WHITE PAPER

Empowering green hydrogen:
Data's key role in sustainable energy generation

Executive summary:

Industry experts increasingly see hydrogen as a major tool to further decarbonization efforts and ease the transition to cleaner forms of energy generation. Hydrogen is a leading contender to be a carbon-free, seasonal energy storage solution. It could be used to balance the short-term intermittency of wind and solar and easily transported using modified natural gas infrastructure.

Research by: zpryme

Executive summary (continued)

However, the green hydrogen value chain will be more complicated than any current energy carrying vector. It will be broader, more complex, and have more stakeholders. Optimizing green hydrogen production will rely on visibility across the value chain. Decisions made at one end of the value chain could rely on events at the other. These decisions may be made in real time, based on data shared across the ecosystem.

The long-term viability of green hydrogen will demand a strong data foundation. Knowing when to profitably produce, transport, and store hydrogen or when to convert it into other chemicals will be dictated by many factors. These include an oversupply of renewables generation, steel, ammonia, or fertilizer prices, or regulated hydrogen reserve levels. A robust data infrastructure can provide all stakeholders with the enterprise-level situational awareness required to make the right choices at the right time.

Once they have this complete view, companies will be able to make more informed, data-driven decisions. From hydrogen production optimization, through equipment- and system-level predictive analytics, to site-level asset performance, all business processes can be monitored both technically and financially for continuous improvement and optimization.

This paper highlights the factors driving investment in green hydrogen, why green hydrogen is a likely future energy-carrying vector, its many uses – both inside and outside of the energy industry – and why utilities need to start planning the data infrastructure that will support the industry. It draws on a survey of 112 utilities, which provides insights into the industry's current preparations. While nearly half of respondents agree that green hydrogen is a significant revenue opportunity, only 19% have a clearly defined strategy for green hydrogen.

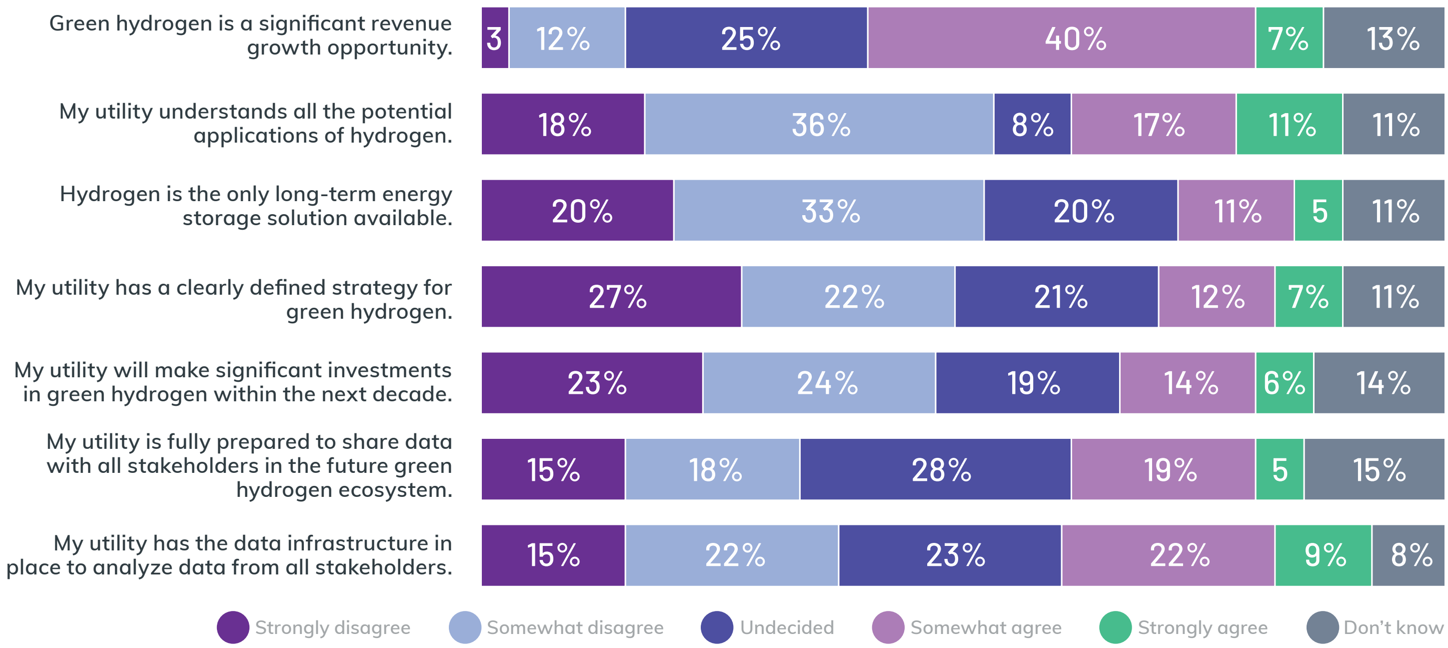
A majority recognize the revenue opportunity of green hydrogen, but few recognize its full potential or are fully prepared for the green hydrogen economy.

Only 32% of utilities have sufficient data structure in place.

Only 20% of utilities will invest in green hydrogen in the next decade.

Despite this lack of investment, **only 15% disagree** that green hydrogen is a revenue growth opportunity.

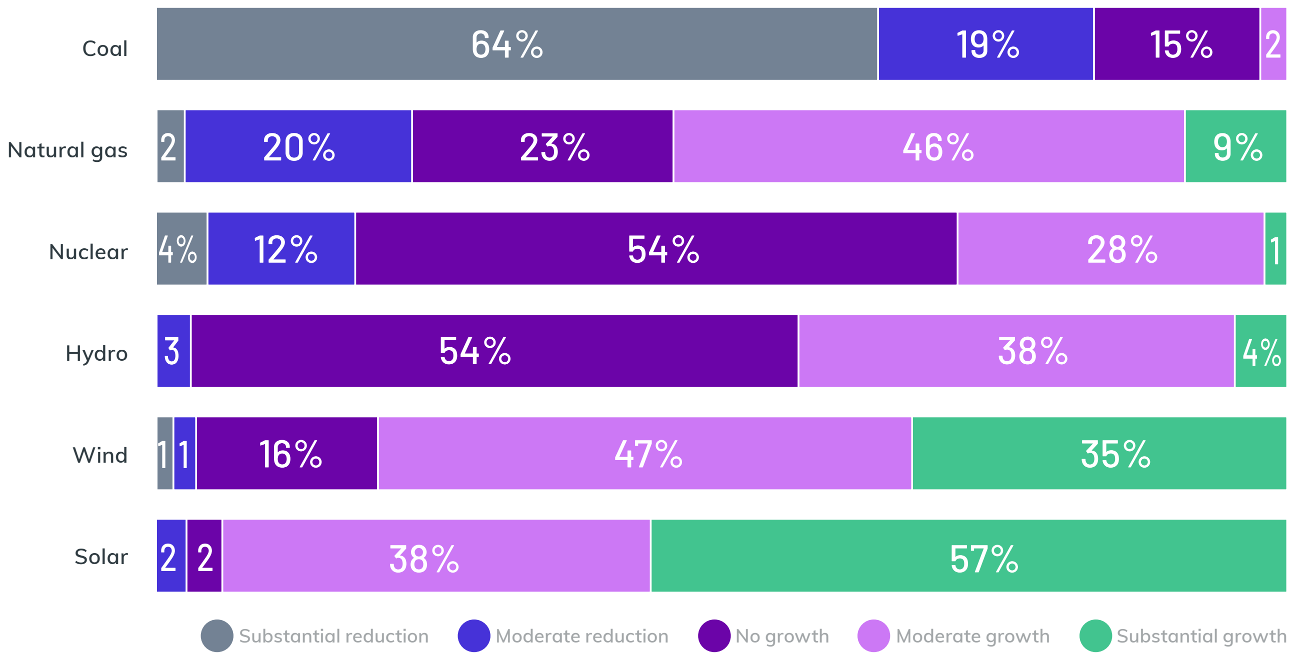
Figure 1: ***How much do you agree with the following statements?***



Renewable energy growth forces hydrogen investment

After decades of relative stability, the electricity sector is undergoing significant disruption. The energy transition is gaining momentum, supported by the development of new energy technologies, such as wind, solar, and battery storage. While 55% of utilities expect natural gas generation to grow, its use as a bridging fuel in the energy transition could mean its long-term future is less certain.

Figure 2: ***How much will the use of different generation technologies change within the next decade?***



However, existing energy technologies will not be able to deliver countries' net-zero commitments alone. One reason is the widely held belief that distributed energy resources (DERs), such as wind and solar, will cause significant balancing issues on grids. While natural gas is currently used as a bridging fuel, it hinders countries' net-zero carbon commitments. Battery storage can help balance networks, but it cannot do so alone.

Renewables will cause significant balancing issues, but batteries alone will not manage these issues. The industry is uncertain about hydrogen's role in future network balancing.

Nearly half (46%) of respondents anticipate carbon capture and storage becoming a viable way to reduce emissions.

78% expect future power network balancing issues from increased wind and solar generation.

62% disagree that battery storage alone will meet network balancing needs.

While many respondents (45%) were unsure, **39% agreed** that green hydrogen will play a vital role in network balancing.

Why the hydrogen hype in power generation?

The obvious advantage of using hydrogen for power generation is its lack of carbon emissions and byproduct waste. Since hydrogen is burned in the presence of oxygen, the only waste it produces is water. The two main drivers for hydrogen use in the power industry are as a fuel substitute for natural gas in combustion turbines and as energy storage to balance the intermittency of solar and wind.

Several original equipment manufacturers (OEMs) claim their combustion turbines are capable of burning up to a 30% hydrogen mix, with expectations to achieve 100% hydrogen firing within 10 years. Using hydrogen to store excess renewable energy has the potential to positively impact the adoption of renewable energy and achieve the goal of zero carbon emission.

With significant cost reductions and technological improvements, wind and solar energy will continue to capture the highest shares of the new electricity generating capacity. However, renewable generation still needs to solve the major challenge intermittency presents.

While sun and wind are available everywhere, they are not available on-demand. While pumped hydro storage and Lithium-ion batteries have been effectively used to store energy, they both have limitations in the form of excessive land requirements and geography limitations (pumped hydro) and storage time constraints (batteries).

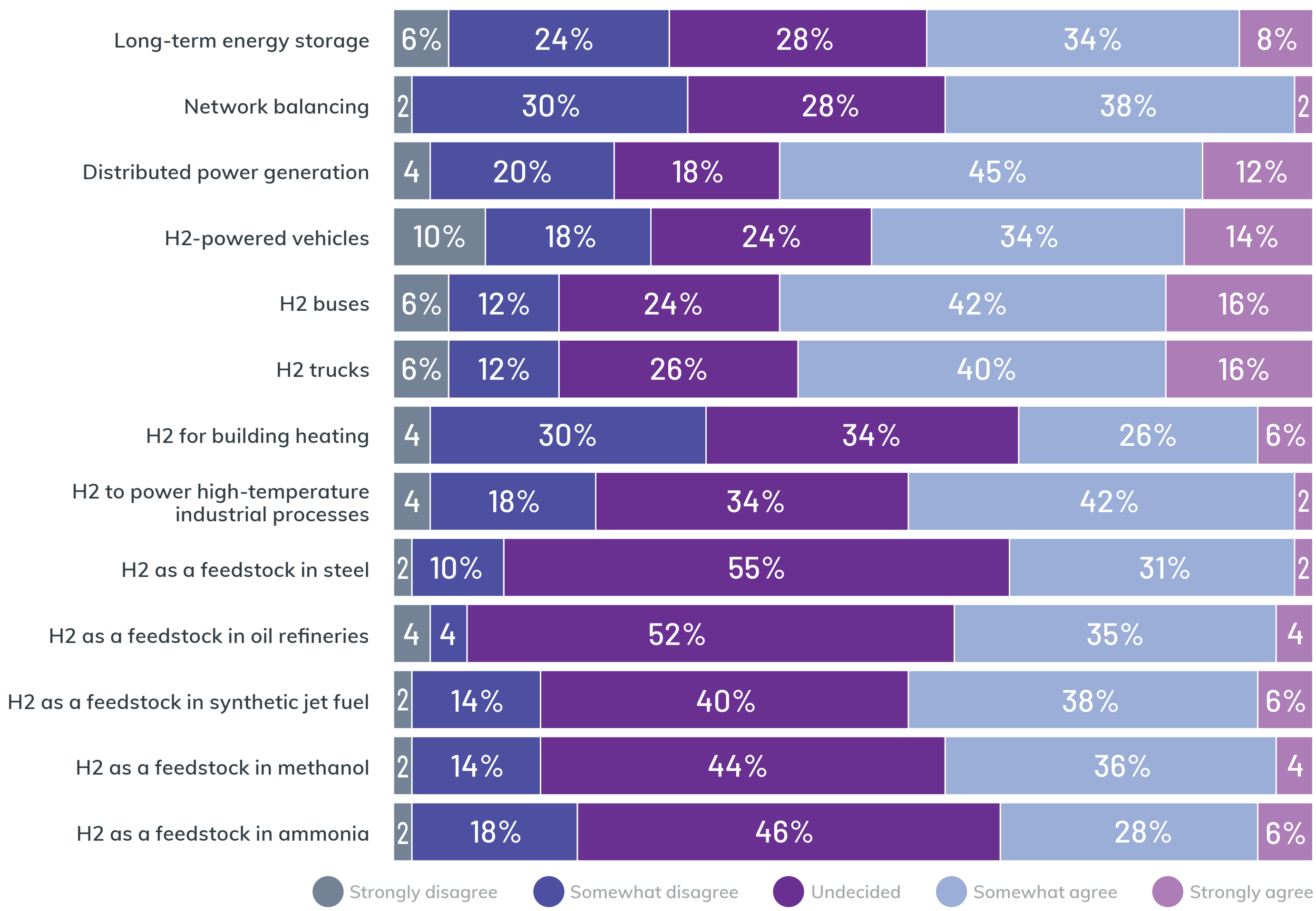
The concept of hydrogen energy storage is based on the ability to use excess renewable electricity to run the hydrogen production process. Hydrogen can be safely stored in underground caverns and eventually re-electrified when needed. The stored hydrogen can produce electricity from a fuel cell or by flowing into a specially designed turbine. Projects in the 100 MW range have been installed in the UAE, Australia, and China. The largest project is being developed in Utah and aims to store enough hydrogen in salt caverns to produce up to 1,000 MW of electricity. The project is expected to come online in 2025, with a modified combustion turbine using a 30% hydrogen – 70% natural gas mix. The combustion turbine will eventually run 100% hydrogen by 2035.

Hydrogen's uses extend well beyond the energy industry

While the utility industry understands the potential for green hydrogen in power generation, it is only just starting to embrace hydrogen's wider uses and the potential role utilities could play in an expanded value chain. Historically, utilities played no role in the gray hydrogen value chain: It was entirely the domain of chemicals companies and their customers. But in a future green hydrogen value chain, utilities could play a significant role.

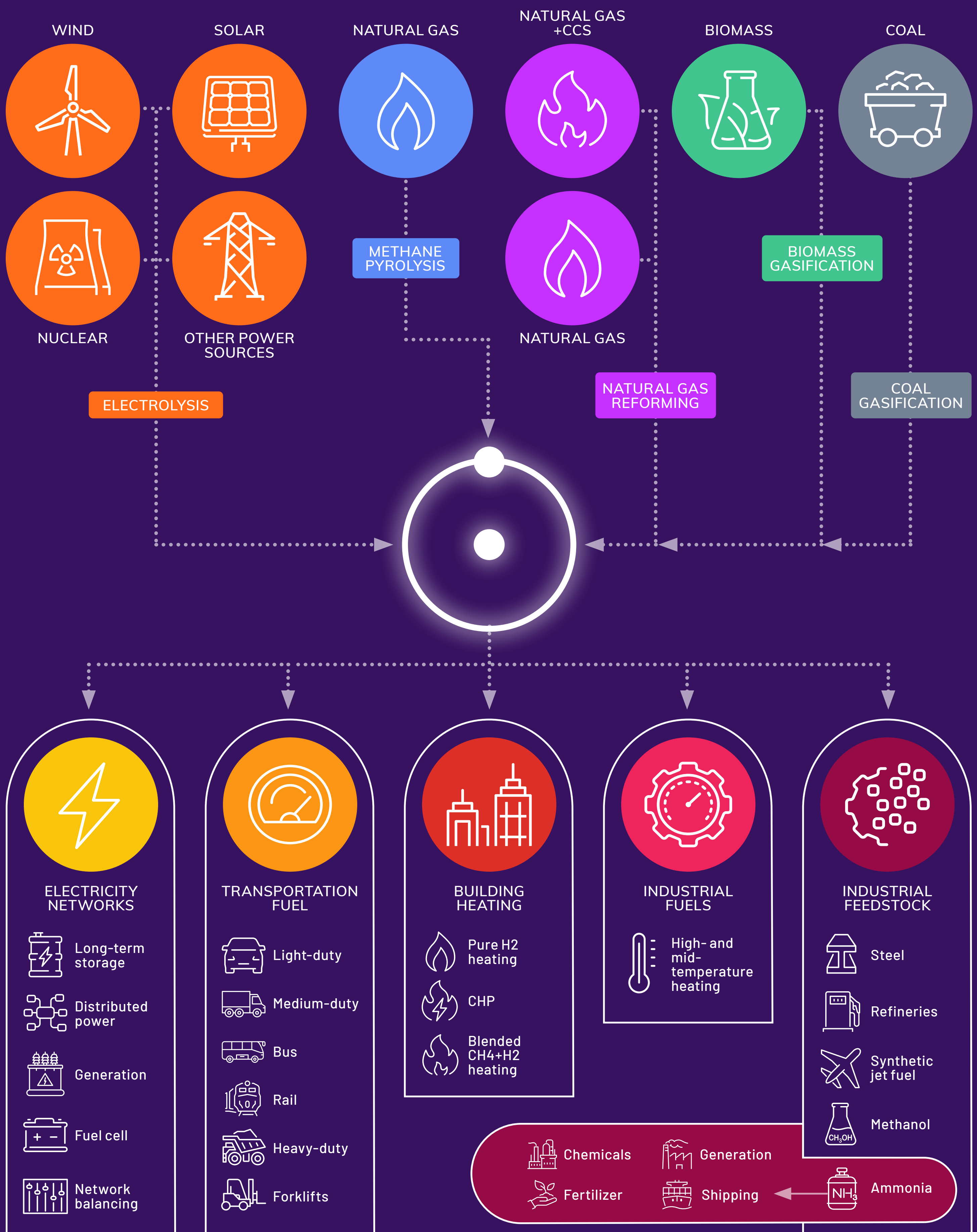
Many utilities recognize hydrogen's potential in distributed generation, seasonal storage, and network balancing. But uncertainty – not disagreement – increases about hydrogen's use as a transport fuel, and even more as a feedstock into industrial processes. As green hydrogen matures, the industry will become more knowledgeable regarding hydrogen's widespread uses.

Figure 3: ***Within the next decade, the following hydrogen technologies will be deployed at scale:***



The most obvious opportunity is to provide the electricity that powers electrolyzers. But utilities are also well positioned to own hydrogen production facilities, transport hydrogen in existing natural gas pipelines, build new hydrogen infrastructure, or own hydrogen-fired generation assets. Other opportunities exist to supply hydrogen for building heating, a blend of hydrogen and methane, or for combined heat and power (CHP) plants.

Future generation plants could also be fired by green ammonia. Ammonia is comparatively cheaper to transport than hydrogen. In remote locations where it is not feasible to build green hydrogen infrastructure, green ammonia could be a viable option as an imported fuel.


WIND
SOLAR
NATURAL GAS
NATURAL GAS +CCS
BIOMASS
COAL
NUCLEAR
OTHER POWER SOURCES
METHANE PYROLYSIS
NATURAL GAS
BIOMASS GASIFICATION
ELECTROLYSIS
NATURAL GAS REFORMING
COAL GASIFICATION
ELECTRICITY NETWORKS
Long-term storage
Distributed power
Generation
Fuel cell
Network balancing
TRANSPORTATION FUEL
Light-duty
Medium-duty
Bus
Rail
Heavy-duty
Forklifts
BUILDING HEATING
Pure H2 heating
CHP
Blended CH4+H2 heating
INDUSTRIAL FUELS
High- and mid-temperature heating
INDUSTRIAL FEEDSTOCK
Steel
Refineries
Synthetic jet fuel
Methanol
Chemicals
Generation
Fertilizer
Shipping
Ammonia

Future uncertainty is no reason not to plan

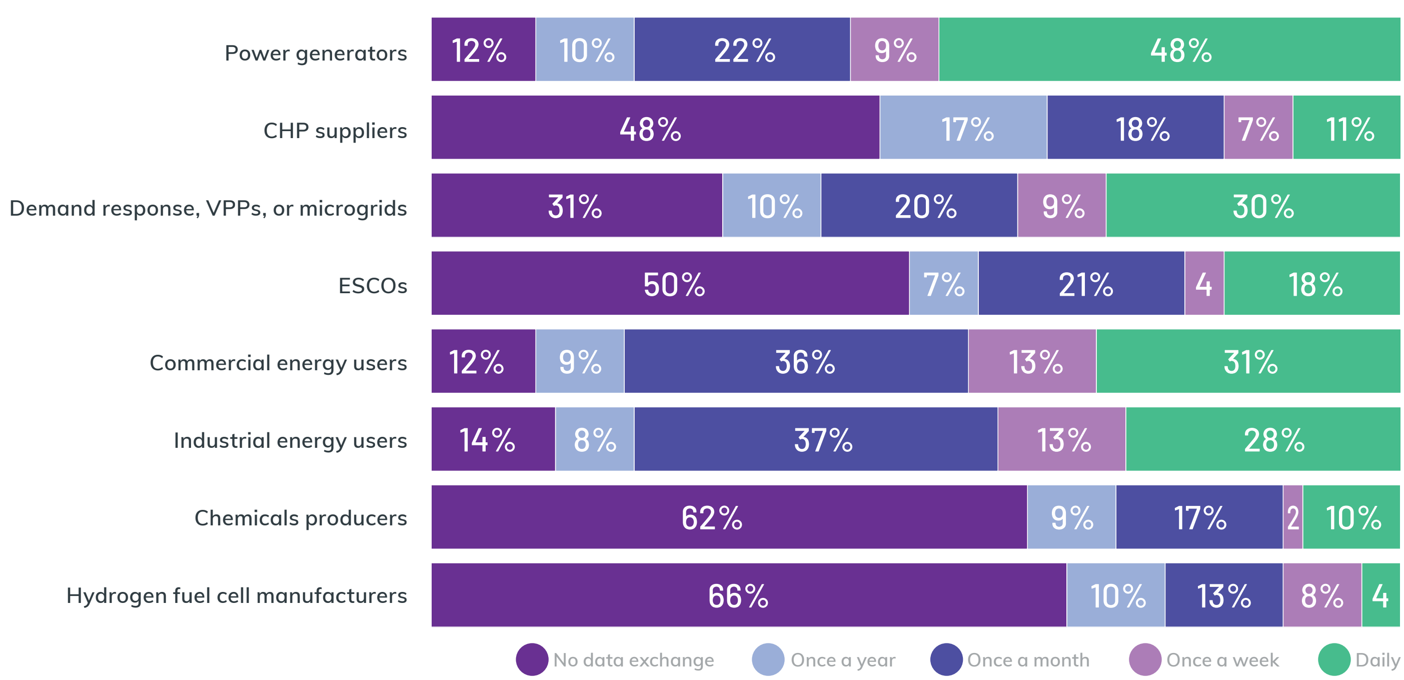
Most recognize that green hydrogen presents a significant revenue opportunity but are unsure where these revenues will be made. It is uncertain what the green hydrogen value chain will look like in a decade's time. Existing technologies are small-scale proofs of concept. Significant infrastructure must be built to support all the green hydrogen use cases discussed above. But the utility industry cannot wait until green hydrogen is developed at scale. Future uncertainty makes upfront planning more of a priority.

Each new green hydrogen project teaches us more about electrolysis technology and its infrastructure requirements and makes the future that much clearer. The challenge for the industry in general, as well as for individual utilities, is to gain knowledge from current projects, learn more about the most viable technologies, and decide on what role to play in the future green hydrogen ecosystem. Some utilities are planning to own a significant proportion of the value chain; in other markets, there may be 4 or 5 companies involved just in its production, storage, and transport, and in green hydrogen-fired generation.

Data infrastructure must be central to any long-term strategy

Whatever role utilities choose to play in the upcoming green hydrogen economy, they will have to prepare for complexity, as the green hydrogen ecosystem extends well beyond that of any current energy source and involves more stakeholders. Data will play an important role, because optimizing green hydrogen production relies on visibility at all points across the value chain. Decisions made by one stakeholder, for instance when to use wind power to create hydrogen, could rely on events at the other, such as changing prices for steel or ammonia. These decisions may be made in real time but will have to be based on data shared across the ecosystem. But most utilities rarely or never exchange data with many key stakeholders.

Figure 4: ***How often does your utility exchange data with the following types of organizations?***



What data will determine when green hydrogen electrolyzers should be turned on, for example? One obvious choice is when wind production is high, but demand is low. Low, zero, or negative electricity prices are a clear incentive. But there will be other drivers to produce green hydrogen. If sufficiently high, commodity prices – driven by rising demand for steel, fertilizer, or ammonia – could make green hydrogen production highly profitable, even when power prices are high.

Green hydrogen generation could cover most of the capacity shortfall when electricity demand exceeds renewable supply. Regulators and system operators may require green hydrogen reserves to be maintained to supply long-term seasonal cover for winter months when renewable generation drops, but demand increases. The levels of green hydrogen reserves – particularly in the months leading up to winter – could also be an economic driver for hydrogen production.

The Hydrogen Council believes that many hydrogen applications will become cost-competitive in 10 to 15 years. That is not a long time in the utility industry: It is just two or three asset planning cycles. If the industry is to mature, it must gain a much better understanding of the end-to-end data flows in this complex value chain. It must also define what information is required to support decisions across production, storage, delivery, and use of green hydrogen.

Many stakeholders are investing in asset research, like testing new electrolysis technologies, but few are developing the data infrastructure or making the plans to facilitate data interchange within the hydrogen ecosystem – a vital step for efficient green hydrogen production in the future.

This added operational data complexity and increased use necessitates that the data infrastructure management organizations select fits the following criteria:

- Ability to aggregate, organize, standardize, and contextualize raw data from any source
- Seamlessly interface with numerous control systems, such as SCADA, transmission-energy management systems, and generation management systems
- Enables data-sharing across the entire enterprise, from operations to business
- Rapid data processing and advanced data visualization capabilities to allow near-instantaneous situational awareness in an OT network or other environment. Create a "passive copy" of critical, real-time operational data for personnel to peer into control room data without interfering with the actual controls. This visibility is helpful for maintenance and pre-detecting common problems, saving precious time, and averting the high costs of major damage.

Conclusion

The survey indicates that the utility industry recognizes the future commercial value of green hydrogen, but there is a lot of uncertainty in the market and few have developed coherent strategies. Green hydrogen is a leading contender to provide a long-term, carbon-free storage solution and balance the intermittency of renewables. Its promise – should the current research be successful – is to help utilities achieve decarbonization goals while providing reliable and affordable electricity.

Owing to the complexities of the future hydrogen ecosystem, modern technologies capable of leveraging real-time data and analytics will be fundamental to the optimization of the overall process. End-to-end situational awareness of the green hydrogen value chain will enable stakeholders to make insights-driven business decisions. Situational awareness relies on a robust data infrastructure that manages a wide range of data types including market-related, critical operational support, asset management, predictive maintenance, long-term planning, and business process optimization.

The industry is at the beginning of its learning journey, but there is a risk that its focus will be mostly on developing electrolysis proofs of concept or modifying natural gas delivery systems to transport hydrogen. These innovative ambitions should be similarly matched with the development of a common information infrastructure and analytics. The future viability of the green hydrogen economy relies on optimized data flow across all stakeholders.

Demographics

Survey demographics from 100% of utility organizations.

Type utility?

Investor-owned	30%
Public-owned	15%
Municipal	26%
Cooperative	24%
District/federal	4%
Other	2%

Which services do you provide?

Electric	91%
Gas	26%
Water	22%
Wastewater	13%
Solid waste	7%
Street lighting	24%
Other	8%

What region(s) do you serve?

Northeast	18%
Southeast	18%
Midwest	22%
Southwest	22%
West	13%
International (Canada)	6%
International (other)	9%

What size by no. of accounts?

2,000,000+	19%
1,000,001 – 2,000,000	11%
500,001 – 1,000,000	14%
200,001 – 500,000	12%
100,001 – 200,000	7%
50,001 – 100,000	12%
25,001 – 50,000	8%
Fewer than 25,000	18%

What is your primary role?

Engineering	29%
Operations	13%
Maintenance	0%
Markets/Forecasting	2%
IT	13%
Customer service	4%
Executive	13%
Finance	6%
Emerging Technology	6%
Marketing	2%
Other	10%

What is your level of job responsibility in your organization?

Executive/C-Level	12%
Director	14%
Management	45%
Professional Staff	27%
Administrative	2%
Other	1%

Figure 5: ***How much do you agree with the these statements or changes happening within the next decade?***