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Blue Hydrogen: What You Need to Know

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QUESTIONS FROM THE CHAT

Answers provided by the speakers

1. **Regarding green hydrogen, we have a political problem in Pennsylvania. Green hydrogen projects are proposed, but with the caveat that it will start as blue and change to green when it's feasible, with no actual plan to move to green. What advice do you have to deal with that?**

   This is a very frustrating, common, and misleading marketing tactic from the hydrogen trade associations. A good thing to do is to set guardrails in policy that require demonstrating a commitment to purchase electrolyzers and renewable energy.

2. **Could green hydrogen be used more broadly than the limited list of viable uses for hydrogen Mark Jacobson mentioned at the start of the webinar?**

   Green hydrogen *can* be used very broadly—for almost anything. The crucial question is: should it? Given the huge amount of energy needed and the problems with handling hydrogen and leakage, many believe it should be limited to only those applications where electricity cannot satisfy the need directly. Hydrogen is hydrogen. The colors only refer to the energy source used to generate the hydrogen.

3. **Southwestern Pennsylvania has lots of coal and gas resources, which were helpful in the past for steel and other heavy industries. Those resources must be phased out if we want to play a meaningful role in the carbon-negative economy. That said, we don't have extraordinary wind or solar opportunities here in Pennsylvania (compared to offshore wind or solar in the Southwest), but we DO have abundant water in the rivers that meet in Pittsburgh. What elements of the carbon-negative economy do our land/rivers/weather best support? What abundance can we leverage for economic vitality in Southwestern Pennsylvania?**

   Solar might not be perfect in Southwestern Pennsylvania, but it isn't bad; wind is pretty good, too. Work on capturing energy from river currents is underway. Southwestern

Pennsylvania certainly has the geography and infrastructure (rivers, highways, rail, educated workforce) to rapidly expand manufacturing of renewable energy technology and export it to other, less endowed regions. I think we need to push back on the narrative that the transition to 100% renewables has to occur uniformly around the U.S. or that to save the planet from climate change, the fossil fuel switch needs to be clicked off all at once and immediately. No one advocating serious climate solutions is saying that! Taking the Intergovernmental Panel on Climate Change's (IPCC) advice, greenhouse gas emissions need to fall 50% by 2030 (not 100%). The Northeast will rely on methane for heat and light longer than the South and Southwest—regions that should already be way ahead in solar by now. Geothermal can be explored faster in the West. Wind has been ramping up in the Plains states for some time. And wherever one lives, energy efficiency and energy conservation can be observed and promoted.

4. **You have confirmed that blue hydrogen is primarily promoted as a use for natural gas [methane]. That said, can we identify the highest and best uses of natural gas [methane] (or petroleum)? We should be clear about any uses for which we do think we'll continue to need fossil fuels, and how those can be responsibly acquired, applied, and offset.**

   I share this view. I think in the transition years where we still use fossil fuels in the hardest-to-decarbonize sectors, we carefully prioritize fossil fuels (including blue hydrogen). But today, blue hydrogen hardly exists as an energy source, so the question is: Is it worth it to build new, long-lived infrastructure for additional dirty energy we know we will need to transition from quickly?

5. **Can Sasan [Saadat] repeat what he said about how we should be thinking about rolling out energy?**

   I believe the priority needs to be maximizing the amount of fossil fuel we displace in the next seven years. This means we need to prioritize deployment of cost-effective, available solutions (like directly electrifying transportation and buildings using renewable electricity) ahead of trying to mature green hydrogen.

6. **What about mining lithium, copper and all resources and minerals to make batteries and electric vehicles, additional appliances, etc.? A majority of these mines are attempting to desecrate indigenous sacred lands. Oak Flat, Thacker Pass, for example.**

   While it is essential that we limit the scale and impacts of mining clean energy (e.g., by increasing use of public electric vehicle transport, denser housing, reducing wasteful consumption, and building a circular economy), we should also recognize that this extraction would be smaller in scale than our current extraction of fossil fuels. In addition, fossil fuels must be continuously extracted and burned rather than extracted once for the life of the

piece of equipment, as in batteries/panels. Hydrogen does not avoid the need for this extraction. Because green hydrogen requires three times the amount of renewable electricity, it will magnify the amount of copper wire, battery storage, and renewable energy need relative we to a scenario where we directly use renewable power more efficiently.

7. **It takes about 25,000 km (about 15,500 miles) to get to break even on a Tesla EV. The main issue in renewables is accounting. Isn't it unfair if we don't talk to credible cradle to grave carbon accounting and the enormous costs to health (emissions and water) even in manufacturing of renewables?**

   Assuming we use green hydrogen, the amount of materials we need to mine and extract to produce that green hydrogen is magnified compared to the lower-intensity pathway of using that electricity in a battery. We should aim to maximize recycling and safe extraction of battery materials, but green hydrogen will not evade these problems. Blue hydrogen (which relies on recurring extraction of fossil fuels) is worst of all.

8. **Regarding green hydrogen, can you touch on the amount of water that would be needed in the electrolysis project and what the source of that water would be? Would it be ground water or streams/lakes? Is salt water feasible?**

   The water demand for hydrogen is high, but some research suggests it is much lower than the water demand for fossil fuel energy systems. Electrolyzers today must rely on freshwater, but there are some proposals for relying on desalination (which adds to the inefficiency and cost).

9. **Sasan [Saadat], how do you scale green hydrogen for agriculture?**

   One way would be for policymakers to require and/or incentivize ammonia producers or the food industry to procure increasing amounts of green hydrogen as a share of all the inputs to their ammonia production. India and some other places have set standards to these effects.

10. **The talk in my part of Pennsylvania is that we should fight for blue but have requirements that they phase to green over time. The thinking being that since the money is there for blue, we should jump on it, create jobs, and then force a transition to green. Seems wildly wasteful and likely to fail.**

    The $8 billion from DOE is for a hydrogen hub. It's up to the applicants to make the case for blue versus green. It's up to policymakers to understand the differences and realize that blue hydrogen is a bad investment that directly and indirectly threatens public health and the planet's climate system.

11. So, are you saying that we probably won't even figure out how to scale CCS [carbon capture and storage] before we have to get off of blue hydrogen?

Exactly. Both achieving very high capture rates (>97%) and very low methane leakage rates (<1%) are needed for blue hydrogen to actually help reduce emissions. Neither of those conditions are close to being met, nor are they likely to be before 2030.

12. Are there any parts of the country where local economies would stand to benefit from an expansion of green hydrogen technology?

Green hydrogen offers the potential for both local development and climate benefit almost anywhere, but it will crucially depend on how the hydrogen is produced, how it is stored/transported, and what it gets used for, as well as the quality of jobs associated. We can imagine, for example, green hydrogen for onsite fertilizer production at farms across the Midwest. This would make them rely less on fossil fertilizer inputs from right-to-work states like Alabama (where gray ammonia [which uses fossil fuels as feedstock and does not employ carbon capture and storage to sequester the carbon byproduct] is mostly produced through nonunion labor).

13. Sasan [Saadat], could you explain your statement, "the amount of materials we need to mine and extract to produce green hydrogen is magnified compared to the lower-intensity pathway of using that electricity in a battery"?

Yes. Because you need more renewable energy to produce a given amount of fuel when you convert it to hydrogen, that equates to three times the solar panels, wind turbines, etc., needed to produce green hydrogen than to use that renewable energy directly in a battery.

14. I am interested in non-hydrogen alternatives for producing ammonia that would be intended for transportation. Any recommendations for large industrial alternatives for ammonia plants especially for transportation uses?

There are not any substitutes for hydrogen as a feedstock for ammonia that I am aware of (since ammonia is NH3, it requires the element). Green hydrogen for the production of ammonia would be a big improvement over our current use of fossil methane. But the question may be: Do we need ammonia? Its primary use is as a fertilizer. Hard to see us eliminating chemical fertilizer use from the global food system, but in an ideal world we will significantly reduce its use. The need for ammonia for uses in transportation is far less certain. It's possible it will play a role in long-haul shipping, though batteries or hydrogen fuel cells may also be contenders here.

15. **Connecting with communities who have existing facilities that pollute and disrupt the quality of life is a great opportunity for education. How could we scale a program like this into a digestible format for folks that are not aware of the potential impacts of hydrogen production?**

    There are a number of nonprofit organizations in Pennsylvania, including EHP, that are doing just that!

16. **What is the risk of explosions [from hydrogen production]?**

    Today, we successfully safely handle hydrogen in the small niche sectors where it's used. But no one knows how safe it would be to use hydrogen widespread across homes and refueling stations around the country close to where people live. Highly compressed hydrogen does pose an explosion risk because of hydrogen's high flame temperature and wide flammability range.

17. **The DOE in the Biden Administration is pushing hard for the development of blue hydrogen in the Ohio River Valley. There are research/consultant groups, industry groups, unions, and local high ed institutions that are pushing for a blue hydrogen future in the region. The political strength of this coalition is incredible. How are we getting this information to these groups and putting them on the record to answer directly to these criticisms?**

    At the end of the day, it's up to all of us to hold the decision makers accountable. It also highlights how corporate boards and trustees of public institutions are corrupted by the fossil fuel industry. As you know, there is lots of oil and gas money influencing what goes on at our universities, financial institutions, and government agencies.

18. **Why are two sets of carbon capture and storage (CCS) necessary?**

    There are really three:

    - Upstream CCS (capturing CO_2 from the well pads, gas compressors, and processing facilities, etc., if that is even being considered)
    - CCS to capture CO_2 produced by steam methane reformation process
    - CCS of the CCS machinery itself (to capture the CO_2 created in order to operate the fossil energy-intensive CCS scheme).