Hydrogen 2021: A Roadmap to Net Zero

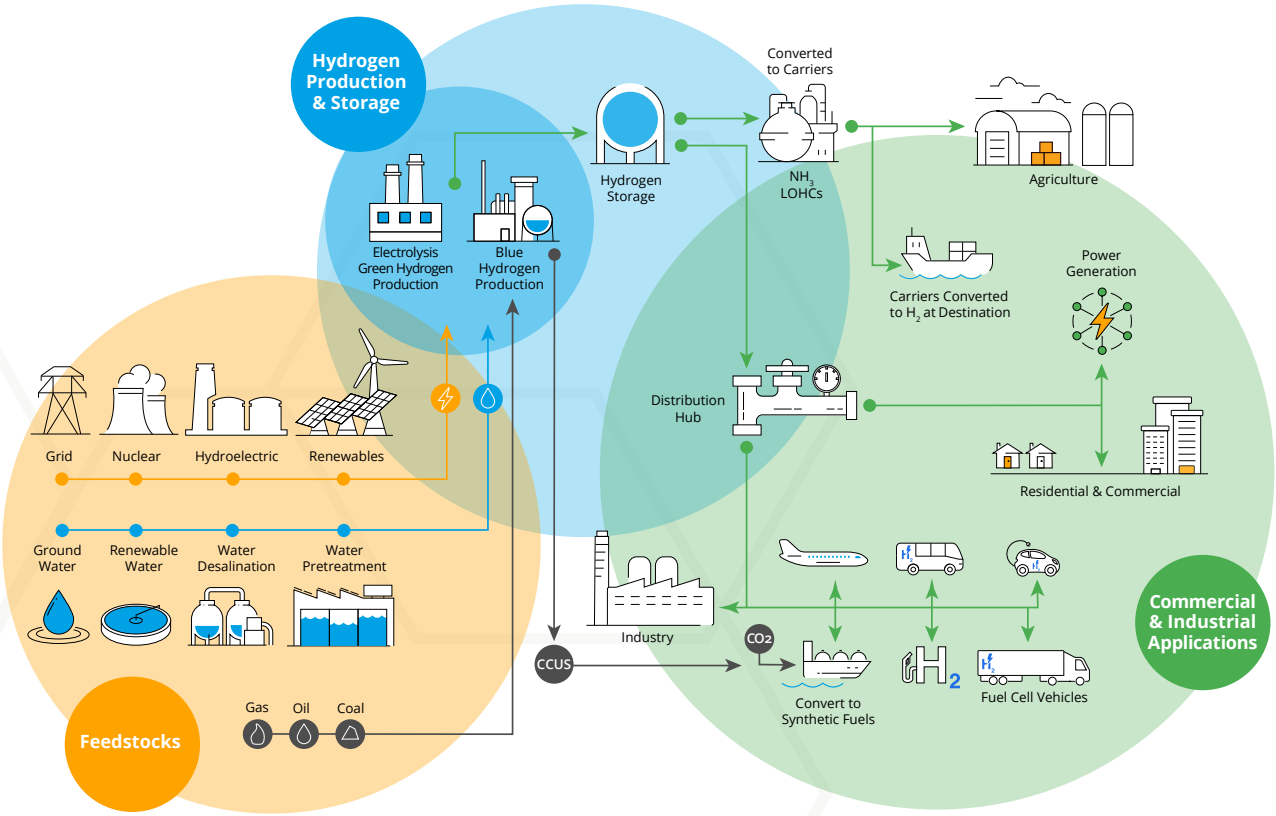
BLACK & VEATCH

Enabling the New Hydrogen Economy

As the world recognizes the growing impacts of climate change, there is a sense of urgency to accelerate the transition to energy, transport and industrial systems with fewer greenhouse gas emissions and effectuate more sustainable modes of production and consumption.

To enable this transition, new energy carriers will be needed to transfer the increased levels of decarbonized energy to consumers, without impacting the quality of service to residential, industrial and transportation users. Hydrogen offers a versatile solution and is emerging as an increasingly important energy vector for decarbonized fuel sources, as well as for the storage and transport of renewable energy.

Hydrogen is expected to play a critical role in decarbonizing power generation and transport, heating domestic and commercial buildings, and supporting industrial feedstock and industrial processes — including hard-to-abate sectors such as steel, refining, cement and agriculture.



Hydrogen can play a critical role in decarbonizing processes across sectors

Decarbonization Uncertainties

Although many organizations are enthusiastically pursuing decarbonization as a goal, it remains unclear exactly how they plan to achieve their Net Zero commitments; or in many cases, how to begin moving decarbonization planning from concept to implementation. This is true for organizations who already see hydrogen playing an active role in their plans, and for those considering other technologies. For most organizations, however, the growing recognition of hydrogen's potential makes it likely that the element will touch most decarbonization plans, either directly or indirectly.

By 2050, according to the Hydrogen Council, hydrogen could meet 18 percent of the world's final energy demand; facilitated in part by the cost of green and blue hydrogen production dropping by up to 60 percent over the coming decade. This is due to the falling costs of renewable electricity generation, the developing economies of scale in electrolyzer manufacturing and the development of cheaper carbon sequestration infrastructure.

Participating in the Hydrogen Economy

Achieving the hydrogen economy outlined above will, the council believes, require annual investments of US$20-25 billion until 2030; with roughly 40 percent of investments going into hydrogen production and one-third into hydrogen storage, transport and distribution. Around one-quarter of the investment, according to the Hydrogen Council, is likely to be destined for product and series development, and scale-up of manufacturing supply. The remainder could go into new business models such as fuel-cell-powered taxi fleets and car sharing.

Broadly speaking, the most significant short- to medium-term applications of hydrogen-based decarbonization are:

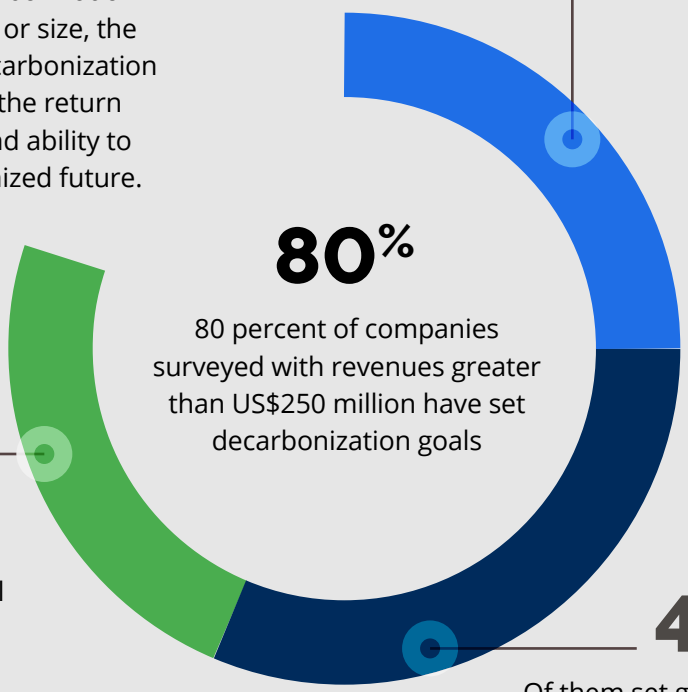
- In power generation, hydrogen is one of the leading options for storing renewable energy, and hydrogen and ammonia are about five years away from feasible use in conventional power plants to increase power system flexibility
- Transitioning to clean hydrogen through electrolysis or carbon capture for industrial use – the element's dominant current application – in oil refining, production of ammonia, methanol and steel
- End-of-journey refueling stations for municipal vehicle fleets and medium- and heavy-duty commercial vehicles; extension of refueling infrastructure for domestic vehicles
- Blending hydrogen into existing natural gas networks for heating commercial and domestic buildings, initially in high density or multiple occupancy environments

It is important to understand that, especially in terms of technology, few of these investments will be pure-play hydrogen. As well as hydrogen expertise, many decarbonization programs will require an understanding of a mix of renewable energy generation assets — most commonly solar and on and off-shore wind — coupled to battery storage; smart power distribution insights; and expertise in conventional gas-fired power generation and natural gas distribution networks. In addition to integrating multiple technologies to facilitate sector coupling, such programs will often require expertise in the successful integration of new and legacy assets.

Why Have a Decarbonization Roadmap?

Investments in decarbonization and the hydrogen economy will continue to grow, even as they vary significantly in nature and scope, and will not conform to a one-size-fits-all strategy. Each investment group and each organization within that group will need to plan according to their own business goals, needs and individual circumstances. According to Black & Veatch's *2021 Corporate Sustainability, Goal Setting and Measurement Report*, more than 80 percent of companies surveyed with revenues greater than US$250 million have set decarbonization goals, yet 25 percent have set goals at such a level that they are unsure how they will meet them.

It is also clear that although many organizations are committed to decarbonization, they lack the strategic decarbonization roadmap that will guide them to that goal. As more and more organizations consider their decarbonization goals, regardless of their revenue or size, the quality of their initial strategic decarbonization roadmap will significantly impact the return on their hydrogen investments and ability to compete and thrive in a decarbonized future.



It's not just about technology

Given that many organizations have made aggressive decarbonization commitments without a clear path, success will require them to now undertake broad-based strategic road-mapping programs that encompass investments in energy efficiency, renewable energy and other new technologies, many of which will have a direct or indirect hydrogen component. But a strategic roadmap that focuses solely on technology is insufficient; an effective strategic decarbonization roadmap has to be multi-dimensional and address a host of other factors which will influence, and be influenced by, technology alternatives.

Many of the factors the roadmap needs to encompass are common to supply-side organizations — those seeking to support decarbonization through the provision of renewable energy or green hydrogen; and organizations on the demand-side seeking to meet their decarbonization targets through the adoption of low-carbon technologies. As the drive for decarbonization continues to gain momentum, we are seeing the increased blurring of the distinction between supply and demand-side organizations.

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Identify the Possible, Accept Uncertainty

Getting started on a decarbonization roadmap can be complex. Decarbonization is a long-term undertaking — looking potentially up to 30 years into the future. To help manage this, the roadmap will need to identify low-hanging fruit, address the art of the possible, and also accept uncertainty. Adaptability has to be built into the plan, often with pre-set breakpoints to assess progress and reflect on changes and developments that will influence the roadmap's future evolution. This approach avoids analysis paralysis in the face of demanding decarbonization targets.

Another important starting point is to address the potential organizational changes. It is vital to understand that decarbonization will not be cost-effective for all organizations, especially in the short term. The organizational mindset may need to change to accommodate this. It is also vital to start to map resources to requirements to see what can be done in-house, and where external partners will be necessary. The key is understanding the extent to which decarbonization can influence business models. For example, developers of renewable energy infrastructure, like wind and solar, who choose to add a green hydrogen component to their portfolio will be able to sell gas as well as electricity — molecules as well as electrons. This may have a profound impact on where they can be most profitable.

Similarly, the introduction of hydrogen will enable the developer to move into long-term energy storage. While battery storage is effective in the short term, hydrogen can convert and store solar energy generated in the shoulder seasons when generation exceeds demand, for instance, for flexible and continuous dispatch during the peak seasons when demand exceeds generation. Places that were not traditionally fuel hubs can now become one. Renewable energy companies can move into the gas sector, just as oil and gas giants enter the renewable energy space. Supply chains, partnerships and solutions will all evolve as a result. The profound organizational changes such tectonic shifts potentially create need to be incorporated into the heart of the strategic decarbonization roadmap.

Chart the Regulatory Landscape

Achieving an effective strategic decarbonization roadmap means navigating a fluid, interlinked web of dependencies. Among the most influential factors, especially in the near term when there is not always a nexus of decarbonization goals and profitability, is the regulatory landscape.

At the international level, and in the U.S. at the federal and state level, the regulatory landscape features hurdles and incentives that need to be accounted for in the strategic decarbonization roadmap. In Western Europe and Japan, for instance, decarbonization beyond transition to renewable energy is more advanced than in the US largely due to initiatives instigated or strongly supported by national governments.

In the U.S., the same technical solution will have very different commercial effects, depending upon which regulatory incentives and disincentives apply at the state level. There is a growing acceptance that there will be a cost associated with emissions of CO_2, likely tied to rates of emission and concentration. A strategic decarbonization roadmap will need to be cognizant of this, as well as the incentives available to those reducing their CO_2 emissions when setting out the pace and cost assumptions of achieving Net Zero goals.

California, usually a good bellwether, provides potential insight into the type of decarbonization incentives an effective strategic roadmap needs to incorporate. An executive order mandates 200 hydrogen fueling stations by 2025, supported by grants to build these hydrogen fueling stations. For organizations considering investing in green hydrogen production as part of their decarbonization plan the prospect of low-carbon fuel standards, and solar credits make the state's transportation market a more attractive option. In addition, for organizations wishing to decarbonize their vehicle fleet using hydrogen, California offers a more economical option than other states.

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Technology in Context

Establishing which decarbonization technologies are best suited to delivering an organization's decarbonization goals is inextricably interdependent on factors such as developing an understanding of organizational change and the regulatory landscape. None of these elements in isolation will give rise to an effective strategic decarbonization roadmap. The technology-focused component of the strategic roadmap needs to address a wide range of business context, performance, CAPEX and OPEX considerations.

Accurate data gathering is required to develop the base case assumptions that will be reflected in the roadmap. Initial data gathering includes assessing the organization's supply and/or demand-side energy production/consumption and CO_2 emissions, with the nature of the assessment depending upon whether the organization is pursuing scope 1, 2 or 3 decarbonization goals. This needs to be mapped to an assessment of the organization's existing and future generating resources and consumption activities – including owned generation as well as power purchase agreements. The assessment also has to incorporate the organization's fuel price projections and CAPEX and OPEX estimates.

The next step is to identify the commercially ready and emerging technologies available over the next 30 years that could be employed to reach the organization's decarbonization goals. This requires the technical competence and in-depth knowledge to:

- Identify the likely timeline of these technologies
- Identify the likely cost curve of these technologies
- Identify the resiliency characteristics of these technologies
- Prioritize technologies based on cost, risk, availability and opportunity to scale as options to help the organization's decarbonization goals
- Identify the signposts in terms of productivity and costs as part of the road map for business decisions

The evaluation of commercially ready and emerging decarbonization technologies then needs to be overlaid with an assessment of the extent, if any, to which these technologies already feature in an organization's decarbonization roadmap or current long-term plans. From this, the picture of the potentially most appropriate decarbonization technologies will form. This should be refined through further evaluation to create a current assessment of each potentially suitable technology's projected development timeline, grid impact, costs, benefits, risks, peer activities and the feasibility of developing at scale, for example.

The other work such as the organizational change and regulatory landscape assessments, and assessments of the costs of hydrogen and other renewable fuels over the planning timeframe, will be interpolated with the technical assessments to develop a rounded technology core for the roadmap.

Technology is at the leading edge of the energy transition to Net Zero. As a result, a decarbonization strategic roadmap that lacks a detailed technology core will be insufficient. The most complete strategic decarbonization roadmaps — and thus those most likely to deliver — will intermesh business goals with high quality, accurate market and regulatory analysis; and first-hand expertise in decarbonization technology solutions in the power generation, power transmission, fuel and chemicals and transportation sectors. The most complete analysis will come from partners with expertise in strategic consulting and the myriad technology solutions, including hydrogen and renewable energy generation that are available and relevant, as well as the complex interfaces between them that define successful decarbonization road mapping.

Real-World Considerations

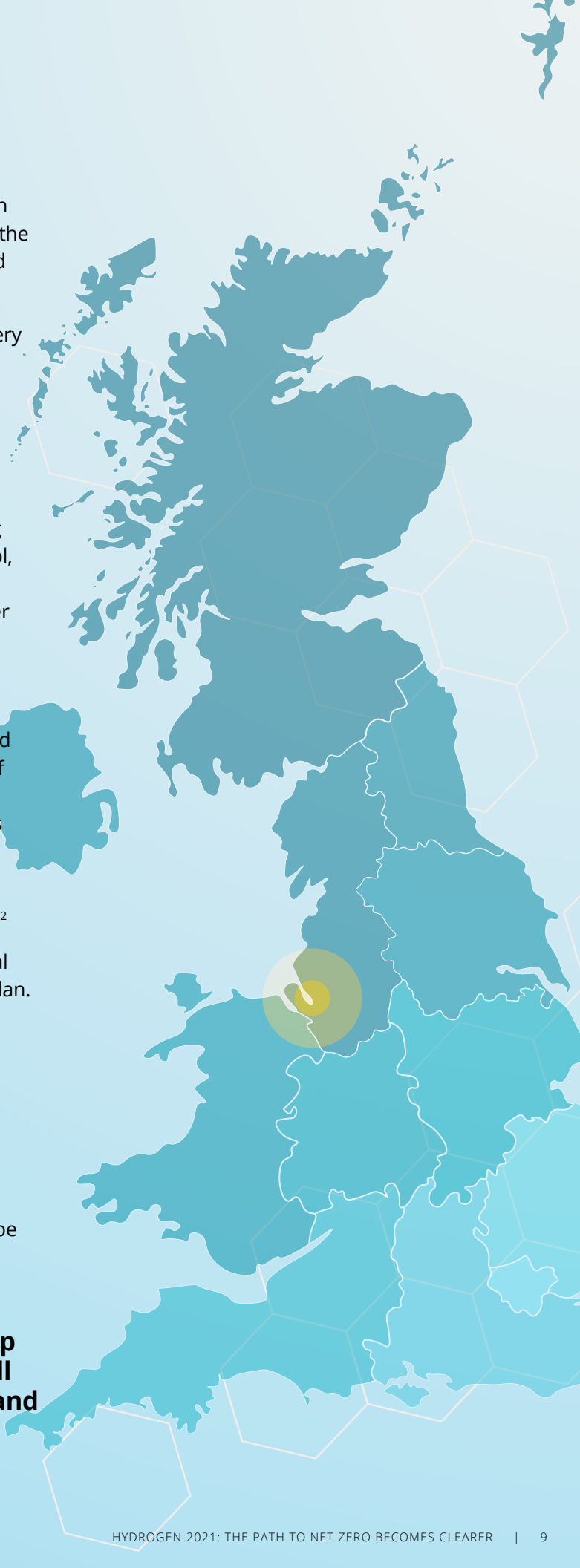
HyNet North West, a regional-scale low-carbon cluster in northwest England, gives an idea of the considerations and interfaces hydrogen-based decarbonization programs need to navigate.

A new plant at Ellesmere Port's Stanlow Refinery will produce 3TWh per year of blue hydrogen from natural gas. The hydrogen will be used as fuel at the refinery and distributed via new pipelines to local industrial sites — and potentially power stations. The hydrogen will also be blended up to 20 percent with natural gas in the local distribution network supplying two million customers in and around Liverpool, Manchester, Warrington, Wigan and North Cheshire. This will allow up to 400,000 tons per year of CO_2 to be captured from the hydrogen plant and industrial sites.

As well as offering the right scale of industrial and domestic customers for the hydrogen, and site for the refinery, the industrialized areas of Deeside and Merseyside chose for HyNet also offered CO_2 storage in depleted gas reservoirs under Liverpool Bay; and salt caverns for safe hydrogen storage. Existing natural gas pipelines will be repurposed to convey the CO_2 to storage. In terms of regulatory landscape financial incentives from both central and local government are central to HyNet's business plan.

HyNet is an example of some of the many strategic decarbonization road-mapping considerations that supply-side hydrogen projects need to address: demand; interfaces with new and existing assets; suitability and availability of land for hydrogen generation and CO_2 storage assets; attractive regulatory landscape. Many of these considerations will be shared by demand-side initiatives.

Once operational a new plant producing blended hydrogen of up to 20 percent with natural gas will supply two million customers in and around Northwest England.



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Black & Veatch is an active industry advocate for the hydrogen economy including membership of the Hydrogen Council, Fuel Cell Hydrogen & Energy Association, California Hydrogen Business Council, Center for Hydrogen Safety, and Ammonia Energy Association.