CLIMATE TRANSFORMED

CLIMATE 2023

A Preview of the Year Ahead

Hydrogen

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Hydrogen

Claire Behar is the Chief Commercial Officer at Hy Stor Energy, a renewable hydrogen and hydrogen storage company headquartered in Jackson, Mississippi.

Mark Selby is the Chief Innovation Officer at Ceres, where he provides leadership for the innovation of technologies beyond the company's portfolio.

Zach Steele is the Co-Head of Fusion Fuel, a company that has created a modular integrated solar-to-hydrogen generator.

Richard Hulf is the Managing Partner at HydrogenOne, the first London-listed hydrogen fund investing in clean hydrogen.

Summary

Our current energy vulnerabilities are desperate for a solution. Has hydrogen's time come or will a lack of infrastructure continue hold back its potential? Can 2023 be the breakout year for Hydrogen contribution to the clean energy mix? **Watch the full session here**.

Key takeaways

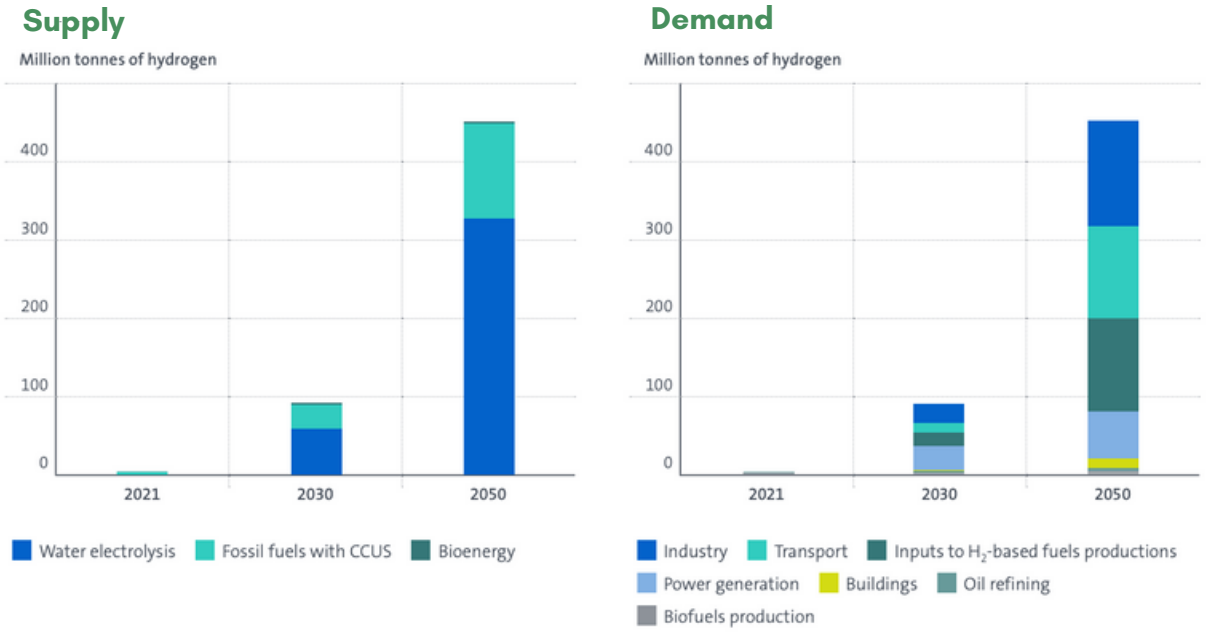
- 2022 has been an incredible year for clean energy due to the passing of the Bipartisan Infrastructure Bill and the Inflation Reduction Act (IRA). The Production Tax Credits have positively impacted green hydrogen and have lowered the costs of green steel or green fertilizers compared to fossil fuels.
- To gain investor confidence, we need to communicate the low risks of green hydrogen production compared to oil and gas technology. In the case of oil and gas, exploration wells have a 1:10 chance of success, making this industry riskier.
- Investors are skeptical about funding large projects as the offtake agreements are not there.
- REPowerEU is the European Commission's plan to make Europe independent from Russian fossil fuels well before 2030 in light of Russia's invasion of Ukraine. Small and medium-sized hydrogen projects are running right now. The European Green Deal has given a roadmap for 40 gigawatts (GW) of electrolyzer capacity in the EU by 2030, coming from the EU, North Africa, and some parts of Ukraine. Germany, in particular, is embracing hydrogen.
- There is a shortage of components such as fuel cell electrolyzer systems and iridium in the hydrogen sector. Costs are currently a concern.
- Because of the enormous infrastructure and transportation, hydrogen facilities must be close to hard-to-abate industries such as steel, cement, and chemicals if it is going to be the preferred source of heat.

Paul's observations

"If you build it, they will come." This is a commonly used phrase when looking at future technology adoption. Skeptics about the use of hydrogen often point to a lack of customer demand for hydrogen as a feedstock for fuel as a sign that hydrogen is nothing more than a solution looking for a problem. While advocates are overreaching with the belief that hydrogen is the solution to most of our clean energy requirements, large-scale infrastructure will be required before industries can commercially adopt hydrogen as a replacement for fossil fuels in heat generation. While this is a natural starting point for the industry, offtake agreements, new customers, and therefore profits and cashflow are many years away. Comparisons to the nuclear industry are valid. Both will require hundreds of billions of dollars and a decade-plus to get to the stage where adoption rates reach critical mass. Unlike nuclear, green hydrogen requires renewable energy, a product that remains in relatively short supply. Green hydrogen production will take away renewable power from other sources. Therefore, the scaling of green hydrogen will first require an enormous expansion in renewable energy. We are a long, long way away from hydrogen being relevant.

"The European Green Deal has given a roadmap for 40 gigawatts (GW) of electrolyzer capacity in the EU by 2030."

Supply and demand for low-emission hydrogen in the International Energy Agency's net-zero emissions scenario



Source: International Energy Agency

Questions & Answers

The outlook for Hydrogen in 2023

Claire Behar:

2022 has been an incredible year for clean energy due to the passing of the Bipartisan Infrastructure Bill and the Inflation Reduction Act (IRA). The Production Tax Credits have positively impacted green hydrogen and have lowered the costs of green steel or green fertilizers compared to fossil fuels. The factors of certainty and price competitiveness are required to grow this industry. We need to start projects on a large scale in the 2020s to meet our goals in the 2030s.

There are a few regions around the world where we can execute large-scale green fuel projects into service. The core model of Hy Stor Energy is salt cavern storage, which requires specific geologies. Our first project is in Mississippi, where we have sufficient land far from the populated cities and access to deepwater ports. We have spent time trying to get permits. Many of these projects require four to five years to get to the design phase. Large-scale industries like green ammonia and green steel require a vast amount of hydrogen fuel to meet their net-zero commitments, and salt caverns are the solution to scale to that point economically. Co-locating our plants with such industries can create opportunities in terms of the increased demand for hydrogen.

Richard Hulf:

Like any other sector, some projects in the hydrogen sector will be successful, and some will fail. The investor community can now see green hydrogen being stored and sold in the system, which is attracting interest. We have to start small and scale production. To gain investor confidence, we need to communicate the low risks of green hydrogen production compared to oil and gas technology. In the case of oil and gas, exploration wells have a 1:10 chance of success, making this industry riskier. Now, we are going into the phase of the practicality of project management. We will not be funding to design a project until the project manager shows us an offtake agreement. This demonstrates to the investors that the projects will have positive outcomes. This sector will start ramping up once we overcome the hurdles. There have been nine investments in the hydrogen sector, two of which are in projects based in Norway and Germany. We expect to move out of the front-end engineering design (FEED) phase of those projects in the first quarter of the next year. We will make the final investment decision (FID) on these two projects. There are five to 10 projects in our portfolio with both companies.

The hydrogen sector is likely to draw the interest of investors who believe in the green revolution. However, the financial community is skeptical about these projects because they rely on past years' data. Therefore, they will be surprised to see the advancement in this sector.

Mark Selby:

There is a rapid change in interest in the hydrogen sector, and we will be excited to see it improve in the next 12 months. We can tell if the hydrogen sector is gaining confidence if it attracts large investments on the industrial scale. There were a lot of investment commitments in 2021, but only 1% of them reached

the final decision. New innovations and failures happen as we start working on the technology. The skeptics will look for strategic investments, so this sector requires innovations to attract the confidence and interest of the investors. On a positive note, legislative factors such as the passing of the IRA are making the hydrogen sector attractive for investment.

Zach Steele:

Right now, hydrogen projects are being developed on a large scale, but these megaprojects have a lot of complexities, such as getting permits, additional infrastructure, and transportation costs. This requires large-scale investments, sometimes in billions, which makes investors hesitant. So, we will have small-scale projects in the next year which can gain investment interest easily. This sector needs to scale gradually until people feel comfortable making big investments.

The co-location of the industrial and green fuel plants

Mark Selby:

The energy transition is not only about decarbonization but also about reducing energy consumption. The major portion of the operating costs for producing green hydrogen consists of energy, which is 30%, but it is likely to come down in the future. We require an intrinsically high-efficiency technology. Secondly, we can co-locate with systems and other technologies that produce heat waste and recuperate that heat electrochemically at a high-temperature electrolyzer. This way, we can produce green hydrogen in an energy-efficient manner. So, coupling industries like green steel or green ammonia with high-temperature hydrogen production can be incredibly efficient and economical.
We need to work on figuring out some systems like the chemical industry, power, and heat systems to scale energy production. In the next few years, we will witness smaller projects growing from tens of megawatts to hundreds of megawatts. Our goal of primary energy reduction in the next 15 years can be achieved by coupling systems.

Overcoming the challenges of developing hydrogen projects

Zach Steele:

Fusion Fuel has recently secured a grant of $36 million. In the last 12 months, the company has been working on getting land and resources. We have been working on executing the plans through concept study to creating FID and developing the stage A process of the discipline. We have been getting a reinforcement of talent with additional hires.

"In the next few years, we will witness smaller projects growing from tens of megawatts to hundreds of megawatts. Our goal of primary energy reduction in the next 15 years can be achieved by coupling systems."
– Mark Selby

Claire Behar:

Salt cavern of hydrogen storage has been around for over 60 years. The first facility was built after only 9 years of natural gas cavern storage. So, the technology to construct, develop, and operate these facilities is well known, but most people are unaware of this.
There is a demand for renewables on a large scale. Increasing their production and long-duration storage will be more important than ever. Our end goal is decarbonization. Therefore, we need to focus on the markets where green hydrogen is the only solution. We focus on providing green hydrogen to hard-to-abate high energy-intensive industries such as steel, chemicals, and maritime.

What is the duration required to develop and run REPowerEU projects, and which countries will they appear in first?

Richard Hulf:

REPowerEU is the European Commission's plan to make Europe independent from Russian fossil fuels well before 2030 in light of Russia's invasion of Ukraine.
Small and medium-sized hydrogen projects are running right now. The European Green Deal has given a roadmap for 40 gigawatts (GW) of electrolyzer capacity in the EU by 2030, coming from the EU, North Africa, and some parts of Ukraine. Due to the Ukraine war, the need for power has been upgraded to 300 GW of power. Our colleagues are funding hydrogen projects to get them started. With the demand upgrade, we will shift from using fossil fuels to hydrogen and back up the projects with increased funding through the European Investment Bank and other sources. This year, we have seen joint support from the UK and the German governments for 10-gigawatt targets for hydrogen production. The challenge lies in funding at a large scale, which can be overcome by direct financing of these projects.
Currently, France is moving at a fast pace regarding its hydrogen policy. Any region in Europe with a strong economy will start green hydrogen projects, depending on where the green electricity comes from.

Mark Selby:

Green hydrogen projects tend to develop faster in Europe as they are funded through programs such as REPowerEU. This way, more investments are likely to flow into these projects. German tranche funds are going to domestic providers and technology companies. Also, big industrialists are contributing to financing these projects. Money flowing from these resources is immediately backed up by a coherent and credible industrial strategy. Most German industrialists will seek a large market share of these programs.

"We need to focus on the markets where green hydrogen is the only solution." – Claire Behar

Gaining the trust of the investors

Claire Behar:

Investors do not want to take risks, so putting together a portfolio of different end users with varying sizes and demand profiles will be crucial. Hy Stor Energy's projects have several large industrial and co-location opportunities. We have a partnership with the Port of Gainesville, which has an international airport, a thriving port, and the Gainesville Industrial Park. This is one example of large-scale industries requiring green hydrogen to decarbonize. We are also focusing on attracting new green manufacturing to the location. After the IRA, we have noticed an increased interest in international companies regarding green manufacturing in the US.

Zach Steele:

We are focusing on two main sectors: mobility and industrial decarbonization. For the mobility sector, we will initially have hydrogen fueling stations for forklifts, buses, and heavy-duty trucks by mid-decade. Our site locations will be next to major distribution centers, and our customer base will mainly be logistics and distribution companies. On the industrial decarbonization side, we are targeting large industries in Portugal and Bakersfield, California. We also focus on gas blending to sell to customers in various regions.

How crucial is an offtake agreement for making investment decisions?

Richard Hulf:

Offtake agreements are crucial for making investment decisions and help build trust while negotiating because companies do not want to commit to an offtake unless they are committed to building the project. Another important aspect to consider is the location of the project. It should be located near the storage side and the off-taker.

Are there bottlenecks in the supply chain?

Mark Selby:

Currently, there are no bottlenecks in the supply chain. For example, a polymer electrolyte membrane electrolyzer uses iridium to produce hydrogen fuel. As we start to scale and innovate, we will get less dependent on this material. We will observe high-temperature electrolysis not being dependent on critical components where supply chains are likely to be stressed. Building a gigafactory for high-temperature electrolysis or proton exchange membrane (PEM) will require 3 to 4 years to work at full capacity. We need to scale the value chain by that time.

Zach Steele:

There is an increase in cost throughout the industry, specifically for iridium. We are working with Toshiba regarding that. Currently, we are working to reduce supply chain issues. These are not long-term issues, but we must solve them over the next few years.

Richard Hulf:

There is a shortage of components such as fuel cell electrolyzer systems and iridium in the hydrogen

sector. The investors are asked to advance more capital into these projects to provide greater working capital because of the high demand. This increased demand depicts the healthy environment of this industry.

Are there concerns about project delay due to a lack of supply of critical materials?

Richard Hulf:

It is a slight concern, and we might get support from China. For instance, the electrolyzer is a critical item in the supply chain, so that we can buy it from manufacturers with reliable delivery, reliable design, backup, and maintenance engineers with smooth communication. This goes in favor of Western European suppliers. As this sector starts to globalize and joint ventures are created between Western and Eastern companies, it will help meet the high demand.

Claire Behar:

Apart from system components, we need to invest in the workforce, such as talents like electrical engineers, mechanical engineers, and geoscience experts.

Mark Selby:

The hydrogen sector can be hard for professionals who have not worked with gases and have experience working only in the oil and gas sector. So, we need to work on bringing engineers to the market who can work with both.

Iridium Price Prediction, 2023–2032

Year	Minimum Price	Average Price	Maximum Price
2023	$0.012	$0.013	$0.015
2024	$0.018	$0.019	$0.022
2025	$0.027	$0.028	$0.032
2026	$0.043	$0.044	$0.048
2027	$0.063	$0.065	$0.074
2028	$0.091	$0.093	$0.11
2029	$0.14	$0.14	$0.16
2030	$0.20	$0.20	$0.23
2031	$0.27	$0.28	$0.35
2032	$0.39	$0.41	$0.47

Source: Price Prediction

Where would be valuable for investors to focus on across the hydrogen value chain over the next 10 years?

Richard Hulf:

New projects have started to scale at a faster pace. Most of them are transitioning from the FEED stage to the FID stage. We will figure out the rate of scale for these projects within 12 to 18 months; then, they will grow quickly from megawatts to gigawatts. I want to position my investors in some of the best project sites around the world, generating great returns on the capital invested. Secondly, I would suggest my investors partner with businesses that are used to scale up.
Currently, we are investing in companies that store hydrogen in compressed form for industrial processes. The aviation industry is considering using compressed hydrogen to go into fuel cells used in turboprops. Eventually, they will prefer liquefied hydrogen to be used in jet engines. Over the next 5 to 10 years, we will be investing in hydrogen liquefaction.

Mark Selby:

Electrochemistry is the bridge between electrons and molecules. We have to decarbonize our economy through electrification. This will be the most fundamental technology over the next decade, be it in the form of batteries, electrolyzers, fuel cells, or any other electrochemical synthesis process. So, the core technology will be important from an investment perspective. Secondly, this technology is growing exponentially, and so are the investment opportunities. Long-duration energy storage will be the next massive hype cycle, but it will face value destruction after some time.

Claire Behar:

Hydrogen storage for a long duration will be critical in terms of investment.

How do you approach the challenges and costs of transporting hydrogen to demand centers?

Claire Behar:

Choosing the right location is critical. It is crucial to have access to major logistics, transportation corridors, deep water ports, and rivers. Scaling hydrogen plants is expensive as it requires building pipelines over multiple states and large storage above ground. This is why it is critical to locate these plants where we can scale them easily and utilize the geography and geology to build an ecosystem with co-location of production, storage, and delivery.

Zach Steele:

Co-locating can cut out around USD 2 per kg of the overall delivered cost model. We are focused on co-locating our system next to the facilities to reduce the logistical cost.

Thank you for reading. Click here to access all of the sessions from Climate 2023.

Learn more about the companies featured in this interview:

- **Ceres**
- **Fusion-Fuel**
- **HydrogenOne**
- **Hy Stor Energy**