people, well they do something called packing the pipeline, which is sort of over pressuring it a little so that they can get as much as they can.

[00:23:49] Everybody's doing their best. I just want you to know that I'm not demonizing anybody here.

[00:23:54] **Nate Hagens:** Yep.

[00:23:55] **Meredith Angwin:** But anyway, so they, they, they've got this pipeline. It may be packed a little, so it's, it's at higher. It can deliver higher. But if you think about it. Has to deliver for a lot of homes and a lot of power has to be built, deliver.

[00:24:15] It's gotta be much bigger than it would be for an ordinary day. You see, it's, my analogy is do we build a freeway big enough to take a football game letting out at rush hour with no congestion happening? No, we don't. Yeah, it would be insanely expensive.

[00:24:37] **Nate Hagens:** Right?

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[00:24:38] **Meredith Angwin:** So it turns out that the intermittent, they, they, they get, they get to be having the, the power, the gas company with the big pipeline says, yo, you know, it's really cold out.

[00:24:50] We've got a lot of demand from our, our, our retail, uh, house companies that supply houses and we're not gonna be able to get you as much.

[00:25:00] **Nate Hagens:** So the, um, the first risk that you outlined is resource adequacy. Um, do you wanna say more on that or what are the other risks?

[00:25:10] **Meredith Angwin:** I think that resource adequacy. Is the major ri.

[00:25:15] Well, it isn't the only risk, but

[00:25:17] **Nate Hagens:** by resource adequacy, do you also include natural gas depletion and things like that? Like there won't be enough gas to buy at? No, I don't. Okay. I mean, I

[00:25:27] **Meredith Angwin:** have a very short. A timeframe view of all this stuff. Okay. I mean, you have to understand that the auctions, the energy auctions run every five minutes.

[00:25:37] So if I have a, a three month timeline, I'm doing great.

[00:25:42] **Nate Hagens:** Is that all computerized or are there people actually like, yes, I decide to buy this at this price? Or is it all algorithms? Uh,

[00:25:50] **Meredith Angwin:** it's, it's pretty much all algorithms. Yeah. On the other hand, it can't be all algorithms because the, uh, dispatchers, the people who are running the, um, the, uh.

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[00:26:03] Dispatch system and the the grid itself, they have to know what's going on. And let me, let me give you an example of this. Uh, uh, the first time I visited, uh, ISO New England, um, I, uh, I was, I, you know, it's a huge, uh, control room with a huge wall with all the different, uh, substations and power plants and major P power lines and, and, and, uh, six different deaths stealing with it and stuff.

[00:26:33] And then at the two ends of the room were TV shows. I thought, what the heck? Do they have time? No. What they're doing is they're watching the weather, they're watching whether there are police action somewhere that could affect the grid. You know, you can't just have an AI algorithm, cannot watch a TV show.

[00:26:54] Not yet. And notice,

[00:26:57] **Nate Hagens:** so, um, so when you say resource adequacy, uh, you, you mean like in the next auction, in the next few months, if there's a cold spell or a hot spell? Right. Do we have. The ability to spin up the appropriate mix of electricity generation to get the amount of electricity to the homes and businesses that demand it.

[00:27:20] **Meredith Angwin:** Yes. That, that, that, that is, that is what resource adequacy is. And of course, you know, when you really get down into it, you got a lot of, uh, issues that are not strictly resource adequacy. Like, for example, uh, if we are turning on every, uh, gas fired plant in the northeast of our state, do we have enough, uh, and, and the problems are in the northwest of our state.

[00:27:45] Do we have enough transmission? You know, there there's, there's, there's a lot of other questions.

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[00:27:51] **Nate Hagens:** So how many of these regional utility, uh, commissions are there? You mentioned the TVA, the Tennessee Valley Authority, like how many are, are, how many grids are there in the United States?

[00:28:02] **Meredith Angwin:** Oh, I don't, I I don't, I'm sorry.

[00:28:04] I don't know that one. I'm, I, okay. I, I, I, I would say that's okay. Say this year. I love it.

[00:28:09] **Nate Hagens:** I love it when people say, I don't know.

[00:28:12] **Meredith Angwin:** Thank you. Because, I mean, there are different sizes, you know? I mean, for example, there could be a, a, a, a municipal utility in, in Utah that serves 2000 people. Okay. You know, I,

[00:28:30] **Nate Hagens:** and it's not connected to some larger grid?

[00:28:32] **Meredith Angwin:** No, it would be, it would be. Oh, okay. It would be, I mean, if you wanna know about the largest grids, I would say there are three of them. The Eastern Internet Connect, the Western Internet, and Texas. Those are the three large grips. I can answer that question.

[00:28:49] **Nate Hagens:** So, um, how concerned should we be about the age of both the generation and the transmission infrastructure in the United States?

[00:29:00] **Meredith Angwin:** I would be, uh, really concerned. Uh, I would also say that one of the problems is that they don't, uh, that, that they're, especially in the RTO system, there's no particularly good way to be, uh, paid to do maintenance. Remember that they're just competing on, on, on, uh, the cost of producing the next kilowatt hour.

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[00:29:28] **Nate Hagens:** So, I didn't think about this when, um, I invited you, uh, but in researching your, your book and your work, I've had this nagging, um, suspicion and realization. What if, uh, let's start from scratch. Let's go back 50 years. Knowing what you know now. If the objective was to provide stable, consistent electricity to the American population, uh.

[00:30:03] Would you, an expert on this topic, would you have done things the way that, that we did them? Um, what's the difference between having an objective of, uh, reliable energy services versus let's get people what they want and they can afford using the fully a market system? What are your thoughts on that?

[00:30:25] **Meredith Angwin:** Well, I don't think there can actually ever be a true market for electricity. I mean, and, and I I, I often use the analogy that I'm going to the farmer's market and I'm gonna buy some zucchinis. They're probably three people selling zucchinis in zucchini season 20

[00:30:43] **Nate Hagens:** where I live. But go on. Yeah.

[00:30:45] **Meredith Angwin:** And if you, if you're in Vermont and you leave your car unlocked, you're likely to get zucchinis in the back seat today, which actually happened to me one time.

[00:30:55] I thought it was just an urban legend or a rural legend. There. It was, um. It didn't happen a lot, but there's a competition and, and, and even if you're looking at, well, I buy my, my Zucchini at the local grocery store. The produce manager there is in, in a co is trying to get the best deal for his store.

[00:31:17] So, uh, what I'm saying is there's a competition, but that means that the, the suppliers are to some extent interchangeable when zucchini looks like

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another. And, uh, and that also, there are a lot of them, but even though one electron looks like another, uh.

[00:31:43] We different power plants act on the grid is not interchangeable. If you have an intermittent plant such as, uh, uh, a wind turbine, then you can't expect it to do things such as a, uh, base load plant has. Now people go and say, oh, base load, you know, that's your grandfather's grid. No, it isn't. It's no more your grandfather's grid than, uh, trucks and, and trains are your grandfather's, uh, way of transporting goods.

[00:32:16] People don't understand that you can. You can build something which is going to be inexpensive to run very steadily, but probably expensive to be flexible. Or you can build something that's flexible, but it, it probably will be expensive to run, uh, steadily. My analogy is do it, let's say you have a, a semi and it's got a lot of stuff in it and it's moving along the, the highway.

[00:32:46] Can it accelerate and decelerate fast? No. Can it, can it stop fast? No. Is it flexible? No. But on the other hand, if you, are you planning to run everything by the most flexible thing you have? Would you like to run everything with, uh, sports cars? Is everything gonna be transported through sports cars?

[00:33:11] Flexible.

[00:33:12] **Nate Hagens:** So the, the issue that we face and, uh, many places in the world face, especially with awareness of, uh, what fossil fuel emissions are doing to the biosphere and the oceans is we're. Building more sports cars, uh, while we also have roads full of semis and how to, uh, be the, the traffic cop, uh, with both of those things growing and, uh, just because of policy, the number of sports cars, in this case, wind and solar is, is growing without looking at the, the whole system itself.

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[00:33:53] And they extrapolate, uh, uh, proforma costs. That might be something. At 5% penetration. But then if we're at 50% penetration of the sports car flexible thing, it has wildly different implications for prices and reliability, et cetera. What are your thoughts on that?

[00:34:12] **Meredith Angwin:** Oh, I think you're absolutely right. I mean, the thing is, if you have a five to 10% sports cars on the road, uh, they're, they're doing fine.

[00:34:21] And, and, and even if you have to, uh, if you say, well, we, we transport some good by sports cars. I mean, I don't know, you would, but it would be very high value good. Or it'd be really important to get it absolutely on time. And meanwhile, the semis would continue to bring, uh, um, uh, food, toilet paper, uh, uh, whatever to your local store.

[00:34:45] **Nate Hagens:** Yeah. So, um, in, in the core of your book, uh, you describe, and you mentioned it earlier, there was a shift in the way the US power grid was managed, uh, that occurred in the 1990s. Uh, and it changed from vertical integration to the grid over to something called the Regional Transmission Organizations or RTOs, uh, to deregulate.

[00:35:07] So this switch to RTOs, um, how is that switch? Uh, um, influencing the fuel makeup of our grids, whether that be natural gas, nuclear coal, or, or renewables.

[00:35:23] **Meredith Angwin:** Well, it's in influencing the fuel makeup greatly because it, the, uh, RTOs don't have any way to reward a plant for being reliable.

[00:35:34] **Nate Hagens:** Oh, so reliability is not rewarded.

[00:35:38] No. And yet, reliability is arguably the most important thing.

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[00:35:41] **Meredith Angwin:** Yeah, they don't have a way to do that. Now they do have a way, in a way, but this is like, uh, do, do you really wanna know this? One of the things I think is gonna happen is that we're never gonna go back to integrated utilities, but we're going to go to the equivalent of cost of service that we, we are going to see that the grid is gonna falter without those, uh, semis.

[00:36:09] And so what happens there is that the plant gets what's called an RMR contract. Reliability must run contract or cost of service contract. So you have a plant that otherwise said, okay, I'm not economical, I'm sorry, I can't, I can't take the clearing price. The clearing price is too influenced by, by, uh, renewables bidding in at zero.

[00:36:34] And, um, I'm not, I'm outta here. At which point the, the grid operator says, uh, no, you're not out of here. You're gonna be, you're gonna keep running. You're gonna have a, a cost of service, reliability, must run contract, and so forth.

[00:36:49] **Nate Hagens:** And they had, they have the ability to enforce that.

[00:36:51] **Meredith Angwin:** Oh yeah.

[00:36:52] **Nate Hagens:** Okay.

[00:36:52] **Meredith Angwin:** I mean, at least as far as I know, they do.

[00:36:54] Well, let's put it this way, they, if somebody says, I can't make a living here. I'm, I'm, I'm outta here. I'm not gonna run my plant anymore. And the PUC says, so what would it take to make a deal?

[00:37:07] **Nate Hagens:** Yeah.

[00:37:08] **Meredith Angwin:** Right. They can answer. They're not gonna say Nothing you can do will help.

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[00:37:12] **Nate Hagens:** Well, let, let me ask you this. Um, I, I actually, I'm gonna have.

[00:37:18] Way more questions than we have time for, because this is a, this is a hugely important topic, but what happens in coming decades or coming years when, for various reasons electricity starts to become more expensive? How much of, uh, doing without like, uh, less use by average people because they can't afford it, how much, uh, is that a wedge that will answer this problem?

[00:37:51] And how much of it will be what you just described, some grid utility manager forcing a, uh, coal plant that's losing money to stay on, uh, because it needs reliable power?

[00:38:05] **Meredith Angwin:** I don't know. I will say that I think that. That of course, conservation by individuals can help, but we've made it into a, a kind of a golden calf or a, a virtue signaling thing actually.

[00:38:22] People say, oh, there is no more baseload. Well, I've seen, uh, some studies and, and, and, and they, they look at, uh, uh, the percentage of a power that's running all the time on a grid versus the power that's load following or peaking, and the, all the time power is usually 60 to 70% of the grid.

[00:38:46] **Nate Hagens:** Yeah.

[00:38:47] **Meredith Angwin:** And, and, and you can see how this would be because let's say I had.

[00:38:52] Five gigawatts of all the time power. Well, that five gigawatts is there 24 hours. Then I've got another 10 gigawatts. This goes up and down, but it's only there between 8:00 AM and, and 8:00 PM and it's going up and down all the time. So, you see, see what I'm saying here?

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[00:39:11] **Nate Hagens:** I, I do. So with that in mind, um, you mentioned the last few decades has been a rapid addition of renewable, uh, largely because of subsidies.

[00:39:20] So how are, how is the rapid addition of renewables to the grid in the United States and elsewhere influencing the type of fuels in total being used for the grid?

[00:39:32] **Meredith Angwin:** It's basically, uh, undercutting any plant that has, uh. High capital costs. It actually doesn't undercut the fuel cost plants very much because, uh, they, they, once they're on the grid, a high fuel cost plant, like a, like a, a, a natural gas plant, it, it'll tend to set the clearing price.

[00:39:59] **Nate Hagens:** So the natural gas plant, since you can on a combined cycle plant. Oh, we have a shortage. We need to switch it on. Um, the flexibility is kind of the gold standard to turn something on and off when you need it. Uh, yes. To have humans access power in a, in a country, in a world, in an economic system that needs just in time electricity, when we want it.

[00:40:23] Right now, natural gas is like the gold standard because we can turn it on. We don't have to wait eight hours for it to boot up like a coal plant or whatever. So what you're saying is paradoxically, uh, adding more renewables makes natural gas the, the clearing, uh, um, choice, uh, often. Right?

[00:40:45] **Meredith Angwin:** Absolutely.

[00:40:47] **Nate Hagens:** Interesting. So let, lemme ask you this, um. Meredith there, there's a common meme, uh, especially in in environmental circles that renewables, uh, solar, wind, uh, et cetera, are the cheapest electricity available to us. And quickly outcompeting all forms of, uh, energy is, is this true?

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[00:41:10] **Meredith Angwin:** No. I'm, I'm gonna say that the reason it appears to be true is that the, the renewables, uh, get enough subsidies that they can bid in it's zero or negative on an energy auction.

[00:41:24] So you, in, in other words, yes. If you look at what can I put on the grid and it'll be, it'll be the cheapest per kilowatt hour while it's available. As a matter of fact, it'll be zero. Uh, then it'll be a renewable, but that doesn't mean they're the cheapest, because when you get right down to it, that renewable has to be backed up by something, it, it, it, it's not gonna be always available.

[00:41:48] And so you, you have to back it. You have to, you have to look at, um, uh, the extra capacity costs of, of, of having a backup plant as well as the renewable.

[00:42:02] **Nate Hagens:** Yeah. And how do batteries factor into that?

[00:42:05] **Meredith Angwin:** Well, batteries are just another backup type plant. As a matter of fact. Let me, let me give you an example, which is so simplistic.

[00:42:15] Okay. I've got a wind turbine. It's available 30% of the time, and I want it to be backed up by batteries. And I only have wind turbines to back it up. I'm just saying, saying that I'm, I, I'm not gonna back it up with a natural gas plant or something. Okay? So I'm, I'm gonna, I, it's gotta be backed up by batteries.

[00:42:35] So I have this one wind turbine and 30% of the time it's making plenty of, plenty of power. Okay? Let's say I need to have that 30% the rest of the time and I, let's not get into when is the wind blowing, when it isn't. I'm just gonna say that you have to build another wind turbine, another two wind turbines, which will.

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[00:43:00] Charge the battery for the, in the time that the main wind turbine isn't there. So you've got three wind turbines in a row. One of them's putting power on the grid. Two are putting power into the battery, and then you've got the battery.

[00:43:14] **Nate Hagens:** So there's a, there's a huge distinction, uh, in my work over the last 20 years, uh, an understanding of there's a difference between something being technologically viable and affordable and scalable at the level society needs.

[00:43:32] And I think this is one of those examples.

[00:43:34] **Meredith Angwin:** It is. It definitely is.

[00:43:36] **Nate Hagens:** So, so why is the fuel makeup that we're currently steering towards with solar, wind, batteries, coal, natural gas, kind of all the above, but dominantly natural gas and renewables, why, why is this dangerous for grid reliability going forward?

[00:43:54] **Meredith Angwin:** Well, I call it the fatal trifecta because basically, no, I do, I, I made up this thing and I've got a a t-shirt I'm not wearing. It's, it's

[00:44:02] **Nate Hagens:** catchy. It's catchy.

[00:44:04] **Meredith Angwin:** I it, I've got a t-shirt. I'm not wearing it, but it's, the fatal trifecta is renewables natural, but gas put in a line to your neighbors. Those are the three things.

[00:44:15] And so you put in a lot of renewables, but they're not always available. So you put in natural gas. Well, natural gas comes through pipelines and they have only a certain capacity. So you can't actually, uh, it, let's say you had 50% of your grid, it was renewables. Then you'd have to have an extra 50%, uh, pipeline

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capacity because uh, you gotta have that natural gas for when the renewables aren't there.

[00:44:42] Okay. So you say, look, that's not reasonable. We'll just get from the neighbors. Well, the neighbors are having the same weather you are having. So the third link of the fatal trifectant, and I see it all the time, we need more interties. Uh, yeah. Uh, and, and, and exactly. How long are these interties you realize that a weather system can cover.

[00:45:08] More than half the country. So if, if, if you're intering to somebody else's, uh, renewables or to somebody else's natural gas and their renewables aren't available,

[00:45:21] **Nate Hagens:** there's, there's an auto correlation risk. Yes. So, um, lemme, lemme ask you some specific, uh, grid related, uh, questions like, when coal is burned or natural gas is burned, or, uh, it spins turbines and generates electrons and they go through transmission lines to a home or a business at, how far can that go?

[00:45:48] Uh, without it, like dissipating, like how close do these grids need to be to the place where the lights are turned on?

[00:45:56] **Meredith Angwin:** Well, it depends. And, and I'm, I'm sorry to put it that way, but it really does depend. You really have, in a way. Two or three, uh, grids

[00:46:07] **Nate Hagens:** by, by by the way, when you say, I don't know. And it depends.

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[00:46:10] It makes me admire and respect you as a person more because a lot of people in our society are not comfortable saying those things. So I actually like it that you say that. Please carry on.

[00:46:20] **Meredith Angwin:** Thank you. Well, I, I just, I'm, I'm too much of a, a scientist to Yeah. Yeah. To just, uh, BS my way through it. Yeah. Keep going.

[00:46:29] Uh, but, okay. This depends on various things. So for example, uh, you can, you can, uh, you can transfer power for hundreds of miles. Okay. For that you generally need to have, uh. Transmission lines, which are a grid. And often you, some of those transmission lines will be DC lines, uh, direct current lines because they have less line loss, uh, uh, over a long distance.

[00:47:02] **Nate Hagens:** What, what's line loss?

[00:47:04] **Meredith Angwin:** Line loss means that the power dissipates, it heats up the lines so that you, you put, uh, you put a power plant here and it, it's putting, uh, uh, 500 megawatts on the line at the other end of the line where you put it in the distribution system. There's only 450 megawatts available.

[00:47:25] **Nate Hagens:** Got it. Got it.

[00:47:26] **Meredith Angwin:** And, uh, so that's line loss. But if you, if you put in high voltage DC lines, you can have less line loss. Um, but you make it up. Unfortunately, at the end of the line, you have to turn that DC into AC again and there's a loss there. Yeah. So it gets to be a very complicated question in there.

[00:47:49] Um. Uh, there's a, a guy on Substack and, and, and on, uh, hi. His, he calls himself Kilo Var. And, uh, and he is, he is a specialist in this. And if you look at his posts, you can see how much planning and stuff has to be done to get this to work.

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[00:48:12] **Nate Hagens:** So with the current, uh, existing grid and, uh, the physical grid and policy grid, uh, as far as the tea leaves that you can see with renewables and natural gas, how does, what's happening, uh, the change in reliability and the system level costs and all the things you've been talking about, how will that impact the average person living in the United States in coming decades?

[00:48:39] Uh, who expects to use their electricity normally, uh, as a, a baseline expectation?

[00:48:45] **Meredith Angwin:** It can be very difficult. And one of the things as I was thinking about, you know, California didn't build power plants, uh, closed down reliable power plants, uh, was very proud of how much renewables they had and so forth.

[00:49:03] And the net result is that in California there are things called flex alerts, and that means that they aren't going to be able to provide, please don't use power. Now. Uh, there, it's, it's, it's difficult and dangerous for us to send it to you. Uh, the, the lines are, haven't been well maintained and they cause fires.

[00:49:28] Uh, the plants, uh, are stressed out, uh, and so forth. And, um. These flex alerts are coming, uh, in the evening. They're coming, uh, from four to nine at night. In other words, so one of my friends in California wrote me this, uh, sort of angry e email, but she wasn't angry at me, but she said, I don't want people to judge me.

[00:49:54] I work, I come home and I make dinner for my kids. I don't have a lot of choices about when I do this. And so I'm not buying into these flexible alerts. I turn on the stove or I turn on the, uh, uh, AC when I come home. That's it.

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[00:50:14] **Nate Hagens:** So, um, recently I had someone on the podcast, uh, French energy expert John Mark Kochi, and he had a very clever framing about the energy risks, uh, coming ahead, uh, that we can solve them, uh, in three ways.

[00:50:29] One is technology. Which will continue apace. The other is what he referred to as sobriety, which is choosing to use less because I want to walk or take a bike instead of drive a car or all, all sorts of things. And the third is poverty, which is we're gonna have to use less because it's gonna be not available or we're gonna be forced to, uh, or you know, policy or lack of availability.

[00:50:57] And I think that rhymes with what you're saying about our grid situation. There may be some tech fixes, but there also may have to be, we have to choose to use less and a lot of us aren't gonna do that. And so the electricity, poverty, the third choice is going to be brownouts and blackouts at some point in some locations, increasingly more locations in our country.

[00:51:21] What are your thoughts on that?

[00:51:22] **Meredith Angwin:** I think it's very likely and very sad. And I also wanna say that, um, you know, a lot of things that we consider, um, you know, well sort of luxurious. Okay, so let's say, let's say a car is luxurious. You should have a bicycle. Well, I remember when, uh, Stephen Chu was the Secretary of Energy and he was famous for going around on his bicycle.

[00:51:56] And someone interviewed me and, and him and said, does everybody in your family have a bicycle? And he said, no, my, my wife has a car. 'cause she has to drop off the kids and pick up the groceries and, well, gosh. So who's the, who's the noble person in this family? I just wonder if you have a good answer for that one.

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[00:52:16] **Nate Hagens:** I don't think nobility is going to be the issue. Um, uh, with all the purity contests and everything, I, I think we have come to massively depend on these invisible energy services. And in the process we've become addicted to, literally addicted to all the things that they provide. Social media and Facebook and comfort controls and just in time, uh, yummy things that are transported and, uh, kept cold.

[00:52:48] And I, I think people are going to want, uh, energy reliability at a cheap price. Um, many of us, most of us, and the, the, the noble, uh, simplify first and beat the rush crowd will be a minority. So I, I am, I mean, there is the. There is the oil depletion story, uh, which is liquid fuels and, um, you know, peak oil and things like that.

[00:53:17] But there's also an electricity availability problem, which is going to be made worse, and we haven't talked about this with the data centers and, and huge hunger for, uh, electricity from artificial intelligence. So I, I actually do think that in the next decade there will be variously, um, either people doing without temporarily, uh, or for longer periods of time.

[00:53:46] And I, I don't know what to do about this. So, so based on what we've discussed here, how fragile is the US electricity grid, really? And are there certain regions of the country that are more fragile than others?

[00:53:58] **Meredith Angwin:** Okay. I would say that, uh, the northwest, northeast is, is fragile because we don't have very many power plants.

[00:54:06] We don't have a lot of sunshine. We, we basically, uh, we we're importing from Canada, but um, if you read my substack recently, I'm discovering that the northern countries have traditionally had a lot of electricity and exported it, but they're getting a little cranky about that. Uh, you know, because exporting the electricity raises the cost.

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[00:54:30] And lessens the availability for their own citizens. And a lot of them are thinking, you know, we could not export electricity and we could have the manufacturers come to us and build their plants here and have more employment in a richer country.

[00:54:46] **Nate Hagens:** So in theory, uh, there's huge amounts of hydro in Ontario and Quebec.

[00:54:52] Is there a significant line loss from exporting that over the border, or is it a capacity issue that they want that electricity for their own citizens, et cetera?

[00:55:01] **Meredith Angwin:** I can't truly answer that, but I don't think it's significant line loss because they use DC Interties.

[00:55:08] **Nate Hagens:** Right. Uh, so, uh, okay, so the northeast, uh, where else

[00:55:14] **Meredith Angwin:** the, the northwest has traditionally had cheap and abundant power 'cause of hydro a lot because they're hydro, but they're not building dams anymore and they have already, their powers become too expensive for their traditional, uh, uh, well, they, they did a lot of aluminum smelting, which is very high energy, uh, electricity use.

[00:55:41] And they, they're not competitive then in that anymore, but, you know, uh. And to some extent, the dams in the Northwest, which basically went in as work projects in the depression also, uh, beat Hitler, uh, because we could build airplanes, uh, because we had all this energy to make, uh, to make aluminum, uh, and, and so to some extent.

[00:56:12] They were very important, uh, in the history of the world. Um, but now they're, they're not that, they're not new ones. The population has grown and being able to compete in, in certain areas, like making aluminum gone away,

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which is actually. Very bad for America's sovereignty, uh, I mean for America's competitive position, militarily.

[00:56:46] **Nate Hagens:** So let me, let me ask you this then. Um, there's a lot of recognition that, uh, our current energy and power consumption globally, especially in the global North, is creating unsustainable pollution for the natural world. Um, but you've already highlighted, uh, numerous times the importance of reliability, uh, affordability and access to energy.

[00:57:16] Something's gotta give. And it seems, uh, kind of obvious to me that energy reliability is going to be preferred at a national level, our country and others over, uh, clean energy. Um, what, what are your thoughts on that?

[00:57:36] **Meredith Angwin:** I agree with that. I don't, I don't know if you have interviewed, uh, Robert Brice on this, but one of the things he says is that if you can't get power, you'll take any kind.

[00:57:46] You, if you can't get electricity, you're not gonna spend a lot of time worrying about whether it's clean or not. And, uh, you can just look at, uh, Generac. I mean, what I'm saying is people are buying home generators and those are not particularly, uh, clean. Uh, they're, they're not horribly dirty, but they run on, uh, natural gas and diesel.

[00:58:08] They don't have pollution control set up. So, you know, but if you don't have power in your house, you're gonna run, you're gonna turn your generator on.

[00:58:18] **Nate Hagens:** So you could power your whole house for how long on those generators until you run out of diesel.

[00:58:24] **Meredith Angwin:** Uh. Depends on how big your tank is. Okay,

[00:58:28] **Nate Hagens:** got it. How does this unfold?

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[00:58:31] What are the, given the, the tea leaves of renewables and natural gas and everything, what is the specific mechanics of a grid problem, uh, that you could foresee in, in the next decade? Like, are you familiar with what just happened in Portugal and Spain a few months back? Oh yeah. Oh

[00:58:48] **Meredith Angwin:** yeah.

[00:58:49] **Nate Hagens:** So I, is that what happened there briefly and could that happen here?

[00:58:53] **Meredith Angwin:** Um, the answer was that Portugal and Spain were, uh, very eager to be as close to a hundred percent renewables as they could. And actually renewables have other problems than intermittency. One of the problems is that they don't have, um, they don't have, uh, uh, they can't ride through fault seasonally. Uh, I don't know how to sur I If you had a.

[00:59:19] Uh, power plant. Let's say you have a, uh, a nuclear plant, it has an immense turbine, and that turbine is spinning and it takes a lot to interrupt it. Hmm. So basically the turbine will keep spinning even if there's a fault on the system, if the fault is short duration. Unfortunately, with the, um, the, uh, renewables, if there's a fault on the system, they echo, uh, they echo the, the effect of the spinning turbine with an what's called an inverter, which is actually a kind of a switch that cuts off the power so that it, it mimics, uh.

[00:59:59] Uh, it mimics a wave. Uh, it, it, it, it mimics the, the, the way the power looks on from a, from a turbine. And, um, but the thing is, if you cut it off, it's off. I mean, there's nothing to keep going. There's no big piece of metal, you know, to keep going. So, um, basically we're gonna have to really think about, uh, renewables and backing them up.

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[01:00:31] And it, and as, as a matter of fact, what I think we should do is put in. Nuclear plants for base load and have renewables, plus natural gas only for the other part of the grid. And that way you say, oh, but you're talking about using natural gas, I'm saying? Yeah. Yeah. Right now we're using 60% natural gas on a grid.

[01:00:54] We're using it for base load. Yeah, we don't have to do that. We could use nuclear for baseload. It doesn't make that kind of pollution.

[01:01:00] **Nate Hagens:** Not, not in the present, but maybe in the future if there are, uh, certain trajectories unfold and nuclear plants go critical or something like that, if there's diesel shortages or societal breakdown, it would be the gift that give keeps on giving.

[01:01:15] **Meredith Angwin:** I don't have a, a time to argue with you about that. I would, I would say, uh uh. How many people died because of Three Mile Island? Zero. How many people died because of Fukushima Radiation? Zero. Okay. I'm just wanting to tell you that those are my favorite kind of industrial accidents when nobody dies.

[01:01:39] **Nate Hagens:** Right. No, I'm, I'm agnostic on nuclear. I, I don't think it's, uh, uh, I, well, we should probably have another conversation. Maybe I'll have you back, uh, on a round table on nuclear, because it's horribly, horribly complex, but at least in a narrow boundary sense. I agree with you that nuclear is base load with renewables and natural gas to, to fill in the gaps.

[01:02:04] Um, I mean, I, I agree with that. Um, so what, uh, you know. Ultimately in this grid system that we've been discussing, uh, mostly in the United States, but I, I mean, by the way, how different is the grid system in the United States from most other industrialized countries? Is it very similar?

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[01:02:24] **Meredith Angwin:** It's a very similar, depending on the country.

[01:02:27] For example, uh, France put in a lot of nuclear, uh, and so that was, that was good. Germany closed down all its nuclear. So we're, uh, is France or Germany the more industrialized country? Well, Germany's becoming the less industrialized country

[01:02:42] **Nate Hagens:** perhaps due to that decision. Uh, yes. Yeah, no, it's a, it's a real thing.

[01:02:48] So, so ultimately this grid system we've been discussing, who is responsible if the grid fails? Uh, like what almost happened for you? Uh, um, in, what was it, 2018 or two 19 in Vermont? Who's responsible?

[01:03:06] **Meredith Angwin:** Uh. Nobody's responsible. The RTOs are LLCs, they're for-profit companies or not-for-profit companies. Uh, the local RTO in Vermont is, is a Delaware company.

[01:03:21] So just to show you, uh, where their heart is, it's not with reliability.

[01:03:29] **Nate Hagens:** So, because the natural human tendency when something goes wrong is to look for who to blame. Uh, and it seems like there's this labyrinthine complex, uh, for-profit at different layers system that has worked in a Rube Goldberg machine sort of way to get us to this point.

[01:03:51] But it's, it's not clear, um, what to do going forward. If you were starting from scratch, um, how would you, uh, at least, uh, structurally, uh, cognitively design a grid? That's primary goal was reliability to the people that used it.

[01:04:11] **Meredith Angwin:** I would basically have a, a grid that was, uh, uh, nuclear and, uh, and, and, and, and, and natural gas and, uh, um, some renewables for the load following and peaking.

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[01:04:27] And that would be a, a very reliable grid. One of the things about, uh, about renewables, which I, I, I don't, I don't like, and people get mad at me for saying this, is they have a sort of common mode failure thing. So for example, if, uh, if you say, oh, but nuclear plants go offline, and they're very big. And I'm like, yes, but only one at a time.

[01:04:52] They, they, they have their individual problems and it can go offline. They're, they're things made by humans and nothing made by humans is infallible. But the thing is that, uh, you could look at, uh, sunset as a common known failure for all the solar area panels in the area. They all go off at once. Bye-bye.

[01:05:14] Yeah. So I would say that if you, I was building it from scratch, I would have nuclear plants with, uh, maybe 10%, 20% redundancy in case one of them went on, one or two of them went offline, and I would have, uh, natural gas and, um, and renewables for the rest. But I would also be very sure that the amount of natural gas I was expecting was not the amount that the, the maximum the pipeline could give me.

[01:05:50] Because it probably wouldn't give me that on a very cold day.

[01:05:54] **Nate Hagens:** Let me ask you this. Um, in my book, uh, I wrote that humans don't need base load ultimately because we are base load our human bodies, uh, going around doing our things. We don't really, as human individuals need 24 7 access to, uh, electricity.

[01:06:16] Our infrastructure and our current economic, uh, and social stories tell us that we do. But could you envision a, a, a world in the future, 2050 years from now where there is a portion of society that has full reliable 24 7 access to the important things we need, but then another section of society doesn't have all the base load and the things we've come to take for granted and expect and we

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reorganize society on like the basic important things the industrial need and then everything else.

[01:06:54] What, what are your thoughts on that?

[01:06:55] **Meredith Angwin:** I think that, uh, anybody who was in. Traffic accident and has to be on a or, or any kind of accident and has to be in a, uh, wheelchair, is gonna be screwed. They better be in okay, they, or any kind of accident. Anybody who's, uh, disabled in any way is gonna be really screwed in that situation.

[01:07:17] You're gonna put all the disa, uh, disabled people and, and four year olds on, on, on, on, on road bikes. I, I'm, I'm, I'm gonna say that e everyday life for people in America is as safe and comfortable as it has ever been for anybody in the uni, in the world over history. And if you say, but we don't need all that.

[01:07:43] I say, who do you mean we, huh? Who do you mean we, do you mean old people? Do you mean. Injured people, do you mean people who need to get to the hospital quick?

[01:07:54] **Nate Hagens:** Well, I don't, I don't disagree with you at all. I just, this is a rock and a hard place situation, um, because we're not all gonna be able to have more energy access and more electricity access at an affordable rate for decades and decades to come.

[01:08:14] Uh, there's something we'll have to give. Uh, so I'm, I'm just speculating on what that might have to be. Um, you're, you're suggesting that nuclear might be, uh, at least part of the solution.

[01:08:25] **Meredith Angwin:** Yes, it would be. I mean, there's a lot of, uh, thorium in the world. There's a lot of uranium in the world and a lot of thorium and, and thorium can, uh, you can make, uh, uh, nuclear plants with thorium.

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[01:08:38] I mean, Rickover did it as a test at one point. He ran a nuclear plant on thorium. So, uh, you know, it's not like, oh, we have to figure out how to do it. You know, well, we have to figure out how to do anything. Are there, um,

[01:08:55] **Nate Hagens:** scalable thorium, plants running in the world now? There's one in China, I think. Yes.

[01:09:00] **Meredith Angwin:** Yeah, I think there are. Now, the thing about the scalable thorium plants is that, um, thorium has become confused with molten salts. Now, molten salts are a very important, uh, technique and, and, and so forth, but, uh, you could use thorium. A regular reactor. That's what Rick over did. He didn't have a molten salt reactor.

[01:09:28] So I, I don't, you know, there's so many people working on, on advanced reactors that I'm just gonna say that someone is going to figure out how to use a thorium efficiently. And, and actually I think some people have already figured it out. So,

[01:09:47] **Nate Hagens:** so in an ideal world, how do you think, uh, we as citizens and as a nation, could change our grid governance to support a more resilient and reliable grid with or without nuclear?

[01:09:58] How, how do we change the, the governance of our current, uh, just in time, uh, Rube Goldberg, uh, um, situation?

[01:10:09] **Meredith Angwin:** Some people have said that I want it. Like autocracy or monarchy or whatever. No, I don't. I want accountability. If you had a group that knew it was gonna lose its jobs or be sued, if the grid went down and that group had power to enforce certain kinds of things, like for example, to say, yes, we'll pay you to put in another nuclear plant because we need the reliable backup, you know, you'll be reimbursed for it.

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[01:10:43] Don't worry. Okay. It wouldn't have to do everything. I mean, what I'm trying to say is we, we tend to be like all or nothing, you know, but actually we can set up, um. Mechanisms to, uh, ensure reliability. But we're, we haven't bothered to do it. We've taken reliability for granted.

[01:11:07] **Nate Hagens:** Well, because for the most part it has been reliable for Yes.

[01:11:10] Much of our lives. Yeah. Uh, which is why I invited you on the show because reading the tea leaves it, I mean, how likely are brownouts and blackouts in the coming five to seven years in the US in your opinion?

[01:11:24] **Meredith Angwin:** Well, we'll continue to have distribution level blackouts, uh, brownouts and resource adequacy.

[01:11:31] Back blackouts will become more common. But I don't know how common, how, how can you know? You couldn't, first of all depends on where you're,

[01:11:41] **Nate Hagens:** yeah, yeah, yeah. What about Minnesota and Wisconsin? Just 'cause I lived there, I'm curious.

[01:11:48] **Meredith Angwin:** Oh, Minnesota and Wisconsin are upper miso, and Miso has had a lot of, uh.

[01:11:56] Issues, but I think Miso can get its act together and not have, uh, as serious a problems as, for example, ERCOT keeps having.

[01:12:08] **Nate Hagens:** Why is Ercot having so many problems?

[01:12:10] **Meredith Angwin:** Okay, ERCOT has problems for, uh, three related reasons. The first one is it made a decision way back when to not be fully

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connected to other grids because it didn't want federal, uh, interference with its grid.

[01:12:28] Look, it's 30 million people, so it's, it's a pretty darn good grid on its own, but it, it, it could be, uh, could be, uh, better connected for bad problems. The other thing is that it, it has an energy only grid, so it doesn't pay power plants. To be built and be available. It only pays for when they have energy, when they're supplying energy to the grid.

[01:12:57] So renewables have an inordinate effect on how, uh, other types of power plants end up getting paid.

[01:13:08] **Nate Hagens:** So for, for individuals who are listening to this program and, and feeling, uh, informed and inspired by what you're saying, what, what actions can they take to get involved with their local or or regional grid governance situation?

[01:13:24] **Meredith Angwin:** Well, the first thing I would do is inform yourself and, and, and you can do that, uh, online. Uh, I mean, you can also read my book. Of course you should read my book, but in the meantime, you can look to, at your, uh, utility company and, uh, uh, your distribution utility and, and, uh, and, uh, your, uh, RTO if you have one.

[01:13:48] And you can look at, uh, they have websites which usually show the hourly mix of what. Is on the grid right now. And I think that you shouldn't really begin trying to affect the grid until you've watched those websites for, I don't know how long. I'm not gonna say a year, I'm not gonna say six months, but at least for a couple of weeks so that you have an idea what's actually happening.

[01:14:16] And then you can go to, uh, utility dive, which is free. It's on online, and you can figure out what's happening, what, what's being proposed, well, who's

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against it, who's for it? And pretty soon you will get an idea, you know? Uh, and I think that more people have to have that idea because otherwise you are liable to fall for, like, we can be a hundred percent renewables.

[01:14:43] All it takes is willpower. No.

[01:14:48] **Nate Hagens:** In, in your speaking and uh, where, where you live or your communities, um, how common is it for people to be somewhat fluent in, in these, uh, topics? In my experience, there's very few people that understand what's going on with the, well, electricity and grid.

[01:15:06] **Meredith Angwin:** No, there, no. Very few people understand because they're all, they, everything you read about is the policy grid.

[01:15:13] And the policy grid is often presented in a way like, and we can do this. In other words, not we have done this, but we can do this. And so pretty soon you live in this world of agreements and, and plans. And

[01:15:28] **Nate Hagens:** we live, we live in a world of words. Not electrons.

[01:15:32] **Meredith Angwin:** Yeah. And so that's why I, I encourage you to look at your, your utility or your RTOs uh, data every day about what's actually on your grid.

[01:15:43] And to look at, um, to look at, uh, utility dive about what are the controversies, because those are more about electrons. So I, I find that very few people, uh, know about it more nowadays. But I remember when I began writing, uh, shorting the grid, people were like, Meredith, you wrote a book about nuclear.

[01:16:06] What's with the grid stuff? I mean, that's just sort of standard stuff, you know? And I'm like, no, you have no idea.

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[01:16:15] **Nate Hagens:** Well, hopefully they, they have a little bit more idea after this conversation. What are you, uh, just generally, um, most concerned about in the future? And what are you most hopeful about?

[01:16:29] **Meredith Angwin:** I, I'm most concerned about people acting as if words are actual actions.

[01:16:38] I mean, I really, I really feel that, that, you know, pretty soon you're, you're in, uh, orals, uh, 1984 or, uh, politics in the English language or something. I mean, it, it can be really, really pretty scary.

[01:16:55] **Nate Hagens:** Which is why I had this podcast, by the way, because I agree that humans, uh, respond to words, but we can, we can say a million times more sentences that are, are practical in the real world of electrons, et cetera.

[01:17:10] So we agree on that point. Please continue

[01:17:13] **Meredith Angwin:** as one my friends said. Uh, when all is said and done, there's a lot more said than done.

[01:17:20] **Nate Hagens:** That's true. Yeah. And what are whatcha most hopeful about?

[01:17:24] **Meredith Angwin:** I'm most hopeful about, uh, people who are, um, younger, uh, because, um. When I was, uh, campaigning for, for Vermont Yankee and stuff, uh, one of the people who was with me said, have you noticed the age of the people who are against Vermont Yankee?

[01:17:44] They're, they're like, I've seen the same people at these meetings for the last 30 years. You know? And I think that the younger people are, they're not, they're not growing up with the idea that nuclear's gonna kill them all. That they

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gotta, you know, that, uh, nuclear weaponry is the worst thing that, uh, I mean, it is horrible.

[01:18:05] But what I'm trying to say is that, that they're not haunted by it. Uh, uh, I think they're more realistic than, than they used to be. I, I, I, I, I don't even know how to say this except that there's the. Generation that really hates nuclear and nothing's gonna change them.

[01:18:26] **Nate Hagens:** So in your, uh, 80 years, uh, on this blue-green Earth, I'm sure you've accumulated a vast amount of, of wisdom.

[01:18:35] What, what sort of just advice, uh, in your experience, do you have experience for people, uh, alive during these times with all the, uh, perceived and real crises and challenges that our culture faces?

[01:18:48] **Meredith Angwin:** I think first of all, you should take care of your family. I mean, your family is so important. If we didn't take care of our families, the human race would die out, which is, you know, that some people might like that, but I don't, I don't think that's a good idea.

[01:19:04] And another thing is that if you. You can't deal with the whole thing. I have, I have found that, uh, anti-nuclear people are quite willing to, uh, discuss, uh, uh, you know, what, uh, Russia should do and what China should do and what we should do, and, and, and corrosion problems and everything. And you can't do that.

[01:19:29] You can't learn enough to do that. So I would say find something in the, uh, world of energy that you can really, um, really, uh, uh. Understand. And then, um, you know, just go with it. You know, just put a, a, a Google, um, a Google marker on when that's reported on. Especially look at your FERC or your, your,

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your local utility about when that topic comes up, become, have some area where you can begin to have some expertise.

[01:20:06] And I'm, I, you could say, well, it's just gonna be huge. No, it'd be huge if you were trying to be expert on everything, but if you're just trying to be expert on some issue, you can, you can, you can achieve that and, uh, you know, two, three months in my opinion. Yeah, you could, you can know mu much more than anybody who's likely to talk to you.

[01:20:27] **Nate Hagens:** No, I, I think that's good advice. Couple more questions. Uh, Meredith, just, uh, what do you care most about in the world?

[01:20:36] **Meredith Angwin:** I, I care most about my family. I'm not ashamed of that. Why shouldn't, why I be ashamed? You shouldn't. I mean, I have two kids and four grandkids and, and, uh, I, I've been married for umpteen years as, as a matter of fact, decades.

[01:20:51] And, and I care mostly about, about them and the, and the world they have, especially the grandkids.

[01:20:59] **Nate Hagens:** And what is, uh, alive for you right now in your, uh, quick curious, uh, reach, research, electron, uh, uh, linked mind? What, what are the questions that are most interesting to you right now? I

[01:21:13] **Meredith Angwin:** tend to get very down in the weeds, but one of the things I've been trying to figure out is wind turbines.

[01:21:20] They, they, they turn at whatever speed the wind is going, then they turn that, uh. AC power, which is totally not connected to the grid into, um, DC power. And then they use an inverter, which is a kind of chopper, uh, to turn that into AC power. So it goes ac with no relationship to the grid DC with no

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relationship to the grid AC with relationship to the grid, so you can put it on the grid.

[01:21:52] And then I was writing about this and, um, someone wrote me and said, oh, you know, they're doing, uh, dual, uh, dual converter things with modern, uh, wind turbines. And so I began looking into it and uh, where I was reading it said. No, they tried that and they're not doing that much anymore. But then I don't know if that's true.

[01:22:20] So I would like to really get into, uh, you know, 'cause wind is huge in some areas. It's, it's huge in Texas, it's huge in Iowa. And, you know, if wind turbines can be better adapted to the grid, that would be a great thing. I mean, I'm pro renewable, but I'm basically pro electricity.

[01:22:41] **Nate Hagens:** Yeah. Yeah. You're pro reality.

[01:22:44] **Meredith Angwin:** Yeah.

[01:22:44] **Nate Hagens:** Uh, yeah. So this has been very informative for me and I'm sure for, for viewers. Um, thank you for your continued curiosity and diligence on, on the topic of electricity. Uh, do you have any closing comments for people watching listening who understand and, and agree with what you've laid out here today?

[01:23:03] **Meredith Angwin:** I am grateful for what a good life I've led compared to the life that my grandparents led. And I just wanna say that we should not be ashamed of defending that life. We're, we're not trying to hurt people. We're trying to give our children the opportunity to live a life with choices. Uh, my grandparents had very few choices.

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[01:23:33] **Nate Hagens:** Thank you very much Meredith, and, uh, great to spend time with you and, uh, look forward to your substack and future, uh, insights and scholarship.

[01:23:43] **Meredith Angwin:** Thank you very much. Thank you for inviting me. Nate.

[01:23:46] **Nate Hagens:** If you enjoyed or learned from this episode of The Great Simplification, please follow us on your favorite podcast platform.

[01:23:54] You can also visit The Great Simplification dot com for references and show notes from today's conversation. And to connect with fellow listeners of this podcast, check out our Discord channel. This show is hosted by me, Nate Hagens, edited by No Troublemakers Media, and produced by Misty Stint, Leslie Balut, Brady Hayan, and Lizzie Ciani.

[01:24:23] I.