Arthur D Little

Viewpoint

Hydrogen at energy companies – A new game

Where and how should they get involved with hydrogen?

Many governments have placed hydrogen on their agendas for decarbonization, making hydrogen a decisive topic for energy suppliers as well. This becomes evident by the government's commitment to funding projects that enable regions and municipalities to plan and implement pilot applications. After spending years as a niche topic on the energy industry's agenda, hydrogen has risen to prominence within a short time, accompanied by a surge of reports about gigawatt electrolyzers and municipal pilot projects. There is no doubt that hydrogen has a significant, if not central, role to play in achieving 2050 carbon neutral targets as set, for example, by the EU. However, in view of its complexity, regulatory uncertainties, need for further technological development, and a market that is still in its infancy, an energy company's approach to hydrogen requires a strategy that balances opportunities and risks. In this Viewpoint, we share one such approach we developed with an energy supplier.

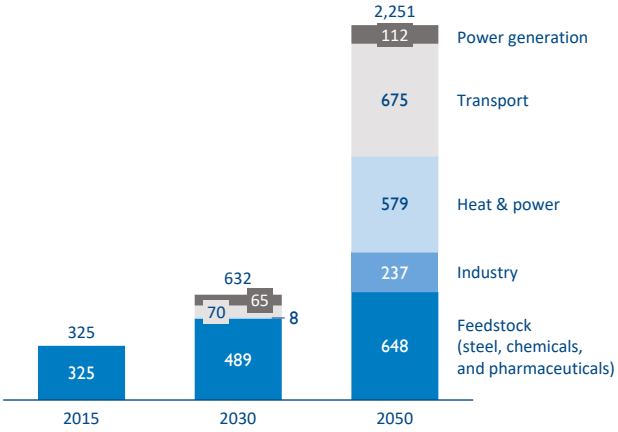
Hydrogen – how much, and when is it needed?

Strategic planning for engagement begins with the long-term demand for hydrogen. Demand depends on the CO_2 reduction targets as well as on the costs of hydrogen and alternative CO_2 reduction technologies. Numerous studies have developed climate protection scenarios that can serve as a basis for a strategic, long-term assessment of demand. For example, a 95% CO_2 reduction scenario – a quantitative target for being almost carbon neutral – for Germany implies significant requirements for hydrogen and hydrogen-based fuels (e-fuels) for the year 2050. Although the quantities and the timing can change dynamically, it is clear that significant use of hydrogen will be necessary only if CO_2 reductions reach a certain level. Germany's carbon reduction scenario for 2030 requires a rather small amount of hydrogen because other CO_2 reduction methods are available at a lower cost than hydrogen/e-fuels, such as increasing energy efficiency or using fewer CO_2-containing energy sources, including electricity from renewable sources or natural gas.

Considering the fact that CO_2 can be reduced significantly without large amounts of hydrogen, it is unlikely that hydrogen will be used as an additional energy carrier on a significant scale until around 2040. However, remaining inactive in this area would be a mistake for two reasons. First, a tightening of the CO_2 reduction targets would necessitate earlier use of hydrogen. Second, technical progress could improve the cost-effectiveness of hydrogen technologies and therefore accelerate the application of these technologies for CO_2 reduction (see figure below). In addition, applications such as the use of hydrogen in steel production require early decisions on the use of the technology due to the long asset lifetime.

It is also important that energy companies identify where hydrogen is needed most. For example, feedstock for the steel, chemical, and pharmaceutical industries, in addition to transport, will dominate the long-term demand for hydrogen. That could therefore necessitate a company's transformation from a natural gas supplier to a hydrogen or even e-fuel producer or an operator of hydrogen pipelines and fuel stations.

Hydrogen demand by sector in Europe (TWh/year)

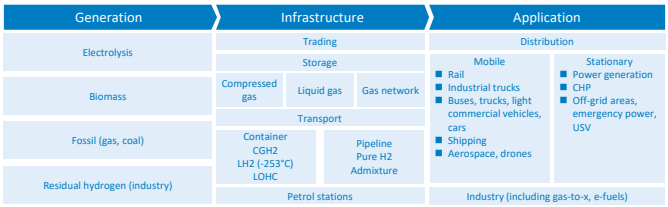


Source: FCH JU (2019), Arthur D. Little analysis

Where in the hydrogen value chain to engage?

While parts of the hydrogen value chain (see figure below) have similarities with upstream and downstream oil & gas as well as utility distribution and customer solution businesses, hydrogen generation via electrolysis, transport via pipelines, and distribution including filling stations will change significantly and thus require strategic approaches.

Hydrogen value chain



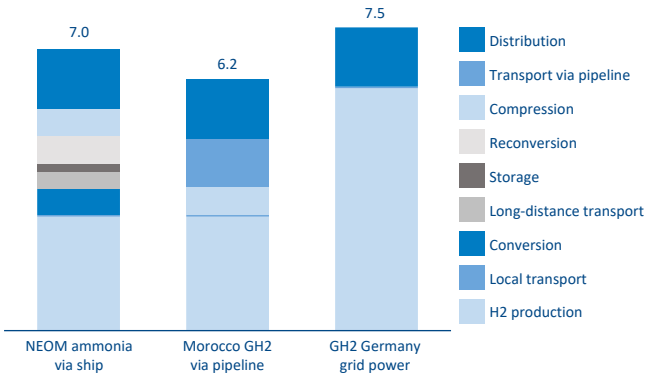
Source: Arthur D. Little analysis
Abbreviations: CGH2 = compressed hydrogen, LH2 = liquid hydrogen, LOHC = liquid organic hydrogen carrier, USV = uninterruptible power supply, e-fuels = synthetic fuels produced with electricity, CHP = combined heat and power generation

Globally, there are currently hydrogen generation projects with up to 140 GW capacity announced and in execution. In most cases, these projects involve major energy players. Examples include HyDeal (multiple sites in Europe), with 67 GW of capacity driven by Snam, Enagás, and OGE; NortH2, with 10 GW planned by Shell, Equinor, RWE, Gasunie, and Groningen Seaports; AquaVentus with 10 GW by a consortium of RWE, Vattenfall, Shell, E.ON, and others; NEOM Helios with 4 GW in Saudi Arabia; and several projects in solar power-rich countries like Australia, Chile, Portugal, and China, as well as wind regions including the North Sea. Large-scale "hydrogen hubs" combine scaled production of hydrogen as well as hydrogen-based feedstock with renewable power generation and logistical infrastructure like industrial-sized terminals. Furthermore, plans to build new, or to dedicate existing, gas pipeline and distribution grids for hydrogen in consumer regions complement this scenario. We expect that by 2030 there will be a global market and supply chain where hydrogen is produced, stored, traded, and supplied like liquid natural gas.

Suppliers should consider their ability to fit in with energy companies' existing competencies. For this purpose, our strategic approach divides the hydrogen value chain into three clear stages: generation, infrastructure, and application. In each stage, there are applications that represent business opportunities for an energy company. With the exception of pipeline transport and distribution networks, applications that are regulated can be allocated to an energy company's nonregulated business, meaning that the energy company is free to decide whether or not it wants to become active in that application. An exception might apply to municipal utilities, which must follow local political priorities and framing conditions for the use of hydrogen. For example, several European municipalities are introducing hydrogen-operated buses or garbage trucks and thus expect the engagement of municipal utility companies.

Essentially based on electrolysis, hydrogen generation is a clear fit for an energy supplier. The efficiency of hydrogen generation depends on the cost-effective procurement of electricity, which is an energy supplier's core competence. If, in the long term, hydrogen turns into a commodity that can be traded supraregionally or even globally, hydrogen trading services (procurement, storage, trading, and hedging) would also fall under an energy company's areas of expertise. The similar cost base of hydrogen production options (examples illustrated in the figure below) will foster competition and drive the demand.

Hydrogen supply options (2030 cost base, in euros/kg)



Source: Arthur D. Little analysis, Prognos

With regard to hydrogen infrastructure, transport via pipeline networks, in particular, is closely related to an energy company's core business. The addition of hydrogen to natural gas and the conversion of unused gas pipelines to allow for the delivery of hydrogen are both of crucial importance for hydrogen's successful introduction. Hydrogen filling stations and transports with tanker vehicles are unlikely to be covered by typical power & gas supply company competencies.

The application of hydrogen in buildings and neighborhoods for heat supply should closely mirror an energy company's current heat, combined heat and power (CHP), and gas business.

However, decentralized applications, such as for emergency power supply, are likely to have different market relevance. Except for CHP plants, transport and industrial applications are mostly outside an energy supply company's current range of activities.

What to do, when, and how?

Due to the many opportunities for an energy supply company to become involved in hydrogen, we recommend a strategic evaluation of the various options.

First, we recommend that energy companies evaluate the attractiveness of the respective business opportunities. In the case of electrolysis, which is likely to be a top priority for many, energy companies should consider the intensity of competition and market entry barriers. The level of competition will strongly correlate with the development of a hydrogen pipeline grid, which will make hydrogen significantly more available and at lower cost. While they are a short-term option for green hydrogen, small- and medium-sized electrolyzers will face competition in the future from lower-cost supply options, which would significantly lower their attractiveness. The situation may be different for large electrolyzers if the opportunity is accompanied by long-term purchase contracts like power purchase agreements (PPAs). We therefore advise companies to carefully sound out the local market before investing in an electrolysis plant to identify existing and future hydrogen sourcing options.

The expansion of gas transport networks to accommodate hydrogen should also play a major role in electrolysis considerations. If a supply of lower-cost hydrogen via pipelines from large-scale electrolyzers near offshore wind parks or via import from solar-rich regions like the Middle East are possible in the medium to long term, energy companies should critically assess the opportunity for an owned local electrolysis plant, as local small-scale electrolyzers have cost disadvantages.

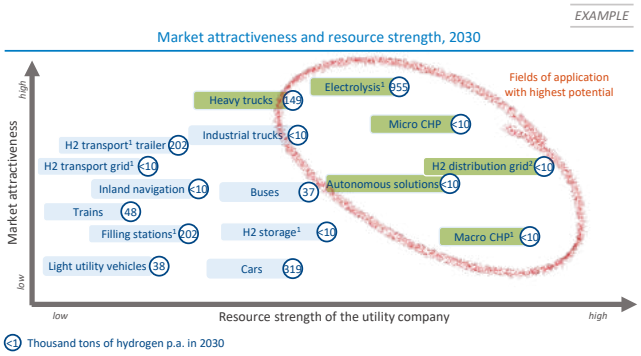
In contrast to electrolysis, hydrogen applications, especially stationary applications in buildings, may be a far more attractive consideration for many energy companies active in the customer solutions business. In these applications, from district heating and CHP generation to the supply of gas to end customers, the market attractiveness and the strength of resources are likely to be high. In the long term, CHP plants must be operated largely CO_2-free. Alternatives to hydrogen for a carbon-free heat supply exist, such as heat pumps, biomass/biogas, or the use of industrial waste heat. However, their potential depends on specific conditions such as electric power prices, biogas availability, and so on. In heat applications, hydrogen further competes with electric heat pumps, which can provide heating from a few kW up to two-digit MW.

Compared to hydrogen-operated fuel cells, heat pumps have a higher end-to-end energy efficiency due to the transformation of electric power to heat without intermediate steps. Specific advantages of hydrogen exist, however, in industrial high-temperature applications.

In general, a fundamental hydrogen potential analysis should evaluate the fields of application in terms of market attractiveness and resource strength. This results in an overall picture that allows companies to prioritize the fields of action. In the example shown in the figure below, six applications have the highest priority with the following justifications:

1. **Electrolysis** – demand for hydrogen, as-yet nonexistent pipelines, and temporary local monopoly position.
2. **Heavy trucks** – demand for hydrogen vehicles in the municipal utility group and previous experience with conventional municipal trucks.
3. **Micro CHP** – demand for climate-neutral heat in residential buildings, local heating networks, and industrial plants.
4. **H2 distribution network** – reuse of existing unutilized gas pipelines.
5. **Autonomous solutions** – need for environmentally friendly emergency power solutions (reduced noise and exhaust gases).
6. **Macro CHP** – climate-neutral district heating networks and industrial supply.

Prioritized application portfolio (midsize utility)



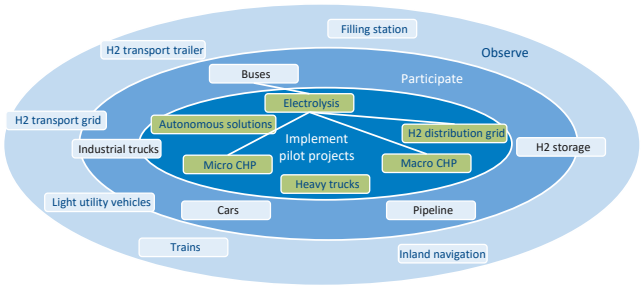
<1 Thousand tons of hydrogen p.a. in 2030

Source: Arthur D. Little analysis, expert assessment

[1] As independent business models; [2] Expected to supply all applications with trailers by 2030

Applications with a high market attractiveness that represent a significant resource strength for the energy company have the top priority. Once the energy company has determined these priorities, it must carry out feasibility studies, set up pilot and implementation projects, find partners, and obtain subsidies. The rapid technological, regulatory, and business development surrounding hydrogen makes it necessary for companies to pursue the topic with appropriate management, time, and resource intensity.

Prioritization of hydrogen activities (example)



Source: Arthur D. Little analysis

Due to the rapidly changing technical and regulatory environment, a graded approach to prioritization according to intensity of effort is helpful (see figure above). Such an approach allows companies to react quickly to changes in the framework conditions on the one hand and to avoid risks from too early involvement on the other hand in the following areas:

- **Pilot.** Pilot projects are used for testing technology and business models together with customers. Both form the core of the hydrogen strategy and therefore require dedicated financial and human resources as well as management attention.
- **Participate.** By partnering in pilot projects, companies can gain experience, build up initial knowledge, and test business and technology concepts without expending significant resources.
- **Observe.** Companies should systematically observe other topics with carefully applied resources (e.g., through participation in working groups, preliminary studies, and exchange of experience). This includes topics that are not yet technologically or economically ripe.

Finally, energy companies should update and reprioritize their hydrogen topic portfolio on an annual basis.

Key messages

Hydrogen will drastically change the energy economy, but energy supply companies must realistically estimate the time horizon of such changes. In particular, companies should carefully consider:

- An analysis of the hydrogen value chain and the developing market as an indispensable basis for decisions.
- The possibilities to get involved in the hydrogen market, carefully evaluating the market attractiveness and the company's existing resource strengths.
- Deliberately measuring and reviewing, on an annual basis, the intensity of activities to allow room for experience and development.

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