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Future Trends

Hydrogen: The Missing Element

Executive summary: Hydrogen will help power the future. The next decade could be for hydrogen what the previous one has been for wind and solar. Owing to its versatility, hydrogen can be used to tackle various critical energy challenges across a range of sectors. It is readily available and is a renewable source; there are no harmful emissions at the point of use; and it is potentially 2-3 times more efficient than other competing technologies. Correspondingly, hydrogen is a seeing a surge in investment as nations seek to decarbonise their economies. By 2050, 20% of global energy consumption could be powered by hydrogen. Achieving this vision will require significant investment though, equivalent to some $280bn over the next 30 years. An increasing range of listed investment opportunities will emerge, with some (e.g. Nikola) just beginning the journey now.

One of the most iconic and enduring images of all time is the landing on the Moon by astronauts in 1969. But how did they get there? Hydrogen powered them. Now think about those wonderful romantic images of airships that glided through the skies in the late 19th and early 20th Centuries. How were they powered? Yes, you guessed it, by hydrogen. **Hydrogen and energy have a long-shared history**. Indeed, the first demonstrations of water electrolysis and fuel cells captured the imagination of engineers during the 1800s. Now hydrogen is poised to capture 21st Century imaginations and power greener economies globally.

What is hydrogen? It is the first element on the periodic table. In other words, **it is the lightest and most abundant known element in the universe**. However, since hydrogen does not occur naturally on Earth in large quantities, it requires a primary energy input to produce it on an industrial scale. Historically, hydrogen has typically been produced from fossil fuels by steam reforming or partial oxidation of methane and coal gasification. The downside of these methods is that they release carbon dioxide (and monoxide) into the atmosphere. The alternative approach is electrolysis. Here, electricity is run through water to separate hydrogen and oxygen atoms. Wind, solar, geothermal, hydro, biomass or nuclear can be used as the input source. It produces nothing but water as a by-product when used to form electricity. When reacted with air in a fuel cell, it provides clean, safe and reliable power. For self-evident reasons, industry experts refer to the former source as 'grey' hydrogen and the latter as 'green' (for reference, when liquefied natural gas is the input, this is 'blue' hydrogen).

Green hydrogen discussions are now becoming more relevant as costs are falling. Bear in mind that the cost of solar and wind power – the largest driver currently of renewable hydrogen production costs – has seen an 80% decrease in the past decade. Correspondingly, electrolysis fed with renewable energy has become 60% more affordable as low-carbon and renewable electricity prices have dropped and electrolysis capex has declined. By way of example, the cost of renewable hydrogen produced from offshore wind in Europe was $10-15 per kilo in 2010, but is likely to have dropped to ~$6/kg by 2020 and ~$2.50/kg by 2030, driven by scale in electrolyser manufacturing, larger systems and lower-cost renewables (all data per McKinsey).

Falling input costs mean that hydrogen will have a crucial role to play in future energy policy. At present, ~70% of global energy demand is met by fossil fuels (per the IEA). However, if the Paris Climate Agreement goals of cutting carbon dioxide emissions to a tune of 40% by 2030 and 60% by 2040 are to be met, then this ratio must flip. In other words, **the vast majority of the world's energy needs will have to be provided for by renewables**. Environmental, economic and political considerations (including increasing energy independence) will therefore drive renewable demand. **Full decarbonisation requires a multi-dimensional strategy**.

The four main end-markets in which hydrogen energy solutions could be deployed are transportation; heat and power for buildings; industrial heating and power applications; and, as industry feedstock, ranked by size of addressable market. By the end of 2019, over 50 countries had already committed to various hydrogen projects (per the IEA). **By 2050, hydrogen could account for almost a fifth of global energy consumption and contribute a similar proportion to the carbon abatement needed to meet international climate targets**, per the Hydrogen Council, an industry body. Under this scenario, hydrogen would power 400m+ cars, 15-20m trucks, 5m buses and around 20% of all locomotives as well as about 25% of passenger ships. It could also account for ~10% of global demand for heat in buildings and be used as a renewable feedstock in ~30% of ammonia and ~10% of steel production.

Begin with vehicles. There is most interest in this segment given that presently the world's transportation sector depends almost entirely on fossil fuels and accounts for 20%+ of total carbon emissions (per the Hydrogen Council). While battery-electric vehicles (or BEVs) have recently begun to make inroads into this market, fuel-cell electric vehicles (FECVs) should be seen as *complementary*. Whereas the former are ideal for short-distance and light vehicles, the latter – which can store energy in less weight – make full cells well-suited for vehicles with heavy payloads and long ranges. Hydrogen-based FECVs have three critical advantages over BEVs: range – they can do well over 300 miles on a single charge, about double the efficiency level of other comparable engines; refuelling times (at around 3-5 minutes) are on a par with gasoline-powered vehicles; and, heavy-duty capabilities – the cells can support construction equipment, ships and so on.

Global carmakers have been investing in both technologies (BEV and FECV) but whereas global electric vehicle sales reached 2.2m in 2019 (or 1 in 40 vehicles sold, per the IEA), only a few thousand fuel cell vehicles have been sold, mostly in Japan and California. The majority of these have come from Toyota, but Honda, Hyundai, GM, Ford and Nissan are all currently involved in FECV projects. More interestingly, Nikola Motor (founded in 2014 and Arizona-based) could be to the FECV industry what Tesla has become to the electric vehicle segment. Without any legacy technology/ production lines, Nikola has focused exclusively on building a hydrogen fuel cell infrastructure comprising both vehicles and charging points. It currently has orders for over 14,000 FECV trucks from customers including Amazon, Pepsi and Walmart.

Elsewhere within the transport sector, California is set to get its first hydrogen-powered ferry this year, which will traverse from one side of the Golden Gate Bridge to the other. Toyota has completed a fleet of hydrogen buses that will be used for the Tokyo Olympics. South Korean authorities have committed to converting 26,000 buses over to hydrogen during 2020 and similar plans are afoot in Japan and China. In Europe, Alstom started trialling hydrogen-powered trains (the Coradia iLint) in 2017. Recently, the Rhine-Main Transport Authority in Germany awarded Alstom a €500m contract to supply 27 trains for operation in the Frankfurt region from 2022.

Although perhaps not as headline-grabbing, developments are also underway in many other industries too. Take buildings. A pilot scheme has been planned by Northern Gas Networks (the principal gas distributor in the north of England) to substitute methane for hydrogen in the local gas network. The authority believes it could cut carbon emissions by almost 75%. Planners say only minor modifications of existing gas infrastructure and supplies will be required. The scheme could be operational by the late-2020s. Larger scale plans are also being discussed in countries as diverse as Australia and the Netherlands. The latter (backed by Shell) will be fuelled by a large new wind farm off the coast of Groningen and could be producing over 800,000 tonnes of hydrogen by 2040, cutting Dutch carbon dioxide emissions by ~7% annually. At an industry-specific level, steel producers such as Thyssen Krupp and Voestalpine have all begun to embrace hydrogen solutions as have fertiliser businesses including Yara.

Lest we get too excited about all the above, **investments will be required**. If the vision outlined by the Hydrogen Council is to be achieved, it would require **~$280bn of cumulative investments by 2050**, on its own projections. Other estimates suggest that were hydrogen to meet 24% of the world's energy in this timeframe, then this would require over $1tr of expenditure (per BNEF). What these forecasts undoubtedly imply is the need for national strategies (Norway launched such an approach in June this year), government-led coordination, the removal of regulatory barriers and industry standardisation.

Separating hydrogen from water through electrolysis can consume more electricity than the resulting energy produced. At a practical level it is also difficult to store and to move around (given its low density). Many in the industry believe that **the biggest reduction in costs will simply come from scaling up existing technologies**. The Hydrogen Council forecasts that cost-parity with other low competing low carbon alternatives will be reached in most industries by around 2030. Of course, in the intervening period, the perennial dilemma of whether to build related infrastructure before there is cost-competitive supply and related demand remains. Making infrastructure (particularly charging stations) interoperable will also likely be crucial. Other factors to consider are how to reassure all stakeholders that hydrogen is safe – it can be highly flammable – and what role other competing technologies (particularly on the battery storage side) may play.

From an investor perspective, **identifying potential winners at this stage is difficult**. The industry is still very nascent, many businesses are private or subsidiaries of larger conglomerates, and almost all will be loss-making at present. The challenge is to scale successfully. At this early stage, it is all not clear whether value will accrue most to companies providing the foundational building blocks or the services (metaphorically, the shovel-makers or the miners). Who adds value *to the industry* and who creates value *for shareholders* may be two different things. Nonetheless, when winners do emerge, they will clearly be attractive, particularly for ESG-oriented investors.

Nikola Corp is one business to watch in the space. Recently listed on NASDAQ (via a reverse merger IPO with the Vector Acquisition Corp SPAC) with a current market capitalisation of ~$23bn, Nikola already counts Bosch, CNH and Iveco as anchor investors and says it has an order book equivalent to $10bn of revenues. Elsewhere, **Air Liquide** is probably the business with most exposure to hydrogen via a range of its activities, although hydrogen accounts for less than 10% of the group's total revenues. Other businesses involved in various parts of the hydrogen value chain include **Ballard Power**, **Bloom Energy**, **Nel ASA**, **Plug Power** and **Powercell Sweden**. Expect many more to blossom in the coming years.

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