Podcast #84 – A Path to Zero-Carbon Industry

[00:25] **Brian:** Well, hello, everyone, and welcome to the Hydrogen Nowcast for April 26, 2024. I'm your host, Brian DeBruine, the director of the non-profit Colorado Hydrogen Network. Now, this is a podcast devoted to encouraging the deployment of hydrogen infrastructure throughout the world. Our intent is to encourage and motivate others to take charge to help deploy hydrogen as a means to decarbonize our energy sectors and accelerate the movement to stop climate change.

Well, my guest on the podcast today is Jeffrey Rissman, who's a senior director of the *Industry* program at Energy Innovation, which is a non-partisan energy and climate policy think-tank. His work focuses on technologies and politics to achieve net zero industrial greenhouse gas emissions. He's the author of the 2024 book Zero Carbon Industry, about how we can revolutionize America's biggest emitters, things like iron, steel, chemicals, cement and other manufacturing, and basically do that through a combination of innovation and smart policy. So, Jeffrey, welcome to the show!

[01:33] **Jeffrey:** Thanks, Brian. Really appreciate you having me on.

[01:36] **Brian:** Well, really appreciate your time, Jeffrey, to come on and to enlighten us about industrial things. So, as I mentioned in the intro, you're the senior director at Energy Innovation. And listeners, by the way, that website is all one word, energyinnovation.com. Jeffrey, could you tell us briefly what energy innovation does and a little bit about your work there?

[01:59] **Jeffrey:** Sure. So we're a nonpartisan research firm or think tank. So we research technologies that can help to decarbonize the economy, shift to clean energy, and the policies that can help accelerate that transition. We have a number of teams, often structured around sectors. Like, we have a team that works on the electric power sector, another on transportation. And they don't always align with sectors. We have one modeling and analysis team that focuses on computer modeling, which is something I used to do. And then my current role is leading the industry team, the one that focuses on how to help manufacturers produce all these goods and materials we need every day without pollutant emissions.

[02:47] **Brian:** Well, Jeff, I'm really pleased to have you on the hydrogen now cast because frankly, talking about how to decarbonize industrial processes is something that I really haven't covered much on the show. Now, I have featured sources of high-volume, low-cost hydrogen, such as natural hydrogen wells and underground hydrogen generation using petroleum deposits. But I haven't really covered how we start this market for industrial hydrogen by bringing up the supplies and enlisting users simultaneously and at the same scale. So what was the catalyst for focusing your expertise on the industrial sector's role in climate change?

[03:27] **Jeffrey:** Great question. So before I started the industry program, at Energy Innovation, I was working on the energy policy simulator, which is a computer model I created that assesses what would be the effects of different energy and environmental policies, things like financial incentives or energy efficiency standards or so on the economy, all the outputs like emissions and public health impacts and jobs and GDP. And it's a cross sector model. It includes each sector, transport, buildings, industry, electric power, etcetera. And we're deploying this in various countries and regions. And one thing I was realizing is that in place after place, the industry sector is this very large emitter. It's responsible for a huge share of the emissions in many countries and states. And yet there were not as many policies targeting the industry sector. And the ones that there were, were not as ambitious as policies focused on other sectors. And it was just way off-track relative to the other sectors and what would be needed to achieve various regions, climate and emissions targets. So I recognized that this was a gap, a knowledge gap, where policymakers needed to have a better understanding of the technologies that can decarbonize industry and what they can be doing to help, and not just policymakers, all sorts of stakeholders and influencers, the media industry, other non-profits, etcetera. So I decided I would create this program and worked on this book, *Zero Carbon Industry*, that aims to make these challenges understandable and really show how we get from where we are to a clean industrial sector.

[05:17] **Brian:** Well, I'm so glad that you've done that, because I, in my travels through the hydrogen space, I just see so much misunderstanding, misinformation, and really, just trying to understand the situation and understand which directions we can go, I think is just so necessary right now. Well, why don't you share some of the advanced technologies for industry decarbonization that you actually cover in the book?

[05:42] **Jeffrey:** Sure. So there's a range of them. The book sort of has three sections.

The first one is about the top three emitting industries, iron and steel, chemicals and nonmetallic minerals, cement and concrete essentially.

The second section is about cross cutting technologies like energy efficiency, material efficiency, electrification, hydrogen and carbon capture.

And then the last section is on policies.

So the technologies, some of them are in those first three chapters where they're specific to those industries. There's a lot in the book to cover more than I can share here, but I'll focus on some that involve hydrogen, since that's the theme of the show. Steel making is a great example. So today, steel is made through two ways, either primary or secondary steel. Secondary means recycled steel, steel from scrap, and primary steel means steel made from iron ore that is mined out of the ground. Secondary steel is relatively clean because it's made in electrical arc furnaces. But it can't serve all of our steel demand because there isn't enough scrap to recycle. So even if we collected all of it, we would still have a lot of additional steel demand that would need to be met by primary steel. Primary steel today is made mostly in a machine called a blast furnace. This multi-story tall machine that takes iron ore and other materials in the top, and it has coal and coke. Coke is a carbon-based fuel derived from coal that it burns both for heat and to chemically reduce the iron ore. Iron ore is iron oxides, minerals, and it takes the oxygen atoms out, leaving metallic iron behind, which is the main component of steel. And this process emits lots of greenhouse gases from the coal and the coke. One of the ways you can make steel without greenhouse gas emissions is called hydrogen Direct Reduced Iron, or DRI. This is where you have a different type of furnace, a DRI furnace. And instead of using coal and coke, you inject hydrogen into the furnace, and the hydrogen is the chemical that strips off those oxygen atoms, leaving the metallic iron behind, which you can then put into an electric arc furnace to melt down and convert it into steel. It's an exciting approach, and it's already being developed. For instance, there's a consortium in Sweden called Hybrit that have operated a demonstration plant and produced steel this way. Another firm called H2 Green Steel, is building a commercial scale facility, and I believe a couple facilities are going to be built in the United States as well, with funding from the Department of Energy. So it's a very exciting time for these new technologies that can decarbonize industry.

[08:42] **Brian:** Well, thanks, Jeff. So often when I hear people talk about solutions for the energy transition, they seem satisfied to just look at technical issues. But there's other things, like regulations and business things like being competitive that also matter. So how does the book address this complexity of manufacturing regulations and also making sure that these companies can stay competitive?

[09:10] **Jeffrey:** So, policy is crucial to industry. It sets the environment in which firms across the economy compete and determines what's allowed and what they're rewarded for. I think of policy more broadly than regulation, because it also encompasses financial incentives and other rewards for producing things in a way that's clean and environmentally beneficial and creates jobs. And one of the key insights in the book is that different policies are most effective for technologies at different points in their lifecycle. So technologies mature over time. They start at the laboratory scale and grow to a demonstration project, and then early commercial. And finally, it could become the dominant way that a process is done. And you want different policies to support a technology at these different stages. For instance, at an early stage, the technology is small and it's trying to achieve commercialization. Direct financial incentives like cost sharing on a new plant using a novel technology is a powerful policy option. That's one that the Office of Clean Energy Demonstrations that the Department of Energy has used. They announced 33 projects with cost sharing, public private investment to produce things in a new novel and clean way. Another early-stage policy, meaning good for technologies that are not yet mature, is green public procurement. Actually, the government is a huge purchaser of industrial products like steel and cement, which goes into concrete for roads and highways and bridges and public buildings. So government can set aside a portion of their spending. Let's just say 5% of the amount they spend on steel has to come from zero carbon primary steel made from hydrogen DRI, or another zero-carbon primary steel process. And that gives steelmakers the incentive they need to invest in a new production line to produce that type of steel cleanly. And then they can scale up, they can produce more, costs come down, government can ratchet up its purchases. Maybe then they purchase 10% and then 20% of their steel from these processes. And then the private companies can start selling steel elsewhere. Maybe they can sell clean steel to car manufacturers who will want to be able to advertise that their cars were produced using clean hydrogen-based steel. Those are examples of how early-stage technologies can be supported by policy. But other policies are useful for middle and late-stage technologies. One example of a late-stage policy is carbon pricing. So the goal of carbon pricing is not to have industries pay the carbon price, like a carbon tax or carbon cap and trade. The goal of carbon pricing is to have industries instead switch to a clean technology instead of paying the carbon price. And for them to do that, there

needs to be a commercialized clean technology available for them to switch to. And that's why it's best used a little bit later when there are affordable, clean options to nudge industries to make the switch. So that's the structure the book uses, essentially finding the right policy match for the right sorts of technologies to help cut through that complexity and really make it clear and simple how to design smart policy.

[12:41] **Brian:** Well, thanks, Jeffrey. And those are some great suggestions for tangible and actionable things that the government can do to help move things along without necessarily just handing out money. And I'm a big believer in doing it. That way. Well, in what ways do you see countries striking a balance between this pressing need for climate action and the practicalities of industrial transformation?

[13:07] **Jeffrey:** So action on climate is urgent because emissions remain high and this is causing climate damages even today. And a lot of these gases will persist in the atmosphere for hundreds of years or longer. And countries have recognized this and have established net zero targets and often ambitious targets. European countries, the United States, China, have all set goals for reaching net zero emissions by 2050, 2060. So I think policymakers are beginning to recognize that it's necessary to begin focusing and thinking more about the industrial sector if they're going to achieve these targets. And this is heartening because there are so many promising technologies for clean industrial production that just need this nudge from policymaker support. We see that in Europe, for example, I would say they're the region of the world that's in the lead as far as incentivizing these clean industrial technologies where they have their European Emissions Trading System, and they have just implemented a carbon border adjustment mechanism. So this is a way of using policy to protect their domestic manufacturers while still achieving climate ambition. Essentially, it says that for products that are being imported into the European Union, if they were made in a dirty way, a lot of greenhouse gas emissions, they'll be taxed based on the amount of emissions that happened during their production. We call those embedded or embodied emissions. So these imports from dirty regions won't have a financial advantage relative to the European manufacturers who are producing things more cleanly. And similarly, if the European companies are exporting materials and products to regions without carbon pricing, it can rebate them the carbon price so that their exports are not disadvantaged relative to the other things available in the country they're exporting to. So the United States is also taking huge strides in terms of new support for clean industry. We've seen that with the Inflation Reduction Act having several new programs to fund clean industry, the hydrogen hubs will direct some of their hydrogen to industry, and there are various tax credits and incentives. So I think these are the leading two regions now and are illustrating how to strike this balance and what is the path forward to achieve domestic economic goals and jobs and prosperity while meeting their climate targets.

[15:49] **Brian:** Well, thanks, Jeffrey. And you just mentioned jobs. And one of the things that has really been at the forefront of this energy transition is this idea of workforce development. We've got people that are displaced from current technologies, and we certainly have a need for train people in these new technologies around hydrogen and other things. So what does the intersection of job creation and zero carbon industrial economy look like to you and your vision?

[16:22] **Jeffrey:** Jobs are a very important part of this transition, because the transition to clean industry doesn't just benefit the environment. If done well, it can boost the economy and achieve jobs and economic growth and technological leadership. Countries and governments spend their money on all kinds of things, and one of the best things they can do for jobs is to use it in a way that leverages private capital and has all of this new money. Public and private finance, go to producing productive equipment, productive capital equipment like industrial machinery, and to workers, because you get the initial jobs from that investment, but then you get ongoing jobs from when that equipment is used to produce and sell all the goods that the economy needs. There are knock on effects as well, and co benefits. For instance, it cuts not just greenhouse gas pollution, but all types of pollution if you're eliminating fossil fuel combustion, let's say, with electrification. And so fossil fuel combustion is responsible for thousands of premature deaths in the United States every year and countless other health issues short of hospitalizations, heart attacks, strokes and lung disease, all of which are very expensive. And aside from the humanitarian cost, they also take workers out of the economy and make the economy less productive. And that leads to fewer jobs and greater burdens. So a transition to clean industry helps the economy in multiple ways. In addition to the public health and the investment, there's also the technological leadership angle, as we know from science and from climate, that we need to be cutting our greenhouse gas emissions in order to stabilize the climate, to stop global warming at any temperature whatsoever. Ultimately, industry is going to transition to clean manufacturing technologies, and the countries and the companies that make these

investments early will achieve technological leadership. They will have more engineering experience, more know how. They may also own the intellectual property which they could then license, either exporting the technology or licensing the ip, which brings in more money. And that, in turn is more jobs. So there are many ways in which this boosts the economy and creates jobs. It's hard to think of anything that government or the private sector could spend money on that would do more for job creation than promoting industry in this way.

[19:05] **Brian:** All right, thanks, Jeffrey. Well, the energy transition is new, and it's still really taking shape, and I think a lot of people are maybe struggling a little bit to understand it, to know what it all means. What do you see as common misunderstandings that people have about this transition to carbon neutral industry?

[19:25] **Jeffrey:** Well, there are two that I highlight in my book Zero Carbon Industry. One is the complexity of the industrial sector, and the other is economic concerns on the topic of complexity. It is true that the industrial sector globally makes millions of different products with countless different industrial processes. And I think for a policymaker who's just coming at this and hasn't really had a chance to research it deeply, that can be daunting. They can think, well, gee, do I have to be an engineer with expertise in every different sub industry in order to understand how to create policy to properly incentivize industry? And fortunately, the answer is no. You don't need to have ten engineering degrees to make good policy. There are cross cutting policy tools that are often technology neutral, that can support private firms as they innovate ways and scale up well understood ways to produce products and materials cleanly. And even the technologies and processes used by industry are not impossible to grasp. This is a key motivator behind why I wrote the book, where there is a lot of information out there about how industries produce their goods and how they can be produced cleanly. But it was often very diffuse in various technical reports, often divorced from policy information. And so by pulling it all together, I can combat this misunderstanding that this is all too complex to be understood. The fact is, no, it can be understood. This book is a roadmap for how to do that. It's essential reading for anyone who cares about addressing climate change and addressing industrial emissions specifically because of the way it provides this comprehensive and very understandable roadmap. The other misunderstanding is about economic implications, the notion that it might be a choice between a transition to clean industry and jobs and GDP. And I think we covered this quite thoroughly in the prior question where I explained how investments in clean industry actually promote jobs and boost the economy. So I won't repeat all of that here, but I hope that the book helps address both of those misconceptions.

[21:49] **Brian:** Well, I think your book is a fantastic reference source. I mean, as well as just orienting people as to how things work and how they're interconnected. One of the things in the book, Zero Carbon Industry, you talk about this synergy between technological innovation and policy reform. That's kind of a deep thought there. Technological innovation and policy reform. Which do you believe is the key to achieve zero carbon industry?

[22:20] **Jeffrey:** Well, of course, ultimately you need both. You need policy to incentivize the deployment of the technologies, and then the technologies are what deliver the emissions reductions physically. But I would say that the next key, the next step lies on the policy side, because we understand a lot of these technologies. For instance, we have a lot of technologies that can produce industrial heat from electricity, whether that's electric resistance heating or electromagnetic induction, infrared heating, dielectric heating, which is radio waves and microwaves. These are all understood principles. They're all used in technologies today. They just need to be further commercialized and brought to new industries and integrated into manufacturing equipment. So if I have to pick something that's the next key. It would be on the policy side. Get the policies in place that will incentivize the deployment of these, make it rewarding for firms, and then the demand for the equipment will be there. That's the next step to unlocking it and making it roll out at scale.

[23:32] **Brian:** All right, thanks, Jeffrey. Well, of course, the energy transition is not all about hydrogen. It's not all about electricity. It's about a mix. What do you think the best role is for hydrogen to play in this transition to clean industry versus other technologies like direct electrification or even just energy efficiency?

[23:56] **Jeffrey:** Sure, hydrogen does have a crucial role in decarbonizing industry, but hydrogen is valuable, and so it's important to put it to its highest and best uses. One important use of hydrogen would be for chemical feedstocks. So feedstocks are fossil fuels that are used by the chemical industry and others to produce their products. And feedstocks aren't just burned for energy like heat. They are chemically transformed to become part of the output product. For instance, petroleum is converted into petrochemicals like ethylene and propylene, which are then converted into plastics like

polyethylene and polypropylene plastic, which then makes up plastic items that we might buy. You can't use electricity to replace these feedstocks directly because they contribute mass to the output product. What you can do is use electricity to form green hydrogen by splitting water into hydrogen and oxygen. Then you can either use the hydrogen directly, for instance, to make ammonia, which is the main component in fertilizers, one of the biggest products of the chemicals industry. Or you could combine it with captured carbon when you need to produce chemicals that contain carbon, as is the case for plastics and many solvents and coatings and other chemical industry outputs, hydrogen is valuable there because it fills a role that direct electrification can't. I also mentioned earlier, hydrogen direct reduced iron, one of the roots for primary steel making. That's another good use of hydrogen in industry. These are, in contrast, to, say, just burning the hydrogen for heat. That's an inefficient use of hydrogen, because if it's green hydrogen, first you're making it from electricity, so you have energy losses in converting the electricity to hydrogen, and then you have heat losses when you burn it, some of the heat is lost in hot exhaust gases. Some of the energy goes into forming water vapor, which leaves the system with the exhaust gas, whereas direct electrification doesn't form exhaust gases and doesn't form water vapor. So it avoids those losses and is just a more efficient way to go about it if all you want is heat. So I think there's plenty of demand, or will be plenty of demand for clean hydrogen in the industrial sector, enough that we shouldn't waste it on low value uses and instead direct it toward those places where it can be the highest and best use.

[26:33] **Brian:** Yeah, I absolutely agree. That's very important to use our resources where they're needed the most, as you say, highest in direct and most direct use. So we talked earlier about workforce development, and that's one of the ways that the energy transition touches people. But of course, there's other things like health. I mean, if we think about the pollution that has come from burning fossil fuels and how that's affected people, could you explain how your proposed framework ensures that this shift to clean industry promotes equity and health and prosperity for everyone?

[27:08] **Jeffrey:** Sure. So my book devotes a whole chapter to equity and human development. Essentially, it's acknowledging that industry is tied up not just with environment, but also with the economic development of countries and communities and has significant impacts on public health from conventional pollutants that they emit, even additional to any impacts from climate pollutants, from climate change. So there's a high level of wealth inequality in the world right now, and many countries are still looking to industrialize, to build up their industrial base. And so it's important to think of how to develop clean industry in a way that allows them to leapfrog over dirty technologies and go straight to clean, modern, efficient options. And the book talks a bit about how to achieve this. Things about making sure that policymakers and leaders in low- and middle-income countries are consulted and take leadership of projects, making sure there's sufficient institutional capacity, making sure that intellectual property for clean industrial technology is licensed under fair and reasonable terms and is accessible globally. Since we can't stop climate change if we aren't all working towards it, there's also measures like education and access to science, engineering, and math talent and ensuring adequate finance and investment, and then even within a country. So it's not just an international question. There are communities in the United States and elsewhere that are industrial communities today. They're centered on maybe one major manufacturer. And so you want to support those communities through this transition and not displace jobs and make sure that they stay and help the communities flourish. Things like retooling grants or community benefit agreements attached to government incentives and strong standards to protect public health, the health of workers and their families who live near these facilities. All of this should be designed into the policies that policymakers use to promote and reward a transition to clean industry.

[29:22] **Brian:** Well, thanks, Jeffrey. And I really think the book does do a great job of laying out a roadmap to give us ideas on how to do these things and the order of things and so forth. Now, as someone who's kind of charted this path for industrial decarbonization, what would you say is the next big step for this sector?

[29:42] **Jeffrey:** Well, it's a big task, and there are low hanging fruit, and there are then measures that are a little further out and focusing on the next step, the low hanging fruit. I would say the three big opportunities that come to mind are energy efficiency, material efficiency, and electrification of industrial heat. Briefly, energy and efficiency is simply a way to produce the same goods and materials we need while using less energy. It's often thought about as a thing that's specific to a given machine, like a motor or a boiler, and there are ways to make those machines more efficient. But it can also be thought of at higher levels, like the efficiency of an entire factory, which relates to how the machines are interconnected and maybe using waste heat from one process in another or other byproducts. And even beyond the factory, there are energy efficiency related measures, such as product design. You can redesign a project to make it more manufacturable at lower energy or supply

chain management. So steps like this can save money and help to make the shift to clean industry faster and easier by lowering the demand for clean energy. Material efficiency is somewhat similar. The idea of making products that we need with less material waste less excess material, for instance. This comes into play with concrete in buildings where not all of the concrete is necessarily weight bearing, like many molds that they pour concrete into have sharp corners because they're from wooden boards hammered together to form the molds. And those sharp corners may not be supporting weight or much weight. So you can use curved fabric molds or other techniques to place the concrete only where it's really needed. And that can, for one thing, saves you on the amount of concrete you use, which then reduces pollutant emissions. It can also benefit the building. It can give the building a more open, airy feel. It can make the building lighter, which means you don't need as thick and heavy a columns and foundation to support it. Industrial electrification or electrification of heat was the last low hanging fruit I mentioned. And that's just because some of those technologies, like industrial heat pumps and electric resistance, which is used in thermal batteries and microwave heating and induction and electric arcs, there's so many technologies out there, as I discussed a minute ago, they're efficient to use, more efficient than forming and burning hydrogen and so on. And that makes that one of the next key areas of focus.

[32:23] **Brian:** All right, well, thanks, Jeffrey. You know, when you talk about efficiency, one of the things that comes to mind for me, which is such an obvious one, is home lighting. I mean, led lights use, what, ten to 12% of the energy of an incandescent lamp. And so I want to challenge the listeners. If you still have incandescent lights in your house, spend the money, change those out to led and help us with this whole drive to efficiency. Well, Jeffrey, obviously the book is a good resource, and we're going to give out the website for that in just a minute here. But where else could listeners learn more if they want to delve into this a little bit deeper?

[33:01] **Jeffrey:** Sure. Well, the book's website is really the best place to go. The first place to learn more about the book, it's zerocarbonindustry.com, and in addition to a preview of each chapter, you can get a 20% off discount code there to purchase it. And there's also a link there to sign up for the mailing list, which is the next place to go to learn more. So the Energy Innovations industry program has a mailing list where we announce whenever we release new research products. The vast majority are released publicly for free. The book isn't free because it was published by Columbia University Press and is in bookstores, but it's not expensive. So zerocarbonindustry.com is the first place then, if you want to learn beyond the industry sector, if you want to see how to decarbonize electric power or transportation or buildings, you can go to energyinnovation.org. That's the website for my company where my colleagues have the other teams and are doing a fantastic job putting out great information about how to bring all sectors of the economy along in the clean energy transition.

[34:12] **Brian:** Well, thanks, Jeffrey. I do encourage the listeners to go to the zerocarbonindustry.com website because as you pointed out, there is a 20% off discount code. Now, I bought your book on Amazon because I wanted the Kindle version. Is the Kindle version available on the website or not?

[34:32] **Jeffrey:** So the website just links to other merchants so it has a link to Amazon, it has a link to Columbia University Press's web store, a link to Barnes and Noble, and in each case, they have both an eBook version available and a print version. So you can choose whichever merchant you want and then choose your format.

[34:53] **Brian:** Ah, great. All right. Well, the key there, though, is to go to the zerocarbonindustry.com website so you can get that discount. And as you pointed out, there's some information about the chapters and table of contents and things. All right. Well, Jeffrey, is there anything that I haven't asked you about that you'd like to add?

[35:10] **Jeffrey:** It's been a great conversation. I guess I'll just add that decarbonizing industry, and the economy for that matter, it's a real team effort. It requires people working on the problem from every angle. It requires scientists and engineers who develop these clean technologies, smart policymakers and those who support them in their campaigns to get them elected and whatnot, to help enact these policies. And it requires media and podcasters to help get the news out and make people aware of all of the promising technologies and policies and all the things they can do to help. So I just really want to thank you for what you're doing and with this podcast and thank your listeners for listening and recognize that we're all engaged in this project together.

[36:01] **Brian:** Oh, absolutely. Well, Jeffrey, thank you so much for your time to be here today. Really appreciate that.

[36:09] **Jeffrey:** Thank you. I really appreciate being able to come on the show.

[36:12] **Brian:** Well, glad to have you here. And who knows? Maybe we'll do a follow up at some point. Well, listeners, if you enjoy listening to the hydrogen now cast, please consider subscribing to the podcast and also give us a rating in your podcast app. A good rating helps us be discovered by other people. And of course, word of mouth recommendations are really important. So consider letting people in your own network know about the hydrogen now cast. And about Jeff's book, I'll add. So also, if you'd like to contact me, the best way is to reach me either through the website at Colorado dash hydrogen.org or on LinkedIn. So until next time, this is Brian DeBruine wishing you health and prosperity. Goodbye.