



# The Perch Pod Episode 45

## Hydrogen & Future Energy Production

### With Gary Golden

**Jacob Shapiro:**

You're listening to the Perch Pod from Perch Perspectives. Hello listeners, and welcome to another episode of the Perch Pod. As usual, I'm your host. I'm Jacob Shapiro. I'm also the founder and chief strategist of Perch Perspectives, which is a human-centric business and political consulting firm. Rejoining us on the podcast for the second time, one of my favorite guests, Gary Golden is back. If you missed our first episode with Gary about cryptocurrency and ADA and Cardano, go back and listen. It's a very, very good episode. It was episode 30. Gary joined us today, however, not to talk about crypto, but to talk about renewable energy and specifically why he is very bullish on hydrogen.

**Jacob Shapiro:**

A little bit about Gary. He's an academically trained futurist who's been providing insights to clients on industry trends for a long time. If you happen to live in the New York City area and you have kids, you should also check out [IntoTheFuture.nyc](http://IntoTheFuture.nyc), which is one of Gary's cool new projects where he's actually taking some of these insights and helping teach and raise a new generation thinking towards the future, rather than inheriting what we have from the past. It's really awesome, and you should check it out. So thanks, Gary, for making the time. Listeners, hope you enjoyed last week's episode and that you enjoy this one. I feel like we've got some really good content heading in to the end of the year.

**Jacob Shapiro:**

As always, check us out at [PerchPerspectives.com](http://PerchPerspectives.com) if you want to learn about the services that we provide to both investors and to corporate clients. You can also find more information there about our free newsletter or our Latin America geopolitics themed newsletter called [LatamPolitik](#). You can also write to us at [info@PerchPerspectives.com](mailto:info@PerchPerspectives.com) if you want to chat or tell us how you enjoyed the podcast or have topics you want to suggest. Last but not least, we recorded this on Tuesday, November 30th on a beautiful morning here in New Orleans. This will come out in about two weeks. Okay, enough of me talking. Let's get to Gary. Cheers, y'all. All right, Gary. Welcome back to the show. It's nice to see you, man.

**Gary Golden:**

Good to see you. Thanks for having me.



**Jacob Shapiro:**

The audience can't see you, but I can see you, and that's all that really counts. Look, so we talked about crypto last time. Now we're going to talk about energy and renewables and all sorts of fun things. And I wanted to start with a sort of higher level question or thought or feeling and sort of sit on the couch and have you respond to it. I'm always equal parts sort of depressed and amazed when I start thinking about renewable energy. And I'm amazed because the level of technological change that is happening is absolutely incredible. I mean, the things that people are doing and what the world could like in 20 years, it seems like the kind of world I would love to live in and have my children live in, et cetera.

**Jacob Shapiro:**

But then when you actually dig into the nitty-gritty of where we are on progress, getting there, it's really bad. Just a couple stats from the IEA to give listeners a flavor. If we're going to hit 2050 net zero targets, we need to basically install the world's largest solar park every day from now to 2050, which doesn't seem like that's going to happen. We need to increase nuclear power production by 80%. Even with all the investments in hydrogen, today we're talking about 90 gigawatts by 2050. IEA says we need 850 gigawatts by 2050. So I find myself depressed and amazed at the same time. Which should I be? Are you depressed? Are you amazed? Is it both? Help me work through that emotion.

**Gary Golden:**

I would say I'm both. I have a much more long-term perspective on everything. It's not even the 2050 targets. It really is end of century for me when I think about where we need to be versus want to be, and a realistic expectation of how long it's going to take to get there as we not only shift energy technologies, but global energy relationships and power structures. It's not simply just replacing an energy technology or input. It's really thinking about the new order of energy geopolitics. So for me, if I couple those things together and embrace the long game, it's generally positive for me. We're in a much better place now than I think we were in 2015 and 2010. And also, quite frankly, I don't think we are going to meet the GHG reduction targets. We're not. So we may have to have more serious conversations about adaptation and other mitigation strategies, because I don't think we will reach those targets by mid-century. I think it's an end of the century play.

**Jacob Shapiro:**

Are we going to be around by the end of the century if we keep up...?

**Gary Golden:**

Yeah, I think so. What will happen in the future in terms of the physical world, in terms of ocean temperatures, and acidification, and the thermohaline cycle that keeps Europe warm, all that, we just cannot know what is going to happen with these large scale systems. I really just kind of hope for the best in terms of the worst of the climate change predictions. I don't think that the rising ocean flooding scenario is the worst of it. I think it's the arid central farming areas. It's the shift of the rain patterns for me that's the worst case scenario. I don't know. I'm not overly optimistic that we will reach the targets, so I am always entertaining conversations about what will we do if we don't.



**Jacob Shapiro:**

Yeah. I mean, the targets seem completely aspirational at this point. Maybe they're trying to drive political or economic investment and things like that, but when you actually look at the numbers, I mean, unless something really crazy happens here, they don't look like realistic targets to me at all. But let's not dwell too much on that. Let's try and dive into some of the interesting stuff.

**Gary Golden:**

Yeah.

**Jacob Shapiro:**

One of the questions I wanted to ask you, I wanted to ask you to give an overview of where you think renewables are today and where you see them 10 years from now. Maybe that's not the right question because you're thinking about a 100 year time scale, so why don't you just sort of give us a picture of where we're at today, and pick a timeline that helps us think about where we're going to be at least in the lifetime of the listeners?

**Gary Golden:**

Sure. Well, I mean, a 10-year horizon is great for a conversation. So where are we with renewables? The policies that guide market transitions have worked, and that we have seen a massive reduction in the costs of things like solar and wind, to the level where I think virtually, the overwhelming majority of new capacity coming online is from solar and wind in certain regions of the world. So it's kind of like check the box where we did it. The policy worked and enabled these economies of scale. And what we're starting to see particular with solar is more investments outside of China. So what's been revealed over the last 10 years is, yes, solar is working, but it's fully dependent on basically a single source provider. So we're starting to see India and even European countries start to say, "All right, let's start to onshore some of this supply chain."

**Gary Golden:**

So that's positive. And all of the costs have been reduced to allow them to do that. Within the wind industry, we're starting to see movement towards offshore. So really, the least politically troubling wind projects are offshore. They're deep ocean with a steady wind, and there's always some environmental impact, but it's not as bad as the onshore land-based systems. So both of those are just running full steam ahead. And what I expect to happen in the next decade is a new lens on how do we grow renewables, where it is not simply solar and wind to decarbonize the power grid, using direct feed into the power grid or battery to help balance the variability and the load, into a decade where solar and wind are going to be converted directly into hydrogen, and we're going to begin to decarbonize sectors beyond the power grid.

**Gary Golden:**



So this notion of renewables into grid battery versus renewables into hydrogen is the big mental shift of the next decade. And my thesis, and the listeners don't know, but you do, I am 100% bullish on hydrogen. Was wrong about it for 20 years, or early about it for 20 years, and I'm no longer early. It's booming. It's the number one story. But there's a mental shift that has to be required. People have to realize, I don't need to have solar and wind to just generate electricity. I don't need that solution to get me to the finish line. I can convert that energy into clean molecules and do a lot more with those sources.

**Jacob Shapiro:**

Yeah. Okay. Well, there's a lot to unpack.

**Gary Golden:**

Yeah. And we don't have to go directly into the hydrogen. We can unpack the China story as well.

**Jacob Shapiro:**

Oh, screw that. I want to go straight to the hydrogen.

**Gary Golden:**

Oh, okay.

**Jacob Shapiro:**

But before we get there, just one thing before we get there. Because I mean, so you talked about wind and solar, and they've done really well, but even in the US, the mix of sources where we get energy from, we're talking... I think the latest EIA estimates were 8% from wind, 2% from solar. It's still 20% from coal, so there's a lot of opportunity cost there. But before we dive into... Because I feel like hydrogen and fossil fuels, all that's in the same family.

**Jacob Shapiro:**

I did want to just pick your brain for a second about nuclear and where you think it comes in with renewables, because I was surprised to read lately that most of the nuclear plants in Europe and the United States are like 30 years old. They're past their life expectancy. We haven't been building any, in part because there was this mental shift that nuclear was unsafe. Most of the new nuclear plants are going up in places like India, like China, which is fooling around with thorium, which sounds like a really cool technology as well. So where is nuclear on your dart board? Is it there? Are you not as excited about it?

**Gary Golden:**

Well, the full disclosure is, my father worked at a utility. He was a welder at a nuclear power plant, so I grew up where the nuclear power plant put food on the table. I've always had a overall net positive view of nuclear energy. I've always been sympathetic to the pro-nuclear side of the energy decarbonization



story. And at the same time, I find the case for nuclear to be stalled and no sign of any hope on the horizon, outside of the occasional Bill Gates to invest in a small modular reactor. I think the UK is putting in a bunch of money for a small nuclear... Yeah, small, modular nuclear reactors should have a future, but I don't see the stakeholder push or the policy regulatory guardrails in place for it to thrive. I wish it would, but I just don't see evidence of it.

**Jacob Shapiro:**

Well, this is probably more of a psychological question, but why is that?

**Gary Golden:**

It may be a hesitancy for influencers of policy within the energy world to step into what is largely a myth, an unfortunately framed, nuclear is unsafe reality. It may just be kind of a third rail type category. It is safe. It is clean. It does scale. Many countries can do it. Many countries can do it safely, and it should be a globally coordinated effort. Why not? It may just be because of perception.

**Jacob Shapiro:**

Yep. Well, that's depressing.

**Gary Golden:**

It's sad. It's very depressing. It's very depressing.

**Jacob Shapiro:**

I want to be slightly cynical and ask, is part of the reason that a lot of these, especially these companies that are involved in natural gas, see an opportunity with hydrogen that they don't see with nuclear, because they think they can retrofit their pipelines to sort of get on the hydrogen bandwagon, and therefore they're helping push-

**Gary Golden:**

Oh, absolutely. Yeah. Yeah. I mean, there're a molecules business. One of the challenges with the nuclear industry is that it's an island unto itself. Natural gas, oil, you could lean into biofuels, you can lean into hydrogen, you can lean into new things. Nuclear is just kind of, you just do nuclear. I don't do anything else. Again, just to open up this door of what's happening, the nuclear to hydrogen coupling is very compelling to the nuclear industry, because the nuclear industry right now has their hands tied because they need to be a solution that can balance out variable solar and wind renewables, and nuclear doesn't do that particularly well. It's not a peaker plant. It's not up, down, ramp up, ramp down type technology.

**Gary Golden:**

If I have a nuclear power plant that can produce a massive amount of electricity, why not just convert it into hydrogen and deal with a completely different market that doesn't care about, I just run nuclear



power plant full load, full capacity, all the time? So I don't know. I think nuclear is too isolated as a technology. It doesn't have enough couplings and pairings and analogs to really give it the support it needs. But it is a travesty for humanity. If climate change and the worst case scenarios happen, I think in 100 years, we'll look back and just question, what were people thinking in terms of the risk profile?

**Jacob Shapiro:**

Well, yeah. I mean, I can only imagine how the scientists who helped discover nuclear fission would feel today, because they thought they were zeroing in on a universal energy source for human beings, and instead we made a bunch of weapons out of it, and then we sort of left it at that. I imagine they're all rolling over in their graves right now.

**Gary Golden:**

Yeah.

**Jacob Shapiro:**

All right. Well, it's good. A lot of optimism and hope here coming from the early section of the podcast. Let's start to dip into the hydrogen conversation. I feel like the way to get into that conversation, though, is we have to talk about something you've alluded to, which is the difference between electrification and decarbonization. And as you were talking about the mental shift from renewables and batteries to renewable and hydrogen, I think even the emphasis on decarbonization as opposed to electrification is probably a mental jump most people seem to need to make. I think the best example of this is that Elon Musk is the biggest celebrity in the financial world right now because he made electric cars, which doesn't really matter if you make electric cars if you're still generating electricity from fossil fuels all over the country and all over the world. So give us a little bit about the difference between electrification and decarbonization.

**Gary Golden:**

Sure. So these are two policy approaches. First, let's all recognize that for the most part, electricity drives the future. It drives all economic activity. The things that we use, computers, electric motors, it's electricity that powers the world. And there's no doubt that electricity is the future. The question is, what is the appropriate and desirable role of molecules in supporting electricity? So an electrification, electrify everything approach, which I would argue is the dominant narrative in the activist side of energy policy, basically says, "Electrify everything. Electrify heat, electrify transportation, electrify the power grid. Get rid of molecules. Scale up the batteries. It's just circuits and electricity the whole way, all the way up and down."

**Gary Golden:**

And we'll just define it at that. Decarbonization says, "We will try to electrify as much as reasonable and economically viable, and where we can't, we will use clean molecules, which could be hydrogen, ammonia, biofuels, renewable gas." Whatever it is, it's a molecule fuel that has tremendous thermal properties. It's got great storage properties, lots of advantages. And we will decarbonize the economy



without electrifying everything. So we can have clean heat, we can have electric vehicles powered by molecule fuels, we can decarbonize steel manufacturing, we can decarbonize cement, an ammonia, a fertilizer production, not through electrification, but through the use of clean molecules.

**Gary Golden:**

So I am in the camp of decarbonization. I think that electrification of everything is a fantasy wrapped in an illusion. It's not possible. It's not desirable. It would be the slowest, most expensive path to reaching our climate change targets. And some of the smartest people in the world in energy activism will completely disagree with me, but the industry consensus is clearly moving towards decarbonization and a more out-weighted role for clean molecules. Electrification is, I think, peaking as a policy guideline.

**Jacob Shapiro:**

Well, if that person was here to tell you that you were wrong, what would their counterargument be to you that electrification is really the path forward?

**Gary Golden:**

Well, they'll probably have a conspiracy theory piece that electrification is the quickest way to kill the oil companies and the coal companies and the power dynamic. And they make an argument that electrification, it's the most democratized strategy. And there's always that piece, an anti big oil, big coal. They will argue that electricity is more efficient, which it is, but efficiency is not the only metric. You need to have scale. You need interoperability, and then cost. They'll argue that electricity is cheaper. And when they talk about that, they're always talking about a very limited definition of where it is cheaper relative to the real world reality. To use electricity to heat your home in New England is four times as expensive as natural gas. But in California, electric heat, which we don't use a lot, is more viable.

**Jacob Shapiro:**

Yeah. Well, and then I think to muddy the waters even more, so within decarbonization, and if you're a self-appointed decarbonization acolyte, and we can maybe dive into hydrogen right here, not all hydrogen is generated equal. Some hydrogen is generated via fossil fuels, and then some hydrogen is generated via renewables itself. So is there space for both blue and green hydrogen in your decarbonization universe, or when you say that you are supportive of decarbonization, are you really saying, "We need to get to the green hydrogen phase"? It's nice to have blue on the path there, but we're talking about really reconceptualizing how energy works, and we're talking about using things like solar and wind to create hydrogen that will power things, which is I think a fundamental shift, probably.

**Gary Golden:**

Yeah. So I am a yes, and both are necessary. So for the listeners, let's say there's this color spectrum of hydrogen. You've got gray hydrogen, which is, let's say, hydrogen captured from natural gas, and the CO<sub>2</sub> is emitted. There is blue hydrogen, which is hydrogen captured from natural gas, which is methane. It's mostly hydrogen. And we sequester the carbon. So there's CO<sub>2</sub> from emissions and getting the



natural gas, but it's largely greener. And then there's green hydrogen, which comes from CO2 free inputs, nuclear, solar, wind, hydroelectric, geothermal, et cetera. There's really kind of big picture, zero CO2 emitted in green hydrogen. Clearly, we are going to want green hydrogen as the end game. And every ounce of evidence that we see across the globe shows that the policy frameworks being put in place in Europe, in Asia, in Australia, in South America, are all green hydrogen friendly.

**Gary Golden:**

And the expectation, just like solar and wind, is that you will need policy supports, subsidies to enable green hydrogen production for probably 10 years before it is cost competitive with blue hydrogen. I think we're going to get there in some regions before 2025. I think there will be many regions that have... Basically, it's a dollar, a dollar 50 per kilogram, is what you're looking for by 2025. I think the cost reductions on green hydrogen are going to happen much faster than anyone is anticipating, just like solar declined faster than anyone forecasted. And that the whole debate of blue hydrogen versus green hydrogen will fade away. At the same time, why would we not want to take our natural gas, sequester the carbon, and use the hydrogen? Why would we want to ignore reality which says that we need to have massive reduction in CO2 output, and natural gas end use is one of those places?

**Gary Golden:**

So I am 100% in support of blue hydrogen, absolutely. And I don't care about the emissions and the flaring. Solve those problems. Solve those problems. Regulate them. Put a bunch of sensors out there. Find the key people that have those rogue emissions. I'm not going to let that argument deflect what is critical in helping the natural gas industry shift entirely into hydrogen within 20 years, which I think is inevitable. It's inevitable that the natural gas sector becomes pure play hydrogen, I would argue within 20 years. There'll be remnants of natural gas infrastructure and markets at 20 years. LNG, all that stuff, they'll kind of begin to fade. There might be some long-term contracts through 2050 from Qatar, like very large producers of LNG, but I think the natural gas industry becomes the hydrogen industry very quickly. So invite them in through blue hydrogen.

**Jacob Shapiro:**

All right. Well, there's two sort of eye-popping or ear-popping things to hear there, which is you're saying that you think that the price of hydrogen is going to go down faster than most people are expecting.

**Gary Golden:**

Oh yeah.

**Jacob Shapiro:**

And I think that's true. I mean, I think it's four to six times more expensive right now to do green hydrogen, and I think the IEA in its projections, it's hoping in 10 to 15 years to bring that down. But you also alluded to the regions where this is feasible, and it seems like Europe is really the one pioneering green hydrogen.



**Gary Golden:**

Yeah.

**Jacob Shapiro:**

I think something like 40% of the capacity for electrolysis that is important to making green hydrogen is in Europe right now, and they seem to actually have the policy framework in place for doing this. You've got a new German government that came out really, really strong hydrogen in its most recent platform and is talking about applying that throughout Europe, and wants to get rid of Russia. So do you see Europe as the main place where green hydrogen is going to take off, or do you feel like maybe they're in the lead now, but we're going to see China and the US and some of these other regions overtake them once they get their policy acts together?

**Gary Golden:**

Yeah. Again, it's a yes and. We've got Australia, Chile, Brazil. What happens if America really puts its weight behind it? So the way to conceptualize hydrogen is as the emerging global energy commodity. That position is still held by oil. It is the global energy commodity. Some variations of what it is and what you got to do with it based on where it was sourced, but for the most part, you buy oil from different places. Natural gas has that dynamic. Hydrogen is a global energy commodity. It will be produced in regions that have large capacity for renewable solar and wind directly into hydrogen. No grid costs directly into hydrogen.

**Gary Golden:**

You'll see it in hydroelectric places like Quebec. You'll see it in river systems in Brazil. You are going to see people exporting hydrogen and buying hydrogen for domestic use as a global energy commodity. So that's the big story. Not who's going to be producing it the most, but who's going to be trading it? So let's unpack this. Europe is absolutely the leader in terms of policy and targets, mostly led by Germany, the Netherlands, UK, France, Poland. Is Poland in the EU?

**Jacob Shapiro:**

Yes, Poland's in the EU.

**Gary Golden:**

Yeah.

**Jacob Shapiro:**

For now. They're flirting.

**Gary Golden:**

You heard it here. Breaking news. And they want to tap offshore wind. They look to the North Sea and they're like, "Well, look, we've been producing North Sea wind, pulling that into the grid for years, and



we can't balance it. We're taking that energy and we're looping it through Poland because we can't deal with it on our grid. We're going to convert that electrical energy of the North Sea into hydrogen, and we're going to ship that energy all across Germany and Poland and et cetera." Scotland, offshore wind into hydrogen. Ireland, offshore wind into hydrogen. France, nuclear into hydrogen. Everyone has their own solution. And despite all of that intended production, gigawatts of electrolyzer capacity, gigawatts, they are importing hydrogen in the future.

**Gary Golden:**

Germany, last spring, put out this grand call to the world saying, "We will buy your green energy." And Quebec said, "We'll sell it to you. We've got a lot of hydro capacity." And Brazil said, "We'll sell it to you." And just last week, Snam, the Italian natural gas provider, announced plans to build a hydrogen pipeline from North Africa. Mauritania has a \$10 billion solar wind to hydrogen project, West Africa, that will sell Europe. Namibia's total GDP is \$9 billion a year. Namibia has a \$10 billion green hydrogen, solar to wind plant that they're going to be building to sell to Europe. So it is literally exploding. And I feel like I'm the TV salesperson who's like, "I've got more."

**Gary Golden:**

Australia and Chile are the number one and number two lithium reserve nations on Earth. Chile and Australia have the top two supplies of lithium. If you go online, the only news you hear coming out of Australia and Chile is green hydrogen exports. Why is that? Why is that? If I have lithium and I sell it to you, it's gone. I no longer have it. I've got to get more out. If I have solar and wind capacity and I sell you green hydrogen, I just keep selling it to you. It's not mineral extraction. Chile has, I think, \$13 billion in tender for projects for the Atacama desert, and Australia is going to be putting in, I would argue, tens of billions of dollars to become the green hydrogen export for Asia.

**Gary Golden:**

The Elon Musk of Australia is the chairman of Fortescue, which is a big, old iron ore company, and he is basically the global champion right now for green hydrogen, and Fortescue wants to become the biggest player in green hydrogen. And they're doing it in Australia. They're partnering with Brazil. It's game on. And anyone that denies the future of hydrogen because of its inefficiency or energy loss you get in converting to hydrogen, they're just not seeing reality. Because the reality is, the embedded hydrocarbon players of the world, including the Middle East, are all sending clear signals that hydrogen is their foundation for the future. Oman, Saudi Arabia, the UAE, they're all making billions of dollars in investments in hydrogen. And we're just at the beginning

**Jacob Shapiro:**

And Russia as well. I feel like geopolitically-

**Gary Golden:**

And Russia.



**Jacob Shapiro:**

... everybody's talking about Nord Stream, too. The bigger story is that Russian energy ministers are saying, "We're going hydrogen in the next 10 to 15 years. We'll see you later on the natural gas stuff."

**Gary Golden:**

Yeah. Why? It is because hydrogen is a molecule fuel. I can use it to power an electric car. I can use it to power a steel factory. I can use it to create ammonia, which I can use for fertilizer. I can use the ammonia as an LNG competitor for long distance storage and shipping. I can decarbonize aviation. I can decarbonize rail. I can decarbonize marine shipping. Electricity cannot do these things. It just can't.

**Jacob Shapiro:**

Yeah. It's funny. The Italian project you were mentioning, I read the quotes from one of the officials there, or maybe it was a politician. I forget who it was, but they were comparing it to Roman streets, like, "Once we build this thing that connects us to the Sahara, we will be like the new Rome." I love the Italian penchant for exaggeration. There's also that recent story about Chile building a massive submarine cable to China to export solar energy there, so I think that's exactly to your point.

**Jacob Shapiro:**

But I think the real, and you sort of alluded to it when you brought in lithium, but the real dagger that you're pointing at the heart of a lot of geopolitical armchair analysis that's out there right now is one of the big concerns is, well, what about, where are we going to get our cobalt, and where are we going to get our lithium, and where are we going to get our nickel, and where are we going to get our rare earth elements? And all these supply chains need to change because batteries of the future, and if we don't have these elements, then we're kind of screwed.

**Jacob Shapiro:**

So I guess the technical question would be, what does the supply chain look like for hydrogen? Is it simpler? Do you need some of these input elements? Are there sort of hidden costs or hidden materials in the hydrogen industry that make it less attractive there? Or is it really, no, if we're getting away from batteries, we don't have to go from fossil fuels to mining all this other stuff, which has its own consequences. We really can't just focus on stuff that's more readily available.

**Gary Golden:**

So kind of the mineral supply chain of hydrogen, broadly speaking, is significantly better, but not perfect. It is more democratized, and it is more diverse in terms of what you need to get what you want to get done. So hydrogen itself, if we're going with the green hydrogen story here, it is produced with electrolyzers, which are basically metal plates that are coated with a spray that contain a small amount of precious metals. And those precious metals eventually will go away, and they'll be non-precious metal substitutes. But they pale in comparison to the supply chain risk and procurement dynamics of lithium. There is some minerals in it, but it's much smaller. The risks of hydrogen are largely dependent on where



you're getting the solar panels from or the wind turbines from. So you're still dependent on China in kind of a baseline scenario.

**Gary Golden:**

In terms of hydrogen storage itself, it's just as a gas or as a liquid, it's in metal containers. No issues there from a supply chain perspective. And then the pipelines to deliver it to EV gas stations or homes or industrial centers, or just pipes, just metal. So it does have some energy trade-offs. It does have a mineral requirement profile, but it is orders of magnitude better and less risky than lithium. I mean, it's not even close. If you're Quebec, you don't care about the price of solar panels in China because you're producing your hydrogen via hydroelectric. If you're Iceland, you're using geothermal. So even if we took out the whole hydrogen solar value chain, others would sprout up, because hydrogen is a universal energy carrier. But it's not perfect. It's not perfect. I mean, lithium is just such a nightmare, such a nightmare, from a mineral supply chain perspective.

**Jacob Shapiro:**

Well, it's not as bad as cobalt. I feel like cobalt is-

**Gary Golden:**

Yeah, yeah.

**Jacob Shapiro:**

... really the worst of it. That's some heart of darkness shit right there. Lithium, at least you've got, Australia relatively reliable, Canada has some reserves. The Lithium Triangle in South America, that's more accessible than going into the heart of Africa where children are mining cobalt out of the land.

**Gary Golden:**

The argument's going to be, we'll have cobalt substitutes, et cetera. A battery saves the day scenario I think is just naive in terms of, it narrows humanity's choices of mineral supply chain realities. It doesn't expand it. Hydrogen projects are literally appearing across the planet. And unless you've got the lithium or the cobalt or whatever it is, you're not playing in that game.

**Jacob Shapiro:**

Yeah. All right. Well, let's open up the closing chapter here with... Talk to me about ammonia, because I know ammonia is something else that you're interested in, and I bet most listeners know nothing about it besides what they're going to do with the cleaning products in their house. So start with a high level overview of ammonia.

**Gary Golden:**

Yeah. So ammonia, chemically it's  $\text{NH}_3$ , so it is a nitrogen molecule with three hydrogen. Compare that to methane, which is carbon and then four hydrogen. So by definition, ammonia is carbon-free. It's a



nitrogen molecule. It is a large industry unto itself today, largely because of ammonia used in fertilizer and some chemical processes. And ammonia is also a natural refrigerant, so it is a less terrible coolant used in the refrigerant industry. So it's a large industry, and the breakthrough idea that is being pushed in the hydrogen world is, we know how to transport ammonia. It's not something we want going across, necessarily, land transportation routes, but on the open seas, it's as safe and as dangerous as liquified natural gas. So the model of the future is, I am an ocean-facing country with clean, green hydrogen that needs to get to a market.

**Gary Golden:**

I go maybe a mile or two offshore. I convert that hydrogen into ammonia. I put it onto a ship that looks largely like an LNG ship. I send that to another nation a mile or two offshore, far from harm's way if it blows up or it leaks and there's an ammonia leak. I convert that ammonia into hydrogen and pipeline it into that market. So for folks that followed it, the idea of liquified natural gas, when it first came out, was terrifying. All the like, "What if this thing comes off the coast and it gets blown up and..." You don't want ammonia to leak. But it's one of these things where the industry does it with LNG, and ammonia can be safe. So ammonia is an ocean shipping-based energy carrier for hydrogen, and it is also potentially the fuel for the marine shipping industry, so the ships could be powered by ammonia. And that's it.

**Jacob Shapiro:**

Well, so talk to me a little... Because before I had you on, I was talking to a buddy of mine in the fertilizer industry as well-

**Gary Golden:**

OH yeah.

**Jacob Shapiro:**

... and picked his brain about that, and he kind of dismissed me. He was like, "Oh, come on. That's not scalable," like you were talking, "10, 15 years down the road," which maybe... I mean, you and I like to think 10, 15 years down the road. But with fertilizer prices surging, it does seem to me that that's actually one of the areas where this could actually also make a big difference as well.

**Gary Golden:**

Absolutely. Well, a couple things are happening. So fertilizer prices are going up. Natural gas prices are going up, which makes green hydrogen more competitive just from a market standpoint. And large companies like Shell and BP and engineering firms and shipping companies, they're looking for the next big thing. So you get a team of people that understands ammonia, and you build a ship and you build a facility. And 10 to 15 years seems about right. I'm perfectly fine with that. I mean, there's no delusion that this stuff is going to be a globally traded commodity anytime soon. But like I said, we have to get beyond 2050 with our solutions. So I think ammonia will be a play. There's also compressed. There's also liquid, cryogenic hydrogen for long distance storage, and there is liquid organic, these LOHCs, which



could come into play. But we need shipping solutions, long distance commodity trading solutions for hydrogen. And I would push most of my poker chips onto ammonia at this point.

**Jacob Shapiro:**

Well, but the other issue, and I mean, correct me if I'm wrong. I'm still getting up to speed on this. But it feels like the other issue with ammonia also, though, is that the process that is used to generate most of it right now for industrial processes is not particularly good from a carbon emission standpoint, that there is new technology that wants to make this renewable and green, but right now it's not in a really good place to scale. Is that right?

**Gary Golden:**

Yeah. Well, and I should have clarified this. The ammonia produced today comes from natural gas. So what we're talking about is green ammonia. So we're talking about, the nitrogen largely comes from ambient air capture, lots of nitrogen there. And then the hydrogen is from electrolyzers. Where are most electrolyzers now sold? They're sold for ammonia production. So it is green ammonia that you're really talking about here. You're not talking about natural gas derived ammonia being shipped. That's a PR nightmare. You're talking about green ammonia.

**Jacob Shapiro:**

Yeah. Okay. That makes more sense to me.

**Gary Golden:**

For the listeners, the larger sector to be researching is what's called power-to-X or power-to-gas. So it's this idea of taking power, electricity, into a molecule. That molecule is almost always hydrogen as your first step through an electrolyzer, but then it can go into a synthetic hydrocarbon. It can go into a synthetic ammonia, a synthetic multi-chain natural gas substitute. So power-to-X is the engineering sector to focus on. That's the highest level.

**Jacob Shapiro:**

All right. Well, I'll get you out of here on this, and this is a two-parter. So if hydrogen doesn't explode the way that you think it is, or if something is going to derail it, what is that going to look like? And then part two of that question is, how do current international political dynamics affect this, especially if we're going towards more protectionism, less globalization? Does that affect how hydrogen's going to evolve either in a positive or a negative way, or do you think that a lot of these processes are simply going to unfold... Maybe they'll unfold at different rates in different regions, but that we're talking about a real global phenomenon here, that international political competition is not going to mess with the fundamental story.

**Gary Golden:**



Yeah. We're, I think, absolutely at the stage of inevitability with hydrogen. I mean, we're about two years in from the very beginning of this conversation, where the people in Germany were like, "Is it okay if we say hydrogen, or are all the environmental activists going to try to cut our throats and say that we're with big oil?" They tiptoed out two years ago. Three. Three. Maybe three years. Now it's just like, "We're going to double our targets for hydrogen. We're going to triple our targets." So it's inevitable, but let's just entertain what could go wrong. It could suffer like nuclear, where we started this conversation, from a skeptical activist, non-scientifically informed, coordinated effort to mischaracterize hydrogen. And it could suffer from that PR campaign.

**Gary Golden:**

From a technology standpoint, well, the policies for green hydrogen could run up against... China could say, "We're not going to produce solar panels anymore." And there could be some sort of derailment of the renewable production that's feeding green hydrogen that keeps the green hydrogen targets from being reached. So you would have to be on the input side of the hydrogen story less than the output. I don't think any of those things are going to happen. I think right now, the largest engineering firms of the world, Siemens, Mitsubishi, ABB. I mentioned Fortescue. Fortescue just hired the CEO from Mitsubishi Power, who was the largest fuel cell hydrogen proponent to lead Fortescue's North American operations.

**Gary Golden:**

The CEO for FFI is the former CEO of Mitsubishi, and who was the number one hydrogen proponent in America? Mitsubishi. It's inevitable. It's not the oil companies, it's the engineering companies that make this happen. And then the dominoes will fall. And again, on my theses within 20 years, all the major hydrocarbon sector companies will be fully hydrogen or clean molecule fuel focused. They'll still have oil coming out of the ground, but it'll be sequestered carbon and converted.

**Jacob Shapiro:**

And will nations be paying for all of this in ADA, or we'll be paying for it in the dollar?

**Gary Golden:**

Cardano will be the largest cryptocurrency platform by 2030.

**Jacob Shapiro:**

I had to get that in there at the end. Gary, that was a lot of food for thought. I hope listeners enjoyed it. You've given me more research to do as well, so thanks so much for taking the time, and we'll talk to you soon, man. Okay?

**Gary Golden:**

Thank you.



**Jacob Shapiro:**

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**Jacob Shapiro:**

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