Nate Hagens (00:00:02):

You are listening to The Great Simplification with Nate Hagens. That's me. On this show, we try to explore and simplify what's happening with energy, the economy, the environment, and our society. Together with scientists, experts, and leaders, this show is about understanding the bird's eye view of how everything fits together, where we go from here and what we can do about it as a society and as individuals.

(00:00:33):

Hydrogen, we hear a lot about it in the news. Is it the fuel of the future or more of a boondoggle or something in between? Joining me today to discuss a wide arc of the pros and cons of hydrogen is chemical engineer and process development expert, Paul Martin. Paul works at Spitfire Research and has had a lot of experience across the chemical process industry working with hydrogen and syngas. Where might hydrogen fit into a lower carbon more sustainable future? Does it have net energy, affordability, scalability aspects to it? Is it really an energy solution or more of an energy problem? This is the first podcast I've had with a hydrogen expert. Let's dive in on this topic with Paul Martin.

(00:01:44):

Hey, Paul. Good to see you.

Paul Martin (00:01:46):

Hi.

Nate Hagens (00:01:47):

Thank you for taking time to be here. I saw you on a Biophysical Economic Institute webinar talking about hydrogen and you know that topic, north, south horizontal, vertical, net, gross, and I thought you'd be a great guest to have on to update us on hydrogen reality.

Paul Martin (00:02:12):

Well, glad to hear that. I have a lot of people accusing me of hating hydrogen, but it would be a very strange choice of career if I hated hydrogen. I've made an awful lot of it and used a lot of it, so I don't hate hydrogen. I just really think it's a bad idea to waste it as a fuel.

Nate Hagens (00:02:30):

Well, we're going to get into that. I don't like to categorize things as like or dislike or hate or love. We're just trying to get a biophysical map of what works, what's our reality and what our paths forward and maybe hydrogen can play a role. So I imagine when you were 12 or 14 years old, you were not a hydrogen expert. What managed to get you from your teenage years to your current role of energy expert? What was the path that got you here?

Paul Martin (00:03:05):

Well, I was very interested in photography, which got me into darkroom work, which got me into chemistry, which got me into chemical engineering, and it was in chemical engineering school at the University of Waterloo that I really got interested in climate change and the transition that we inevitably have to make away from burning fossils as fuels. And hydrogen is a seductive simple-minded first attempt at doing that. It's what do we burn aside from fossils? Well, if we burn hydrogen, we get water. So it's the simple-minded thing to reach for that every chemistry textbook points you in the direction of. And that's how I came to be thinking about it from an energy perspective. But actually when I was doing my master's degree, I was using hydrogen every day. I was working with it and contending with its terrible properties and so on as a chemical and got to know it very well under those circumstances.

(00:04:07):

That's how I got to understand about it. And then I spent three decades working with it, making it and using it for clients and making synthesis gas and which is mixed use of hydrogen with carbon monoxide and so on, and trying to use it for all sorts of purposes. So I got quite familiar with it.

Nate Hagens (00:04:30):

Excellent. So many watchers, listeners of this program probably are reasonably well-versed in hydrogen, its pros and cons. But many probably don't know a lot about it. Maybe we'll just start out with a speed round and I can ask you just some real basic questions, 30-second short answers and then we'll get into an advanced take. So what is hydrogen and what generally do we use it for in our current economies?

Paul Martin (00:05:03):

Sure. Right now, hydrogen is one of the largest commodity chemicals that we use. So it's a chemical and that's all it is. It's just a chemical. It's used in a variety of different things, but the most important ones, they're pretty important to human thriving. So for instance, about a third of the hydrogen that we make in the world we use to make ammonia and ammonia is the basis of the whole nitrogen fertilizers and chemicals industry. And that literally feeds half the humans and their food animals on earth. So it's pretty hard to imagine something more important than that. We don't use it as a fuel, we don't use it as an energy storage medium, we just use it as a chemical.

Nate Hagens (00:05:47):

But ammonia comes from natural gas.

Paul Martin (00:05:50):

Well, ammonia comes from hydrogen and the hydrogen comes from natural gas. And 99% of the hydrogen in the world right now, about 120 million tons of it per year is made from fossils without carbon capture. So the notion that hydrogen's a green thing is maybe a statement of future or wishful thinking, if you will, about what the future might be. It's certainly not a statement of the present. Hydrogen today is a fossil fuel made from fossil fuels without carbon capture.

Nate Hagens (00:06:24):

So other than ammonia, what are a couple, three, four other uses that we use hydrogen for today?

Paul Martin (00:06:32):

So another big use, it's a use that's very popular today, but it's going to go away in the future. About another third of hydrogen is used to sulfur fossils before we burn them. So to get rid of sulfur from things like petroleum and natural gas to desulfurize diesel-

Nate Hagens (00:06:48):

And why do we need to get rid of the sulfur?

Paul Martin (00:06:51):

Well, because if you burn fuels with sulfur in them, they make sulfur dioxide, which turns into acid rain and is also really toxic. So we really need to get rid of that. And so we've got very strict rules about sulfur content and fossil fuels. But of course in the future we won't be burning fossils as fuels because we can't tolerate the CO2 much less the sulfur dioxide that comes out of them when you burn them. So we'll have to transition away from that. So right now about 40 million tons a year of hydrogen is used to refine petroleum and desulfurize it, and in future we'll need about 10 of that. So about three quarters of that will go away. The other 10 will need because we'll keep using petroleum and gas to make chemicals and materials like plastics, and we'll still need to desulfurize those.

Nate Hagens (00:07:37):

And any other major uses of hydrogen?

Paul Martin (00:07:39):

Yeah, it's used to make methanol. It's used to make a bunch of different chemicals that I won't bore the audience with, but it's also used as a coolant in electrical equipment and gas turbines and other things. But by and large, it's used as a chemical for those purposes that are mentioned. Also, about 10% of it is used to reduce iron ore to iron metal by a process that's called DRI or Direct Reduction of Iron. But again, that's done not as pure hydrogen, but as hydrogen mixed with carbon monoxide. That's made from natural gas.

Nate Hagens (00:08:19):

And what percent of our current hydrogen now comes from fossil fuels?

Paul Martin (00:08:24):

99.

Nate Hagens (00:08:26):

And the other 1% comes from?

Paul Martin (00:08:28):

The other 1% is a byproduct of making bleach and sodium hydroxide and chemicals like that by the chlor-alkali process. Actually, that's about 4% of hydrogen production, but only about a third of that is made from green electricity or nuclear electricity, and the other two thirds is made from fossil electricity. So it's not green either.

Nate Hagens (00:08:54):

Okay. So earlier you mentioned in your darkroom and college chemistry that you learned that hydrogen has terrible properties. What did you mean by that?

Paul Martin (00:09:07):

Oh my goodness. Yeah. When you start working with it, it becomes a love hate relationship because it does really cool things from a chemistry perspective, but from a mechanical engineering perspective, it's just really difficult to work with because it's very small. It's a very small molecule. And so it wants to go places that you don't want it to go, like it wants to sneak out of every seal, every flange gasket, every stem seal on a valve, it wants to leak containers. It wants to leak right through the grains of metals and permeate between the grains of the metals. To give you an example, tell you how extreme this stuff is. The company I used to work for designed to build pilot plants for the chemical process industry, those are prototype facilities that are used to test new chemical process ideas that are working in the laboratory and see how they're going to work commercially and to get all the data that you need to do that safely and figure out if it'll make money and the like.

(00:10:16):

And so, one of the things that we did a lot of was hydro treaters and hydro crackers for petroleum. So again, those are the reactions that take out sulfur and other molecules from petroleum before you can use them as fuels or products. And so in those units we'd use hydrogen at high pressure, and we have these devices that measured the level inside containers, inside tanks and so on. And those devices measured the level by measuring pressure with thin diaphragms made out of stainless steel that would flex backward and forward depending on how much pressure was on. Hydrogen would diffuse right through those diaphragms, right through the solid stainless steel and get on the backside and start affecting the measurements.

(00:11:02):

And in order to slow that down, you couldn't really stop it. But to slow it down, we would gold plate the diaphragms. That's how sneaky this stuff is. It moves right through intact metals and that causes all kinds of problems. It can cause materials to get brittle, it can cause them to break sooner than they should. It can cause damage and in plastic materials, it'll just walk right through it. It'll just permeate right through it and lead to the atmosphere.

Nate Hagens (00:11:32):

So there's an economic damage there because if you bought 100 units of hydrogen to use and it's sitting there for a few months and you only have 70 units left because it escaped, that's an economic damage. But is there environmental damage if there would be a large scale use of hydrogen one day and it would be escaping from everywhere?

Paul Martin (00:11:52):

So there's two kinds of scary things about hydrogen leaks. The first one is of course it's very flammable and it has a very wide explosive range, very low ignition energy. So it's very easy to light it off. And wide ranges of different concentrations and mixtures of hydrogen with air are capable of being ignited so much wider range than with methane, for instance. That makes up most of natural gas. But the other thing is it's also quite a powerful greenhouse gas and not in the simple way that CO2 is a greenhouse gas. It's a greenhouse gas by virtue of the fact that it messes with the garbage disposal in the upper atmosphere. So the upper atmosphere has a lot of intense radiation from the sun and it makes a whole bunch of very transient chemical species called free radicals. And hydrogen quenches those free radicals and hence stops the upper atmosphere from destroying things like methane that are powerful greenhouse gases. And as a consequence, it gets assigned a global warming potential just like methane does. And that's a multiple of that of CO2.

(00:13:03):

So on the 20-year time horizon hydrogen's about 11 and a... Sorry. 20-year time horizon, it's about 33 times as warming as CO2. And on the hundred-year time horizon, it's about 11 and a half times as warming as CO2. So if you compare that against methane-

Nate Hagens (00:13:21):

And the reason for that is it because hydrogen is not a greenhouse gas itself, but it interrupts with other processes that help mitigate methane and other greenhouse gases.

Paul Martin (00:13:40):

Correct. It slows down the destruction of powerful greenhouse gases in the upper atmosphere and hence adds to global warming.

Nate Hagens (00:13:48):

Now, is it the reason that very few people are concerned about that, at least in the public press, it's because when we burn hydrogen as a fuel, then that doesn't happen. So this risk that you're talking about in the garbage dump in the stratosphere is only if it escapes when in an unburned state?

Paul Martin (00:14:08):

So yeah, I think part of it is that people are selling the meme of hydrogen rather than its reality. So that they're selling the truth about hydrogen that you can tell with your head nodding yes, and not the truth about hydrogen that you have to tell with your head nodding no. There's a famous Simpsons episode that gives a very excellent explanation of the difference between those two kinds of truth. Anyway, the thing about hydrogen is they'll say, well, when you burn it, you'll only get water. And that's true if you burn it on a catalyst like in a fuel cell. It's not true if you burn it in a fire. So if you just light a hydrogen tube, a jet of hydrogen on fire, you're going to make nitrous oxide... nitrogen oxides the same way that you would make it if you burned anything else in air.

(00:14:56):

It doesn't matter if you burn wood or petroleum or natural gas or hydrogen, if you burn it in air at high temperature, nitrogen in the air reacts with oxygen and makes nitrogen oxides, which are toxic. They cause asthma. They cause acid rain. And one of them that's not produced very much by combustion but is produced to some degree by combustion, nitrous oxide is not particularly toxic, but it's a very persistent greenhouse gas itself. But the thing is, I guess in past people thought that it hydrogen had a global warming potential, but it wasn't very bad. They figured it was about five times that of CO2, but recent researchers indicated that no, in fact it's much worse than that, especially on the short time horizon. So that's recent knowledge.

Nate Hagens (00:15:45):

So I'm going to go all over the place here because I'm actually learning along with our listeners. If we somehow were able to massively scale the hydrogen economy as some of the memes in the news are portraying, would we have to then change some of the IPCC, CO2 forecast because of some of the things you just said? Because I haven't seen that in any of the models or discussion really.

Paul Martin (00:16:16):

Yep, that's absolutely true. If we were to try to replace natural gas with hydrogen, we would have to contend with hydrogen leakage rather than methane leakage. And in fact, if we make the hydrogen from methane, which by the way is what the fossil fuel industry wants to do, we would have to contend with both methane leakage and hydrogen leakage. So in fact, to put it very clearly the problem with hydrogen as a decarbonization strategy is that hydrogen is actually a decarbonization problem. It's a decarbonization problem we have to solve. And feeding humanity and their food animals is one of the things that's on the hook for us if we don't solve that in a decarbonized future. And it's being pitched as a decarbonization solution, whereas it's a decarbonization problem. So that's really worrisome.

Nate Hagens (00:17:13):

So that leads into my follow-up question for the things that we use hydrogen for now, you mentioned ammonia and desulphurization. Is it is hydrogen substitutable or is it critically unique in its functions that it offers humanity?

Paul Martin (00:17:30):

Yep. There's no substitute for hydrogen in making ammonia, and there's no substitute for ammonia in growing food. So there are things we can do and must do, should do to reduce how much ammonia that we produce to make nitrates and other things, urea and the like for use and fertilization. It's important that we do those things because using nitrates and urea and pneumonia, in fertilizing crops, results in making nitrous oxide in the soil, the soil organisms do it. And so there are things we have to do in order to reduce how much nitrogen fertilizer we use. So there's less runoff, there's less nitrous oxide generation and there are fewer other problems associated with it. But there really is no substitution. In 1911 when the Haber Bosch process for making ammonia was invented the following years, the next couple of decades after that saw a doubling in crop yields directly as a result of just the fact that we could now fertilize fields with nitrogen.

(00:18:40):

And we humans are now half the nitrogen cycle on earth. So if you were to look at the nitrogen atoms in the proteins in your own body, half of those came from the Haber Bosch. Okay. That's how important this stuff is. It's so critically important. And people that think we're going to switch to regenerative agriculture and just eliminate the need to make ammonia from nitrogen in the atmosphere are just kidding themselves. It's not practical.

Nate Hagens (00:19:07):

So I'm so glad you're here, Paul, because I've stated what you just said in some papers and in the past, and I never knew who to ask this question. How do we know that that half of the nitrogen in our cells comes directly from the Haber Bosch? How could one prove that?

Paul Martin (00:19:26):

Well, it's in fact measurable. We know we understand the respiration of plants, and I'm not a biologist. I own a farm. My neighbor farms the fields for me because I'm too busy earning a living here in a city. But the reality of the situation is that we know what it's like to try to farm without adding artificial nitrogen. And we know how the soil organisms fix nitrogen and that we can do crop rotations and we can use animal manure. We know all of that stuff. We know all that stuff in the 1890s. We were actually really awesome at so-called regenerative agriculture in the 1890s. And crop yields were hashed that they are now.

(00:20:11):

And as to that statistic of us, we humans being half the nitrogen cycle on earth, again, that's something that you can calculate from a mass balance. And that comes from a professor in western Canada named Vaclav Smil, who honestly, I think is quite a difficult guy. Not necessarily the best influence on the whole decarbonization debate because I think he messes up on a few things. But he does get that one right. And if you want to look up the technical reference for it, you can get it out of Smil's paper.

Nate Hagens (00:20:49):

Well, I know Vaclav and I'm trying to get him on the podcast, but he's too busy writing books.

Paul Martin (00:20:58):

Yeah, he's too busy committing the second sin of thermodynamics as well. And that's the issue Bo I have to pick with Dr. Smil.

Nate Hagens (00:21:04):

I'm going to get to that. I have that up ahead. But on this issue it's a mass balance thing. It's how many calories are we growing from these chemical inputs? But if you took a microscope and looked at the nitrogen in my body, it wouldn't have a chemical signature from methane.

Paul Martin (00:21:24):

Yeah, it's not like CO_2 where you can look at whether the CO_2 is carbon 12, carbon 13 or carbon 14 and figure out whether it's old or new. So you can't really do it that way. It's not like the nitrogens that come from Haber Boche are colored purple or something. But you can do a mass balance, then you can calculate, if you look at the number of calories that are generated in the yield and the nitrogen uptake required per calorie of cereal crop generated, those figures are all understood. They're all knowable. And we know how much ammonia and urea and nitrate use because those are industrial chemicals that are taxed. So we keep record of all those things that are produced and taxed. And as a consequence of that, we have a pretty good estimation of how much nitrogen fertilizer's made and used in the world because we don't tend to use make it and then not use it.

Nate Hagens (00:22:23):

As you're well aware, since we scheduled this interview even, the hydrogen hype in the news is accelerating and our media portrays hydrogen as the fuel of the future, in a similar way to nuclear fusion. What are the current nominal stories told about hydrogen and its future in our economies? Before you criticize them and give pros and cons, what are some of the stories that we're being told about hydrogen now?

Paul Martin (00:22:55):

Oh, sure. The meme of hydrogen is portrayed as the Swiss army knife of decarbonization and energy use and storage, it's super useful for all sorts of purposes, and it's a general purpose tool. You can use it for transport, you can use it for heating, you can use it for comfort heating and industrial heating. You can use it for energy storage. You can use it for energy transport from places that are rich in energy to places that need lots of energy that are poorer in the potential to generate it. So that's the story that's being told. Right? And we are always told that hydrogen's the fuel of the future, and I agree with that. It really is the fuel of the future. Problem is, it's unlikely to ever be the fuel of the present.

Nate Hagens (00:23:44):

So this is a receding horizons question that X, Y, Z fuel-

Paul Martin (00:23:50):

Yeah. It's exactly like nuclear fusion. Nuclear fusion, the way I always put it is that there are a bunch of constants in the universe. There's pie and there's Planck's constant, and the gravitational constant and the number of years into the future that fusion will be a practical source of electricity generation. Those are all constants.

Nate Hagens (00:24:13):

So while the same thing with oil shale and massively scaling algae into biofuel, it's if oil gets to $200 a barrel, then we will be able to do this. And that statement, assumes that everything else will...

Paul Martin (00:24:28):

And then when it's $200 a barrel... Sorry.

Nate Hagens (00:24:31):

All the other inputs will go up too.

Paul Martin (00:24:34):

When it's $200 a barrel, then they'll find it. It'll take $300 a barrel.

Nate Hagens (00:24:38):

Exactly. Exactly.

Paul Martin (00:24:42):

Here's the crux of the matter. We've had this great party burning millions of years worth of stored solar energy in the form of fossils every decade. And that party's gone on for 300 years. And it's resulted in an incredible thriving of humankind and release from abject poverty and slavery for billions of people. But the party's over, and of course people want the party to keep going on any way they can and they reach for anything. And hydrogen's just one of the things they reach for because of course you can make hydrogen from fossils and then capture and partially capture and partially bury the CO2 that comes along with it. And that's sort of better than burning fossils if you do it right. Do you know what I mean? So the trouble of course with all these schemes is that the devil's in the details. And in fact, he's not hiding in the details. He's there waving his pitchfork at you from the details.

Nate Hagens (00:25:48):

This is something that I've been saying for a long time. I liken the transition away from fossil fuels to the tragedy of the energy investing commons, which is eventually, and now with Ukraine, Russia situation, rather suddenly society is realizing that energy is fricking important. And so all of a sudden, we're trying to get things that are energy for lots of reasons, but we're focusing on the output. This process gives us energy. That's good, but we're neglecting the Rube Goldberg mousetrap and all the crazy inputs that have to go into the product and the net energy losses along the way. And I think that's what you meant by the Simpsons feelgood nodding your head meme is we're just looking at the output without looking at all the inputs. What do you think about that?

Paul Martin (00:26:50):

So I mentioned that people are talking about hydrogen as being the Swiss army knife of the energy transition and the applicability of that analogy is ironic. It's just deliciously ironic because if you think about a Swiss army knife, it's handy in a pinch, but if you had the right tool, you would never, ever reach for your Swiss army knife instead, right? It's a terrible can-opener. It's not a particularly good knife. It's a absolute miserable screwdriver. You end up slicing your finger every time you slip off the screw if you ever try to use it.

(00:27:26):

So it's never the tool that you would reach for out of choice. It's something that you reach for out of desperation because you're back in the woods somewhere and camping. And it's better than using a rock. And hydrogen's very much like that in terms of wasting hydrogen as a fuel, using it as a fuel. It's not something that people reach for by choice. It's something they reach for at a desperation or a lack of imagination. And there therein lies the problem when you reach for something because you're desperate, you're not necessarily making the most informed choices. So yeah, my problem with hydrogen is that it's neither energy efficient, nor is it effective as a fuel. And that's for reasons that you can't fix with innovation. So yeah, you can't invent a way to make hydrogen an effective or an efficient fuel.

Nate Hagens (00:28:16):

Hold onto that. I'm going to ask you to unpack that. But first, the final question in the introductory section here, there are a growing list of colorful descriptors of hydrogen. Could you for the audience just quickly run through blue, black, green, gray, pink, et cetera, the different types of hydrogen of what they are?

Paul Martin (00:28:43):

Here's the very simple answer. They are the colors of euphemism because all hydrogen requires a word that we don't have in the English language, which is something that's blacker than black. The way that we make 99% of the hydrogen in the world is we make it by reacting fossils with steam and producing the hydrogen that way and releasing the CO2 to the atmosphere. So if you take a joule of energy-

Nate Hagens (00:29:09):

Add an energy loss as well.

Paul Martin (00:29:11):

Yeah. If you take a joule of energy in the form of hydrogen, it's 1.4 times as emissive in CO2 emissions and methane emissions as the same joule that you would get from just burning the natural gas to begin with. Unless you capture the carbon and store it. And if you make it from coal, it's even worse, it's two to three times as emissive.

Nate Hagens (00:29:33):

So from a climate standpoint, if we didn't care about money or economic growth or net energy, just from a climate standpoint, using hydrogen for a fuel generated from fossil fuels generates 1.4 times the emission impact as burning the original fossil fuel.

Paul Martin (00:29:57):

If you don't capture the CO_2, yes, that's accurate.

Nate Hagens (00:29:58):

If you don't capture it?

Paul Martin (00:29:59):

That's correct.

Nate Hagens (00:30:00):

And how much of accurate of that 99% of hydrogen that goes to ammonia, et cetera, is sequestered today?

Paul Martin (00:30:12):

A tiny fraction of a percent. A tiny fraction of a percent.

Nate Hagens (00:30:16):

So right now, hydrogen in our world economy is actually our use of it is a greater deleterious impact on climate than the fossil fuels used to create it?

Paul Martin (00:30:29):

That's right. And it's a GHG emissions sector that's bigger than aviation. Just making hydrogen right now emits more CO_2 than the aviation industry.

Nate Hagens (00:30:44):

How can the entire climate community not be squawking and talking about this all the time? I didn't know that.

Paul Martin (00:30:52):

Because they're hoping that we're going to make hydrogen from renewable electricity. It's just hope. And in fact, I've been referring to this hope that's been using people's willing suspension of rational thought as their hope, as a way to shut off their rational minds. I've been referring to it as the drug hopium. Now, I didn't come up with the idea of hopium, and people have been talking about hopium since the first time Obama ran for the presidency at least, and maybe before that. But the whole idea here is that people not thinking clearly and rationally about things, let their hope run away with them. And they say, well, we could use vast quantities of electricity to make something that we can burn and then we could use it in place of things that we burn right now. And wow, wouldn't that be a wonderful world to live in? But the devil's in the details and he's hiding.

Nate Hagens (00:31:49):

I wonder if it's hope or fear. Because if given a choice, we either have to use less or we could create a lot more hydrogen if people are going to choose the hydrogen route, even if it's nodding your head sort of naive way.

Paul Martin (00:32:05):

Or we could do it smarter. The wrong way to ask the question is, we can't burn fossils anymore. What else do we burn? Right? Because the answer to that, you can hear Eric Idle from Monty Python saying, "More fossils," in the background it's the wrong way to think about it. We shouldn't be looking at fuel substitution. That's just simple-minded. Instead, what we should be saying is we can't burn fossils to do this thing anymore, move people around, keep our houses warm, et cetera, whatever it is, and heat something up in industry. How else do we do it without making greenhouse gas emissions? That's the question we should be asking.

(00:32:49):

And the answer to that question is almost never make hydrogen from electricity. And making hydrogen from natural gas and burying the CO2, the trouble with that is the worst a job you do of it and get away with it, the more money you make. So back to your original question, which is about the colors of hydrogen. They're all the colors of euphemism, as I mentioned, they try to make this pretty spectrum, but the reality is 99% of hydrogen is blocker than black. And we don't have a word for that. What is that? Black hole black or something. But what they do instead is-

Nate Hagens (00:33:25):

What is black hydrogen?

Paul Martin (00:33:25):

Well, you see, there's the thing in this lexicon of colors, black hydrogen is used to refer to hydrogen that's made from coal, which is about a third of the hydrogen in the world. Okay? And then they call hydrogen that's made from natural gas, they call that gray hydrogen, even though it's 40% more emissive than just burning gas. And hence it's blacker than black, if gas is black-

Nate Hagens (00:33:50):

And is black hydrogen also 40% or worse?

Paul Martin (00:33:56):

No, it's worse than, it's worse still than just burning coal because you're starting with pure carbon and then you have to shift it.

Nate Hagens (00:34:04):

Gray hydrogen is pretty black but not as black hydrogen.

Paul Martin (00:34:07):

That's right. This is the trouble. It's like the Inuit have apparently many different descriptive words for types of snow. And we in English lack them because snow is snow to us. We just don't have words for how black something can be if it's blacker than black. And that's a bit a problem.

Nate Hagens (00:34:28):

Okay. So black hydrogen, gray hydrogen. What is blue hydrogen?

Paul Martin (00:34:34):

So blue hydrogen is like when you put those pucks in your toilet or your urinal, in order to make it look blue and sanitized. It's the notion that you can take gray hydrogen and bury the CO2 and it suddenly becomes blue. So it's making hydrogen from natural gas and capturing and burying some of the CO2. That's what blue hydrogen is. I call it-

Nate Hagens (00:35:04):

So it's gray hydrogen with an extra step?

Paul Martin (00:35:09):

Yeah. I call it bruise colored hydrogen because it's black and blue because of course, in order to do carbon capture and storage, first of all, somebody needs to pay you to do carbon capture and storage because it consumes energy and it requires capital equipment that somebody's got to pay for. And the energy that you use to run the carbon capture equipment is often made by burning fossils without carbon capture. So it results in a bunch of emissions. And then on top of it, you have the methane leakage up front, which gets... Well, first of all, you have, you're taking methane in as a feed to make your hydrogen from, so, part of that leaks, a world average 1.5%. But if you're getting it from Russia, it might be 7% of the methane that's leaking from the well to your plant.

(00:36:00):

And then when you use that energy, which you get from burning natural gas, there's methane leakage associated with that. So by the time you're done with that... there are a couple professors, Howard and Jacobson did a paper in 2022 called 'How green is Blue hydrogen?', and they basically trashed the whole concept because they said, "Look at realistic methane emission rates and using the 20-year time horizon for methane's global warming potential relative to CO2, this whole thing doesn't really even do anything. It generates as much CO2 as if you didn't bother, as much effective CO2 or global warming potential as if you didn't bother, even though you're capturing some of the CO2 and burying it, you're not doing a good enough job of it. And as a consequence, the emissions are increasing per joule or staying the same or only very modestly in the best case, very modestly reduced."

(00:37:01):

So that requires you to do different hydrogen production a different way to get the capture to improve. And that becomes very expensive. And you also have to take methane that comes with very low leakage. So that means you can only get methane from certain parts of the world.

Nate Hagens (00:37:17):

So much of your blacker than black label on hydrogen is from a climate standpoint. Let's, for the moment set climate aside, let's say that's not a constraint. Are any of these hydrogens viable from an economic and net energy standpoint in the future if emissions wasn't an issue or not so much?

Paul Martin (00:37:44):

So if CO2 emissions don't have a cost or we've not worried about them for some reason or another, because I guess we've turned off our brains and ignore the science.

Nate Hagens (00:37:56):

No, I agree. I'm just trying to parse out which of the...

Paul Martin (00:37:59):

Yeah, yeah. But I'm just clarifying. I'm just clarifying for you. If global warming weren't a thing, we would just keep making hydrogen the way we do now because that's the cheapest way. So the numbers are instructive here. In the United States, there's this wholesale price metric for natural gas called the Henry Hub price. It's like the Brent Barrel of crude or West Texas Intermediate or whatever for natural gas. It's called the Henry Hub price. And they measure that per million BTUs, so $3.50 per million BTUs, which is about a gigajoule of energy if for those who want metric. $3.50 per million BTUs or per gigajoule is about what natural gas cost wholesale averaged over the last 10 years before the war and the pandemic.

(00:38:48):

And you could turn $3.50 wholesale gas into $1.50 per kilogram wholesale hydrogen not distributed to customers or anything, just at your plant gate. That's $11 a million BTUs or $11 a gigajoule. So we just multiplied the cost per joule by a factor of three by making hydrogen out of it. So would we want to burn any of that? No, we'd be stupid to burn any of it. It would be much smarter to just burn the gas, wouldn't it? So of course, in a future where decarbonization is not important, if we need hydrogen will make hydrogen, if we don't, we'll just burn gas because gas is cheap.

Nate Hagens (00:39:33):

So the reason that we're making gray and blue hydrogen is for climate reasons, but we're not realizing the wide boundary impacts of the blacker than black hydrogen in its impact on the garbage machinery in the stratosphere, et cetera?

Paul Martin (00:39:52):

So we're making gray hydrogen, that's the way we make hydrogen now, gray and black hydrogen's the way we make it now. And we emit all of that CO2 to the atmosphere, and hence we only use that hydrogen for purposes as a chemical. Now some of those purposes are environmental, like desulfurizing fossils before we burn them, but most of those purposes are just using hydrogen as a chemical. The only reason that you would ever do, quote, unquote, blue hydrogen production capturing the CO2, is if you got paid money for burying CO2, that's the only reason you would ever do it. So that only arises from the climate concern.

Nate Hagens (00:40:32):

Got it. One of the colors are there, green.

Paul Martin (00:40:35):

Then there's green hydrogen. So green of course evokes all kinds of lovely feelings, and that's hydrogen that's made by deliberately electrolyzing water. So breaking water up into hydrogen and oxygen using electricity. And that electricity has to be itself green, it has to be renewable or nuclear or depending on who you talk to. Some people want to call hydrogen made from nuclear electricity pink for some reason or another. But anyway, the notion here is that if you use electricity and the electricity has no greenhouse gas emissions associated with it, or very low greenhouse gas emissions associated with it, and you use that electricity to make hydrogen and oxygen from water, that hydrogen is now considered green. And of course, to the extent that your electricity is green, the hydrogen is green. If you start using grid electricity that's got a bunch of fossils in it very rapidly can emit more CO2 than if you just made it from natural gas the normal way.

Nate Hagens (00:41:39):

And in the large glossy orders of magnitude scale of hydrogen in the future that's currently being promoted, especially in the EU, but also in the us, would that green hydrogen almost always have to be created in a plant or a factory that's near a body of water?

Paul Martin (00:42:07):

Okay. So are you asking about the water use concerns related to hydrogen?

Nate Hagens (00:42:12):

Yeah.

Paul Martin (00:42:12):

Okay. Yeah. Okay. So water use is really not an issue. Making hydrogen today using natural gas or coal takes a lot of water too. Making electricity using natural gas or coal takes a lot of electricity. And in fact, it takes orders of magnitude more water to make the electricity to make a kilogram of hydrogen than it takes to make a kilogram of hydrogen from water. So here's the way to think about it, let's say that I have a project in Western Australia, and it's a dried place, and I need water to make my hydrogen, but I've got lots of solar and wind electricity available to do it, to make a kilogram of hydrogen from nine kilograms of water will take something between 50, very, very best case and 65 kilowatt-hours of electricity. To make the nine kilograms of pure water from the ocean takes 0.035 kilowatt-hours of electricity. So which of these two is-

Nate Hagens (00:43:30):

And is some sort of desal plant?

Paul Martin (00:43:32):

Desal plants, people are confused about water because of course water's essential to life and extremely valuable in that sense. And in another sense is dirt cheap. I buy water, potable water up at the farm for $3.50 per ton for a thousand kilograms.

Nate Hagens (00:43:53):

So energy will be by far, the limiting variable rather than water if we scale hydrogen?

Paul Martin (00:44:01):

Yeah. If you need water and you have energy, the thing to do is don't make a kilogram of hydrogen. Use that energy instead to desalinate water and you'll get 14,000 liters of water in return. So the issue isn't water use, it's energy use.

Nate Hagens (00:44:20):

Got it. Okay. That was super helpful. Now I'd like to ask you some deeper questions on hydrogen and its potential, but before I do that, let me take a step back. Some of the articles and other interviews, and you even mentioned it earlier today, something you call the sins of thermodynamics. Can you briefly break that down and what these are, and why they can create misleading ideas when people think about our energy future?

Paul Martin (00:44:56):

Yeah, I think this is a really important point because Vaclav Smil as an example, is one of these guys who's just jumping up and down and trying to tell us that the transition away from fossils is going to take forever and it'd be next to impossible to accomplish. And the reason that he draws that conclusion, I guess until fairly recently, he's smartened up. But the reason that he draws that conclusion or drew it in past was that he would look, he looked at how many joules of energy we use per person, or how many joules of energy we use on Earth every year, and what fraction of the number of joules of energy that we use comes from fossils and finds out that most of it comes from fossils. And as a consequence, this is a terrible problem. What are we going to do?

(00:45:43):

We have to replace, I don't know, let's pick a number. I don't know what the number is, but 10 units of energy we have to replace, and nine of those come from fossils. Oh boy, we're in trouble. The problem is Dr. Smil's committing the second sin of thermodynamics, the sin against the second law of thermodynamics. And the second law of thermodynamics basically says that not all forms of energy are worth the same. The first law says that energy's conserved. So you can't make it or destroy it. You can only change its form from one form to another. The second law says that there are different kinds of energy that are worth different amounts if you want. A good analogy is money. So we can have an amount of money denominated in dollars, but if I don't tell you whether they're Canadian dollars or Jamaican dollars or US dollars, I haven't really specified the problem.

(00:46:42):

So if I've got a joule of electricity, a joule's worth of electricity or a BTU or a kilowatt-hour, you pick your unit of energy, if I tell you that it's electricity that's telling you enough. But if I just say I have a joule or a kilowatt-hour or a BTU of energy, that's not telling you enough. It's not telling you whether it's work, thermodynamic work like mechanical energy or electricity or it's heat like chemical energy or heat for that matter, a hot slowing liquid or steam or the like. So the people that commit the second sin of thermodynamics fail to realize that in the world of energy, we take these days an awful lot of chemical energy, which is a proxy for heat. So it's the Jamaican dollars of energy, if you will. And then we put it through expensive equipment to convert it into work or mechanical energy in engines and power plants and the like.

(00:47:40):

And that's the American dollars of energy, if you will. And if you just say, "Well, we need so many dollars, or we need so many joules or so many BTUs or so many kilowatt-hours", and we fail to denominate whether they're work or heat or light or whatever, we're going to lead ourselves to wrong conclusions. And so the reality of the situation is these days we burn fossils largely to make heat that we then use to make work, which we use to make things like electricity or to move vehicles. And in the future, we're not going to be starting with heat or chemical energy, we're going to be starting with work or electricity. So guess what? We don't need to convert all that electricity to chemicals or to fuels or to heat. We can use it to do work directly, the exchange rates one to one rather than one to three, which it is for heat to work. Or three to one. You need three units of heat more or less to make a unit of work.

(00:48:46):

So that's the second sin of thermodynamics people messing up heat and work and it leads to wrong conclusions. And in the future, our decarbonization journey is actually going to be about a half to a third as hard as these people imagine, because we'll be starting with electricity.

Nate Hagens (00:49:04):

Okay. I understand that logic because I have long thought that energy properties are important. Spatial distribution, intermittent temporal density, transportability, all these things are an American dollar is not equal to a Jamaican dollar.

Paul Martin (00:49:26):

Correct. That's right. All of those things matter.

Nate Hagens (00:49:31):

But it cuts both ways, right? Because right now only around 20% of the global energy use is electric. And we can change that a lot. And the more that we change it, the more we get that energy benefit that you're just talking about because we don't have to do the three to one loss. But our current over-extended global financial system and six continent supply chain are dependent on this liquid fuel hemoglobin transporting goods around the world, and we can't change that overnight. So what are your thoughts on that?

Paul Martin (00:50:10):

Darn right. Well, first of all, we have to be really careful because whatever it was, 50,000 years ago or so, we started figuring out how to mess with fire. And ever since then we've had this box on our heads, this intellectual fire box on our heads, which is need heat must burn something. And we got to get that box off our heads in its heart. In a world where you're burning stuff to make heat and then using that heat to make electricity, using electricity to make heat is dumb, right?

Nate Hagens (00:50:42):

Right.

Paul Martin (00:50:43):

And in a world when you're starting with electricity, using electricity to just grind it up into heat is dumb, right? Now, there are places, there are times when it actually does make sense and it's necessary and we'll do it without any hesitation in the future, but there are applications where it's just not smart.

(00:51:03):

So let's say I need comfort heat to keep my home warm because it's cold outside and we're in Toronto here and lots of snow on the ground at the moment, and I've got electricity, bunging it into a resistor, baseboard heater or whatever to make heat would be nuts. Now people do it, but it's not the best idea. The thing to do instead is to use a machine, run a machine with that electricity called a heat pump, and then pump heat from outside into the home and hence get three joules inside the house for every joule worth of electricity we use. So there's the difference.

Nate Hagens (00:51:45):

Okay, so why don't we do that, where I live here in Northern Wisconsin. By the way, if it starts to get cold, my initial reaction is not to turn up the thermostat, but put on a sweater and a pullover and stuff. That's my initial reaction. But there are, where we have in the office here where I'm doing this podcast, there is electric baseboard heat. Why has culture gone that direction instead of heat pumps? And could we have a mass adoption of heat pumps? A little bit tangential, but not really.

Paul Martin (00:52:17):

Sure. Now this is really important, and the answer to that is, it depends where. So Wisconsin, Minnesota, Alberta, Saskatchewan, those are places that it gets quite cold in the winter, much colder than it gets here in Toronto as an example. So heat pumps become harder and part of the year you end up having to basically grind up electricity to make heat the old-fashioned way. So if your alternative is to burn a fuel and to dump the CO_2 to the atmosphere, that's going to be super cheap in comparison. And that's the reality in Toronto right now. I ran the numbers for my house and of course being who I am, I wrote an article about it where I warned everybody at the beginning, "Warning, this is all about numbers and if you don't like numbers, just stop reading before I hurt you." But I ran all the numbers for my house and I looked at what electricity costs me, everything in taxes, debt, retirement charge, all of that crazy stuff.

(00:53:16):

And I worked out, we bought so many kilowatt-hours last year and we paid so many dollars to Toronto Hydro and it cost us this much per average kilowatt-hour. And then I looked at, we burned so many cubic meters of natural gas last year to heat our house, to heat our water and to cook our food, and that cost us so many dollars. So that's so many dollars per equivalent unit of energy per kilowatt-hour. And I compared the two and I went, "Okay, fantastic. If I were to switch over to baseboard heaters from my natural gas boiler that hydraulically heats my house in a very efficient way, but emits a lot of CO2 to the atmosphere, I would drop my CO2 emissions by quite a lot because the grid here in Ontario is mostly nuclear and hydro and as much wind as natural gas," which is about 7% of each and no coal since 2013.

(00:54:11):

So I dropped my CO2 emissions by a lot. But the cost per ton of CO2 emission that I averted would be very high, like hundreds and hundreds of dollars per ton. It would be way smarter for me to buy an electric car, which by the way, I did. But I also built one, I converted one, a gasoline engine car to an electric car in 2014 just to figure out what was going on and make sure that this stuff was actually what it was cracked up to be. Certainly here in Ontario, the lowest hanging fruit of decarbonization is not home heating, buying a heat pump, it's transport, because transport right now uses a hundred percent fossil fuel or 90% fossil fuel and 10% bio ethanol and you can get the benefit of the higher efficiency of the electric drive train charged directly with electricity. And by so doing that car that I converted, same car, identical car, just different drivetrain, I dropped its operational CO2 emissions by 97%.

(00:55:15):

And relative to my Prius, which is the most efficient car you could buy in Ontario without a plug attached to it, I dropped my emissions from my commute by 94%. Okay, so you see the efficiency gain that you get from no longer converting chemical energy into work by using electricity directly. That's a tremendous benefit. And of course with heat pumps, the real benefit is in places where it doesn't get that cold in the winter, like Toronto as an example. We get to minus 25 degrees Celsius only a few days a year. And up to minus 22 degrees Celsius, a heat pump will give you 2.2 joules of heat for every joule of electricity you put into it, which is pretty awesome.

(00:56:01):

But the problem is, even if I were to buy a heat pump and I take that coefficient of performance, that multiplier on how much heat I get in, how much electricity I put in, it's still going to cost me quite a few hundred bucks per ton of CO2 averted. So I'm not reaching out to change my gas furnace into a heat pump anytime soon. Even though in Canada we're going to have $170 a ton carbon tax in 2030, gas is just so cheap, and retail electricity isn't cheap here, and as a consequence, the economics are not particularly good. I might change because I want to make the world better, but as an economic actor, as somebody making decisions about what is best for my pocketbook, that's not the best way to spend my money. Buying an electric car certainly was.

Nate Hagens (00:56:51):

And there's probably many aspects of this conversation that would give you different decisions if you're trying to be a good citizen to the planet versus a consumer. So I would love talk to you about that.

Paul Martin (00:57:04):

But let's be clear, burning hydrogen to heat your house is nuts. That's just not good economics-

Nate Hagens (00:57:08):

Are there people that do that?

Paul Martin (00:57:11):

Well, they're talking about it in the UK in a big way. In fact, I'm co-founder of an organization called the Hydrogen Science Coalition, which is a bunch of it's financially disinterested engineers and scientists and academics who know a lot about hydrogen and its applications but don't have any money tied up in it one way or another. I don't make my living from hydrogen, I don't make my living from batteries or alternatives to hydrogen. I make my living as a technology consultant, and that's what I do. So I can say whatever I like, and if customers don't like it, they can just go find somebody else. And that doesn't bother me.

(00:57:50):

At the point being here that a big thing that the Hydrogen Science Coalition has been doing is trying to help out these residents of a couple communities in the north of England, the town of Whitby and the town of Redcar in particular, who the local gas utility wants to do a hydrogen heating trial on their homes and wants to compel their compliance. It's not like you sign up for this and they'll pipe hydrogen into your house if you want it.

(00:58:19):

No, they want to convert all the gas mains over to a pure hydrogen and rip out all your appliances in your home and replace them with hydrogen appliances and they're doing this-

Nate Hagens (00:58:31):

The initial response that an intelligent person would have to that statement is, well, those people have to be smart people, and so there's something that you're missing. So what is their angle? Why do they want to do that?

Paul Martin (00:58:49):

Well, they're a gas utility in a decarbonized future, unless they can sell something else in their pipes, they're out of business. So yeah, they're smart people. They understand that their days are numbered. They have to sell hydrogen. It's existentially important to them. And by the way, the kind of hydrogen they want to sell is blue made from fossils with carbon capture, not green. Green hydrogen is just being used as the bait because if you've got electricity and your choices are make it into hydrogen and then put it in the piping system and burn it in your house, or instead feed it to a heat pump, the difference in electricity use between those two chains is a factor of five to six in favor of using the heat pump. So if you've got to pay for electricity and electricity's not cheap guarantee, you're going to want to buy the device that uses one fifth to one sixth as much rather than just using the gas pipes and having to buy a new boiler anyway because the old boiler can't run a hydrogen anyway.

Nate Hagens (00:59:52):

So the economic and the climate decision for those communities in England would be heat pumps instead of new infrastructure to burn hydrogen in their homes?

Paul Martin (01:00:02):

Absolutely. Because winter temperature in the UK isn't cold enough to ever need to use something other than a heat pump. It doesn't get to -40 in the UK.

Nate Hagens (01:00:17):

Not until the AMOC totally shuts down. That was a joke.

Paul Martin (01:00:23):

Maybe it will. That's right. Because they're north of us by a long way.

Nate Hagens (01:00:28):

Yeah. Okay. So let's get to the heart of this conversation on hydrogen on your work on this topic. Perhaps you can start off listing maybe in the order of importance what the biggest problems are with scaling hydrogen the way that we're being told right now. You've mentioned a couple of things, either from an implementation or a risk perspective. Do you have a five bullet points or an elevator pitch on that?

Paul Martin (01:00:59):

Yeah, it's super easy. So our focus needs to be on fixing the problem of hydrogen. So there are no regret uses for hydrogen that are plentiful. Making ammonia to make fertilizers is one of them. Making other chemicals is another. The direct reduction of iron ore to iron metal is another, it is going to be a big boom in the future. And right now we're doing it with syngas mixture that contain fossil carbon and we've got to switch to pure hydrogen for that. Those are all no regret. We should be focusing on those. I keep hearing people talking about the so-called hard to decarbonize sectors. Oh, well we've got to have hydrogen for the hard to decarbonize sectors. And it's like, great, if there are hard to decarbonize sectors, there must be easy ones. Why aren't we focusing on the easy to decarbonize sectors, which are transport, as an example? We should really be focusing on the easy to decarbonize sectors.

(01:01:53):

But we should be decarbonizing hydrogen for use as hydrogen first. And let's say we get to 70% of the world's hydrogen being made from renewable or nuclear electricity. If we get to that point, then maybe at that point, decades from now, we can start thinking about wasting hydrogen on inefficient uses like as a fuel. So it's literally that simple. It's all about the use cases. There are use cases that make sense. Those are hydrogen being used as a molecule or as a reducing agent to replace fossil reducing agents. And then there are use cases where hydrogen's being used as a fuel or an energy storage medium, or an energy transport medium. And all of those are questionable when you dig into the details. And okay, here we are in a very short conversation. I don't have the time, the hours to explain in detail why that is. I refer people to my writings, which you can find on LinkedIn or on my blog, on my website.

Nate Hagens (01:02:53):

We'll put them in the show notes.

Paul Martin (01:02:55):

Yeah. So you can refer to those articles. And I explained in detail why it is that hydrogen and hydrogen derived molecules are not the new LNG because nothing is the new LNG. And why it doesn't make sense to use hydrogen for transport, because the lion share of transport applications can be electrified either directly or via batteries. And the ones that can't be or are a poor fit for hydrogen because hydrogen is just too bulky, it's too big, too low in energy density per unit volume and too difficult to distribute and hence expensive to distribute as a fuel. So people want to make it into other things.

Nate Hagens (01:03:31):

How is the energy density of hydrogen compared to methane or gasoline?

Paul Martin (01:03:36):

So hydrogen as a liquid is about a quarter. The energy density of methane as a liquid, so LNG. And hydrogen as a gas is about a third. The volumetric energy, volumetric energy density of methane as a gas. So you have to move three times as much volume-

Nate Hagens (01:04:03):

Everything else being equal. If we scaled hydrogen as a fuel globally, the devices that we used it in would have to have much bigger tanks. Everything else being equal.

Paul Martin (01:04:16):

That's one way to put it. So let's say that we were to say that we were to try to make liquid hydrogen at 24 degrees above absolute zero using 30% of the energy in the hydrogen to just make liquid out of it and then transport that, we would need four times as many ships of the same size to carry the same amount of energy as we do today. But the real issue is how much energy's being wasted in that process. It's buy 10 kilowatt-hours, get one or two back at destination. It's just great business if you're selling electricity, terrible business if you're a consumer of electricity. So not all that smart.

(01:04:57):

And then when you look at trying to stuff hydrogen into natural gas network as a replacement for natural gas, you run into all kinds of problems. You run into problems with the materials of construction being wrong, you run into problems with compression. It takes three times as much energy to compress hydrogen like a unit of energy in the form of hydrogen as it does to compress a unit of energy in the form of methane. So it's much lossier to move through a pipeline.

Nate Hagens (01:05:25):

What does lossier mean again?

Paul Martin (01:05:27):

It just means that you lose more of the energy in the process of doing the thing. So if you look at natural gas, moving it from place to place is fairly efficient. If you replace natural gas with hydrogen, if you want to move a joule of hydrogen from point A to point B, it's going to take three times as much energy as if you moved a joule of methane from point A to point B.

Nate Hagens (01:05:52):

So let me ask you this, Paul, instead of saying what you think should happen, just put on your speculative hat and given the tea leaves of what's happening in Europe, in the UK you mentioned, and the narratives with subsidies for hydrogen seems to be picking up momentum. What do you think is going to happen with hydrogen?

Paul Martin (01:06:22):

I think tens of billions of dollars are going to be spent trying to use hydrogen for inappropriate purposes. I think an awful lot of people will earn an awful lot of salary on the attempt whether it succeeds or fails and it will fail. And I think that we will end up decarbonizing the economy by electrification and not by virtue of fuel substitution. I think honestly, hydrogen's role in heating and transport are both niche at best. They're very small, minor secondary applications in heating and transport. Maybe we'll use some hydrogen to boost the yields of biofuels production for things like trans oceanic ships and aviation. But we'll use biofuels and not hydrogen for those purposes because they're a much better fit.

(01:07:16):

And I don't think that we're going to have a hydrogen economy. I think the whole hydrogen economy thing is based on the notion of hydrogen as a fuel, and that's a notion that doesn't hold weight or it doesn't hold water as either a decarbonization strategy or an economic proposition. I think that means a lot of misery for a lot of people living in countries like Japan and South Korea as an example that are totally dependent on imported energy, are not good friends with their nearest land neighbors and have a lot of heavy industry and are very hungry for energy per capita. I think those guys in a decarbonized future and big, big trouble. And I think they hope hydrogen will save them, but hydrogen won't save them, honestly.

(01:08:02):

It's a false hope.

Nate Hagens (01:08:03):

I e-mailed you a few days ago about a big article that was been floating around in science mag and this weekend there was an article in the New York Times talking about the new discovery of enormous amounts of low carbon hydrogen deposits under earth's surface.

Paul Martin (01:08:23):

Yeah. Natural hydrogen. Natural hydrogen. It's so-called clear hydrogen.

Nate Hagens (01:08:24):

Does this story fall victim to the sins of thermodynamics or is this a big deal or a bunch of hand waving?

Paul Martin (01:08:31):

Well, to my knowledge, there's one producing well in the world. It's in Mali. They were drilling a well for water and ended up producing hydrogen at fairly high purity. I think the likelihood that that's widespread on the earth that we've just been drilling holes for water and oil and gas in all the wrong places and magically avoiding it is pretty low. I think there's a gold rush mentality there. There's certain geological conditions when hydrogen might be produced. I think they're pretty rare. I hope we find a bunch of geological hydrogen that's not full of CO_2 and methane that we can actually use. But I'm not hopeful that that will be a major source of hydrogen anytime in the future. I think it's mostly a gold rush.

Nate Hagens (01:09:23):

Time has been flying here. I want to be respectful of your time. If you don't mind, I have some questions that I ask all my guests near the end of an interview. So given your lifetime of work on energy sustainability issues and your awareness of the difficult times we're in, do you have any just personal advice you give to people or to listeners of this show on how to navigate these times?

Paul Martin (01:09:51):

Yeah, it's tough. It's very easy for me to say as somebody that's quite senior in my career, I've gone out on my own as a consultant and having the time of my life doing it honestly. But what I do is, and what I've tried to do my whole career, even when it was hard, was I tried to ask myself, is this work making the world better? And if it's not, don't do it right. I realize people have to keep body and soul together and you got to earn a living. If Shell comes knocking on your door and nobody else is knocking on your door, I guess maybe end up working for Shell now. I never did. I made that choice and I think I feel better about it for not doing that. Those guys were customers, those guys were customers of mine.

(01:10:41):

Let's be clear, I made lots of money from the fossil fuel industry. And what we were doing was trying to make the world better in that context. So we were always trying to reduce energy use, reduce waste generation, make the processes more efficient, reduce how much capital was required, make sure the equipment lasted longer, whatever, we were doing something to make it better. So that's my advice to people is regardless, even if you're working in the fossil fuel industry, try to do that work in a way that makes the world better. And if you can't find something else to do for a living, that's it. Real simple.

Nate Hagens (01:11:18):

I resonate with that and I wish we had the sort of economy where there were choices that people could do the better things for the future and maybe that'll change at some point.

Paul Martin (01:11:32):

And I would say that something I found very frustrating in my career is I was helping people develop new technology and I'd have smart, creative, motivated people come in all the time and they'd say, "Hey, we've got this great idea. We're going to decarbonize X, whatever X is, and if we get $50 a ton carbon tax, we'll break even." And so we designed them a pilot plant and they'd run it for a couple of years and they'd say, "Yeah, well we were optimistic. We actually need a hundred dollars a ton now that we know everything." And they would bet that the world would pay them a hundred dollars a ton and then the world wouldn't do it and they'd go broke. And you only have to do that a few times before you go, "Mm, is this a technical problem or is this an economic problem?" So without the economic problem being solved, a lot of us technical people are basically twiddling our thumbs. We can't fix it.

Nate Hagens (01:12:21):

Yep, I hear you there. What specific recommendations do you have for young humans who become aware of our economic and climate and broader systemic issues?

Paul Martin (01:12:36):

I would say don't panic. The great advice that's on the cover of the Hitchhiker's Guide to the Galaxy. Don't panic because panic doesn't help. Don't fall prey to hopium, which is the willing suspension of rational thought. Don't let your hope overwhelm you. But if you've got a choice between hope and despair and those are the alternatives, pick hope and technology can do a lot of good in the world if it's directed properly. Don't blame technology, don't become a Luddite. Don't think that there's some agrarian past that we can return to when everybody was in the harmony with nature. Be practical and focus on solving real problems every day.

Nate Hagens (01:13:26):

What do you care most about in the world, Paul?

Paul Martin (01:13:31):

Yeah. What do I care most about in the world? It's a values question. I love my family and I love the intellectual challenges of my work. I love being creative and doing interesting things and all of those things. I guess if what you're really asking is what do I value the most or what would I fix about the world to make it a better place? It would be that we right now, we don't value the way we exploit the world. And as people living in a society that has the rule of law and has government, we don't hold governments to doing what they need to do for collective benefit, which is tax and regulate for collective benefit. We've been conned into this notion that taxation is theft and regulation is just red tape and governments are worthless. And that's a con. That's a straight-up con.

(01:14:36):

So I would say it's something that we need to get our heads around and stop believing because it's leading to just further destruction of the earth that we live on. And if I love my kids, I want them to have a place to live in. That's not a torture chamber because past generations have made dumb decisions.

Nate Hagens (01:14:56):

So you would be an advocate for a carbon tax over time?

Paul Martin (01:15:01):

Oh, I've been an advocate for carbon taxes for 30 years. And here's the thing, a lot of people don't realize that in Canada we were told we would never have a carbon tax. We were told that. We were told that repeatedly, loudly, shrilly. We have a carbon tax in Canada, it's been defended in two federal elections and in a Supreme Court challenged, it was challenged to the Supreme Court by four provincial premiers who are closeted climate change denialists and couldn't bear the thought of carbon tax. And the Supreme Court upheld it. And it's the law of the land and it's increasing to $170 a ton by 20 -- sorry, it's increasing to $170 per ton by 2030. And it's widely supported by the population. And the reason that it's supported by the population is not only do the population in Canada get it. They understand that climate change is a real thing and we've got to do it, do something about it, but we also get the money back.

(01:16:04):

So it's not like it's going into some nebulous government coffer and then just being spent on schools and hospitals and whatever the priority is of the day. We get the money back at the average rate makes a huge difference. So poor people who don't consume much and hence don't admit much because they don't consume much, they get more money back than they pay in tax. Their lives get better, they get rewarded for their low emissions' lifestyle. And rich people who emit a lot because they have a lot and they consume a lot, they have all the capital in the world to invest in reducing their emissions if they choose to do so, because they don't paying this carbon tax. So it's a very well-supported thing and I absolutely support it. I think it's fantastic and necessary. But insufficient. That's not enough. You got to do that, but you got to do more.

Nate Hagens (01:16:55):

I didn't know that about Canada. So what, in your own work, Paul, are you most excited about on your contribution to our collective future? What are you working on now that's exciting and hopeful and gets you going?

Paul Martin (01:17:12):

So I put four tests on my clients before I do business with them. First of all, that very most important one is are they making the world better or are they making it worse? I make a subjective value-based decision on that basis and then determine whether they're going to work with them or not. I have to be able to help them. So I have to be able to contribute something that will make it worth me being part of it. Otherwise, I'm just grinding my gears and not really helping. They have to be able to pay me, because I do enough pro bono work through the Hydrogen Science Coalition and other things and I need to make a living just like anybody else.

(01:17:52):

And the fourth one that's really undervalued by a lot of people, but really highly valued by me, especially as a private consultant, is I got to have the impression that's going to be fun. That these are going to be people that are going to be a good time to work with, that they're not going to be officious and difficult and making my life miserable, thought they're going to be cool and they're going to be fun. So I give people those four tasks before I work with them. And I'll tell you, that makes for a very satisfactory working experience.

(01:18:23):

As far as what projects am I working on that are making the world better? Well, a lot of that I can't really talk about because I'm under non-disclosure agreements with people that are developing new technology. But I can tell you I'm working with groups of people that are doing things like novel ideas for energy storage, both as electricity and as heat. People that are working on materials of construction that are lightweight and hence will be a better choice for mobility applications as an example. People that are improving materials and construction in terms of their impact on the environment. Working with people that are trying to make hydroelectricity and tropical climates greener. There are methane and CO2 emissions associated with hydropower and tropical environments that are not negligible and need to be dealt with. And these guys are doing clever things working on that. I'm working with all kinds of people on all sorts of things, but it's working on battery materials and working on electrifying heating and electric vehicle, applications and all sorts of cool things. Yeah, I'm having a riot.

Nate Hagens (01:19:39):

You wake up in the day and you almost don't need coffee. Sounds like you are quite motivated and engaged.

Paul Martin (01:19:47):

Oh yeah, no, I'm having a good time. And it's certainly something that was a pleasant surprise to me because I'd retired and hoped that I would pick up enough consulting to keep myself occupied, keep my brain in the game, and maybe make some money to travel and do a few things that I wanted to do. And I'm actually working almost a little bit too much.

Nate Hagens (01:20:11):

Thank you so much, Paul. And if I do come to Toronto in April, I'll e-mail you. Maybe we could go grab a coffee or a beer or something.

Paul Martin (01:20:20):

Absolutely.

Nate Hagens (01:20:22):

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