Interview with Mark Chung

Annie Luo 0:17
Thank you for taking time to speak with me today! Just to re-introduce myself, my name is Annie, and I created Sustainability Beyond the Lab to showcase sustainable research and make it more accessible for a general audience. Sustainability Beyond the Lab also highlights the barriers that prevent scale-up. To begin, could you also introduce yourself and then describe your role at the National Laboratory of the Rockies.

Mark Chung 0:43
Yeah, sure thing. So nice to meet you, Annie. And again, like I said in my e-mail, it excites me that the younger generation is also excited about sustainability. My name is Mark Chung. I'm a group manager and a researcher here at the National Lab of the Rockies.

Annie Luo 0:55
Cool, okay.

Mark Chung 1:02
I've been here for about 5 years, and we focus on TEA (techno-economic analysis) of hydrogen systems and behind the meter systems as well. Regarding my background, my bachelor's is in electrical engineering, and my master's is in energy economics.

And the reason I'm here at the lab is because I strive to drive impacts for a sustainable world.

Annie Luo 1:32
Yeah, thank you for that overview!

Your research focuses mostly on hydrogen energy systems. For audiences who might not have a technical background in this, what role do you see hydrogen playing in the transition towards cleaner energy or a more sustainable future?

Mark Chung 1:50
So the way to think about hydrogen, hydrogen is the element number one. So it's the first element on the periodic table, which means a couple of things, but the

most important thing means it's very light. It's extremely hard to contain. So hydrogen is typically looked at as not a competitor, but a complement to direct electrification.
Hydrogen is typically created by reforming natural gas. That's the primary way it's done today to support refinery consumption. But the other cleaner ways of producing it are via electrolysis. So we use electricity and water as inputs to produce hydrogen. And hydrogen is important because it's an energy vector.
So that hydrogen can either be typically stored or transported to use the electricity or be turned back into electricity either later in time or a different place. So that's what we mean by energy vector. It moves electricity from one location or one time to another time or a different location, or where it might be more useful. So that's generally hydrogen's role in the energy system.

AL **Annie Luo** 3:01
I see.
Your work also examines the entire hydrogen value chain, including production, transportation, storage, and then end use. Why is it important to analyze hydrogen in an integrated system rather than its individual parts?

CM **Mark Chung** 3:19
Yep, that's a great question. And hydrogen, you know, is useless if you just produce it by itself. It has to be moved somewhere, as we just explained a second ago. Hydrogen infrastructure is critical to the value chain because you have to move hydrogen somewhere else for it to be useful. Once you produce it, you have to store it and then transport it somewhere else. So the systems analysis view is important because you have to understand all the infrastructure that has to be built to support where the hydrogen might move to. And to understand the economics of it.
The value chain includes storage, transportation, and end use. Understanding how these systems tie together and the ultimate cost of what the hydrogen will be is important to understand from a systems level perspective. So that's why we study not just production, but our group studies production, storage, transport, and end use all within the same lens.

AL **Annie Luo** 4:19
Yeah. That's really interesting how you analyze the integrated system versus just its production.

Mark Chung 4:29
Absolutely. And what's also important to note is that hydrogen is going to fit somehow into our US energy infrastructure. And because of that, it requires a system level analysis. There's no doubt. There is infrastructure today for it, but it's not as mature or as well-built out as, say, natural gas infrastructure. So a key challenge is to understand the whole supply chain or the whole value chain and what other components need to be built out to support and integrate it with the existing energy infrastructure.

Annie Luo 4:59
I also think a lot of people don't really consider the other factors other than production or its use.

Mark Chung 5:08
Right. I mean, I think if you live outside California, then yeah, people are less familiar with hydrogen. Californians, I think they understand it a little bit more just because, you know, it's in their ecosystem today and used for vehicles.. There's production, there's transportation, and there's end use. There's fueling stations in California. So it's more visible to Californians. But yes, for anyone who's outside California, it may be more difficult to grasp if you don't see it, you know, on a daily basis.

Annie Luo 5:37
Yeah.
A major focus of your work is also like techno-economic analysis. How do factors like cost, infrastructure, as you mentioned, and then emissions like influence whether a clean energy technology can successfully scale?

Mark Chung 6:35
Cost is an extremely important determinant. The delivered cost is important. The cost of production is also important. But as we said before, what matters is the delivered cost of hydrogen. So by the time that molecule is produced, stored, transported, and dispensed, that delivered cost to the end user adds up and is important to understand. So that's why we bring a systems level approach to understand: this is how much it's produced for, but when it gets to the end user, how much is it really going to cost, right?

On one hand, understanding the delivered cost is extremely important. On the flip side of that coin, though, is also willingness to pay. So the customer's willingness to pay to adopt a new technology is extremely important because we understand whether that consumer's willingness to pay matches up with the delivered cost of hydrogen. If not, then there's a major problem there that has to be addressed, and we need to understand why. So cost is a primary determinant.

Efficiency, I would say, is more of a hidden cost. Efficiency in terms of production methods, when you produce hydrogen and then you store it and then reuse it again, you lose quite a bit of efficiency between through the value chain.

AL **Annie Luo** 7:45
Yeah, definitely.

CM **Mark Chung** 7:56
On top of that, there's also the possibility or potential for leakages. Because hydrogen's so light, it can escape from storage, it can escape from pipelines. That leakage is energy that is otherwise wasted; you could have monetized it. So understanding efficiency and potential for leakages is really important because that can add up along a large value chain. And the bigger the scale of the value chain, possibly the bigger the impacts of efficiency are going to be on your project.

I think infrastructure was the last one that you pointed out. Yeah, infrastructure is so important because people have to have confidence in developing infrastructure. Infrastructure is expensive. A pipeline is expensive. It takes many years to permit and develop. And if investors don't have confidence that the infrastructure is going to be viable for the next 10, 15, 20 years, then the likelihood of them building this infrastructure out is going to decrease. So it's really important to understand the cost drivers for infrastructure, and why investors may or may not be willing to invest in it.

AL **Annie Luo** 8:56
Yeah.

CM **Mark Chung** 9:04
And then kind of on the flip side of that, which you didn't really mention, which I think you're implying, is also policy. So having some policy in place that's

consistent is also important for that long-term thinking, that confidence that infrastructure is going to be used.

Annie Luo 9:08
Yeah. Thank you for that explanation. There's so many different, complex factors that go into whether a technology would succeed.

Mark Chung 9:28
Yes, absolutely. It's a very complex picture when you start to piece all the components together.

Annie Luo 9:35
What would you say are kind of the primary barriers of today that prevent them from scaling? And would they be mostly based on technological innovation itself, economic, policy-based, or a combination of all these factors?

Mark Chung 10:03
Well first of all, hydrogen is commercially available, it's mature. We know how to produce it. The problem with production (electrolysis) is that we haven't scaled it large enough to be able to reduce the cost, right? So manufacturing capacity is, I think, the next nut to crack, if you will, on the production side, to help bring those costs down.

Economics is definitely a key driver. If no one's willing to pay for it, then there's no point, right? Right now, there's no, at least in America, there's very little demand pull. There's little interest in (clean) hydrogen consumption. It's just not big enough to say, "I want more, develop more technology for me." If you look at Europe, there's a strong demand pull. Europeans are all for it. They want more hydrogen.

Annie Luo 11:05
Yes, definitely.

Mark Chung 11:18
Policy, we can talk a little bit about policy. With administration changes every four years, it also makes it difficult to maintain confidence and foresight for investors

who are making 20-year infrastructure commitments. Policy is important and it has to be somewhat consistent to give investors sufficient confidence.

And then coordination, because infrastructure is integrated, I don't think there's any vertically integrated hydrogen players today. So there's no one out there that goes and builds production, builds storage, transmission, and end use. So a coordinated approach between all these players in industry also needs to happen. And there are groups, there are business groups that help foster that. I think there could be improvement in coordinating building out the value chain.

AL **Annie Luo** 12:11
Mhm.

CM **Mark Chung** 12:31
And last thing that I think people miss a lot. If shareholders and stakeholders demand more from the companies that they're a part of, and maybe they tie executive or board compensation to sustainability outcomes. This could be a strong mechanism to properly align incentives and drive these companies to deliver more sustainable solutions.

AL **Annie Luo** 13:25
Yeah, that's really interesting seeing how there can be different challenges and incentives to hydrogen production and usage. As energy systems become increasingly more interconnected in modern day, how important is it for a system level analysis and deciding which technologies should be prioritized?

CM **Mark Chung** 13:41
Right. As I mentioned before, hydrogen is a complement to electrification. In some cases, they compete. But generally speaking, we know hydrogen has its sweet spots. It's not going to, it's not a one-size-fits-all solution. So for example, in transportation, it's not light duty vehicles. We know it's most likely going to be long or heavy duty vehicles, long haul transport, aviation, marine, freight. Those are places where hydrogen makes a lot of sense. In heavy industries like steel and ammonia, it's very difficult to directly electrify those industries.

AL **Annie Luo** 14:16
Mhm.

Mark Chung 14:23
So again, that's another instance where hydrogen makes more sense than direct electrification. And so what I'm getting to is having a systems level approach or thinking about where hydrogen makes sense, where it doesn't, helps give policy makers and people in Washington who fund R&D clear answers as to where it makes sense, where it doesn't. And it allows them to funnel funding into the right areas to make sure that we're good stewards of taxpayer dollars, and we're pushing research in the right ways, wherever it makes sense for hydrogen.

Annie Luo 15:12
That's really interesting how hydrogen fits in some industries and not others. Before we wrap up, is there anything that we didn't get a chance to discuss during the interview that you think is important for people to know about hydrogen systems or sustainability in general?

Mark Chung 15:23
Yeah, I think it's, like I said before, hydrogen is not a silver bullet. So I think some skepticism is always healthy. So people push back because hydrogen kind of gets a bad rap, especially due to certain events in history that have branded it differently. So people should question, "does hydrogen make sense?" They should question, "is this technology affordable? What other indirect effects is it going to have on us?" And when stakeholders or when the public speaks up about that, it gives us better direction on where we should develop and how we should also educate the public.

Annie Luo 16:04
Yeah.

Mark Chung 16:04
Some people's beliefs are slightly misplaced. At the labs, we're not advocates of hydrogen. We're agnostic. So our job is to help out and say, this is where hydrogen fits, this is where it doesn't, this is what it costs, these are the benefits, and overall give the public that information so they can make their own decisions based on that. Skepticism is definitely important for the community because these technologies will be deployed in communities around the world. It's healthy for them to question it.

And we're here to help with the iteration, the feedback, and for education as well, and to make sure that we're answering all the questions that people have on these technologies.

Another thing is gaps. So I think what we didn't talk about is well-trained personnel. So for technologies to be adopted, we also had to catch up on the workforce side. It's education, but it's also training, whether it's technicians or policy makers or EMT personnel, emergency response personnel, that all needs to happen as well to be able to foster and develop an ecosystem that's sustainable.

Annie Luo 17:16

Yeah.

Mark Chung 17:35

We can't develop a technology and not have the supply chain and trained personnel. Having those things work in parallel is important.

TEA (techno-economic analysis) is also important, but as we mentioned, for young people like yourself who are getting into this, engineers are definitely needed, there's no question. But, we also need people on the policy side who can communicate this effectively to a non-technical audience. That's extremely important. People that help write policy, economic analysts, those are all important parts of the ecosystem that we need to develop as well. And so I hope it's a key to continue to see that get developed here in the US over the next several decades.

Annie Luo 17:35

Yeah, definitely. Thank you for taking time to do this interview with me today! I really enjoyed hearing about your research and then also your perspective on scaling technologies, including techno-economic analysis.

Mark Chung 18:31

Yeah, you're welcome. Glad to have done this and hope you find it useful!