Hydrogen Flow and Treat Market Niches

Revised 8 -16 -21

Markets

There is a significant current market for flow and treat products in the production of hydrogen. A number of technologies and applications are evolving. There is considerable funding from governments who believe that hydrogen is an important option to achieve zero net carbon emissions by 2050.

There is an opportunity for flow and treat system and product suppliers to develop unique products which can boost EBITA as well as revenues. But in addition to the uncertainty about applications and technologies there is no clear ranking of potential users and suppliers of the hydrogen.

Another challenge is the likely fragmentation into many sub segments which have different total cost of ownership factors and therefore unique product requirements.

McIlvaine is continually compiling information on these unique requirements and the products which are best suited to meet the needs. This data is being used to provide extensive forecasts by purchaser, application, industry, and geography.

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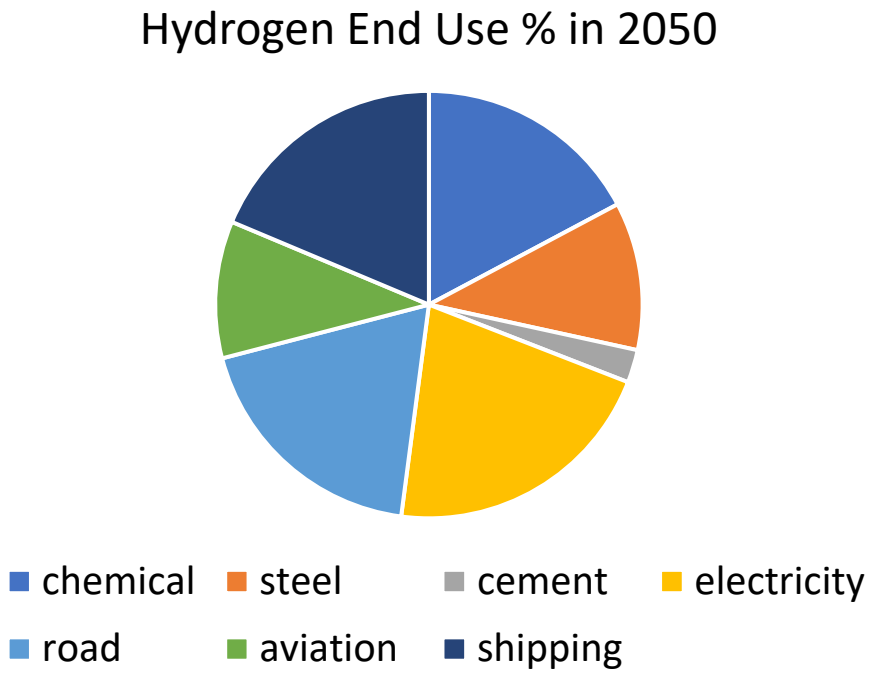
The sales of flow and treat products to produce hydrogen in in 2050 could range from $15 billion to $50 billion. This market will to some extent be shaped by the suppliers. Other methods of energy storage will compete. To the extent that the flow and treat industry can improve the economics of hydrogen the larger the market share for this fuel option will be.
Individual flow and treat suppliers will need to determine their specific potential revenues and EBITA depending on several variables including

- Total amount of hydrogen consumed
- Percent used in different industrial sectors
- Sources of power
- Geographical distribution
- Technologies utilized to make the hydrogen



Energy Sources

The energy source to produce hydrogen has significant impact on the size of the flow and treat market and the competitive position of specific flow and treat companies.

Suppliers such as Andritz with strengths in hydropower will benefit to the extent that hydropower is the energy source.

Wind and solar plants do not use many flow and treat products. Coal and biomass with carbon sequestration would use the most.

In the case of bioenergy hydrogen can be just one of the products produced.

The energy source can also shape the geographical markets. Hydropower opportunities occur in areas of the world which can differ greatly from that of other energy sources.

Energy Sources
Solar
Wind
Hydropower
Nuclear
Coal
Biomass
Municipal Solid Waste
Municipal Sewage
Medical Waste
Food Waste
Tidal

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Hydrogen Transport

Hydrogen can be transported as a gas, liquid or as ammonia. The choice of ammonia as a method for transport has a number of advantages and is being pursued as a blue hydrogen approach.

Ammonia can be produced in Australia with CCS to eliminate the CO2 emissions and then shipped around the world.

A number of flow and treat companies specialize in products for ammonia manufacture and transport. They will benefit to the extent that this ammonia option is selected.

Transport Method
Gas
Liquid
Ammonia

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Lots of Green Hydrogen Needed for the World to Achieve Net Zero Emissions

Achieving global net-zero emissions by 2050 will require about 306 million tons of green hydrogen derived from renewable energy each year, according to the International Energy Agency (IEA) report, *Net Zero by 2050 – A Roadmap for the Global Energy Sector*.

The landmark IEA study, which sets out the steps needed to get the world to net-zero emissions by mid-century, also says that 197.6 million of blue hydrogen would be required annually, derived from natural gas or coal with carbon capture and storage (CCS).

A further 16 million tons of low-carbon electrolytic hydrogen would be also produced annually from electrolysis powered by nuclear power and fossil-fuel power plants with CCS. In total, the report says, 520 million tons of renewable and low-carbon hydrogen would be used across a wide range of industries. By comparison, 87 million tonnes of largely grey hydrogen were produced from unabated natural gas and coal in 2020, mainly for use in the chemicals and oil refining sectors.

This would require a compound average annual growth rate (CAAGR) in clean hydrogen production of 66% between now and 2030, and 23% between 2030 and 2050, the IEA says. The 322 million tons of green and electrolytic hydrogen in 2050 would require a global electrolyser capacity of 3,585GW, up from about 300MW today, and roughly 14,500TWh of electricity — about 20% of the world's electricity supply (71,164TWh). Electrolysers are machines that split water molecules into hydrogen and oxygen using an electric current.

Power Capacity In A Net-Zero World

According to the IEA, reaching net-zero emissions would require the following power capacities to be installed in 2050 (with 2020 installed capacities in brackets):
Solar PV: 14,458GW (737GW)
Wind: 8,265GW (737GW)
Hydro: 2,599GW (1,327GW)
Hydrogen power plants: 1,867GW (zero)
Nuclear: 812GW (415GW)
Bioenergy: 640GW (171GW)
Coal-fired with CCS: 222GW (1GW)
Gas-fired with CCS: 171GW (zero)
Concentrating solar power (CSP): 426GW (6GW)
Geothermal: 126GW (15GW)
Marine (wave and tidal): 55GW (1GW)
“Rolling out electrolysers at the pace required in the NZE [Net-Zero Emissions by 2050 scenario] is a key challenge given the lack of manufacturing capacity today, as is ensuring the availability of sufficient electricity generation capacity,” the IEA report says.
Of the 538 million tons of hydrogen needed in 2050 — eight million tons of which would be grey — about 25% will be produced and used at the same industrial facilities, with the remainder produced and sold on a global hydrogen market.
“Global trade in hydrogen develops over time in the NZE, with large volumes exported from gas and renewables-rich areas in the Middle East, Central and South America and Australia to demand centers in Asia and Europe,” the study explains.
About ten million tonnes of hydrogen would be blended with natural gas in gas networks, with a global average blend of 15% in 2030, reducing CO_2 emissions from methane consumption by about 6%.
The IEA says that blue hydrogen from natural gas will cost around $1-2 per kg by 2050, with green hydrogen at $1-2.50/kg.

Hydrogen Demand by Sector

By 2050, hydrogen will be required for electricity generation (to back up renewables), road transport, shipping, aviation and heavy industries such as chemicals, steel and cement, the report states.

Heavy Industry
The largest demand for hydrogen in 2050 will come from heavy industry, accounting for about 35% of the total, or 187 million tons — with 83 million tons used in the chemicals sector, 54 million in steel and 12 million in cement.

Power
Electricity generation will account for roughly 19% of the total, or 102 million tonnes a year — including 13 million tonnes of ammonia derived from hydrogen.

“After 2030… hydrogen and hydrogen-based fuels provide an important low-carbon source of electricity system flexibility, mainly through retrofitting existing gas-fired capacity to co-fire with hydrogen, together with some retrofitting of coal-fired power plants to co-fire with ammonia,” the report explains. “Although these fuels provide only around 2% of overall electricity generation in 2050, this translates into very large volumes of hydrogen and makes the electricity sector an important driver of hydrogen demand.”

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Road Transport

The third-largest demand for hydrogen (about 17% or 91 million tons) will come from road transport. About 35% of the world's heavy trucks would be fueled by hydrogen in 2050, with the remaining 65% driven by batteries. Hydrogen would power about 10% of the world's light-duty vehicles (cars and vans), with 90% being battery electric vehicles (EVs).

This will require 200 million public EV charging points, 3.5 billion private EV chargers and 90,000 hydrogen refueling stations, the report states.

However, the IEA report also includes an "all-electric case" to make all road transport run on electric batteries, "if other technologies such as FCEVs [fuel-cell electric vehicle] and advanced biofuels fail to develop as projected".

The shipping sector would require about 90 million tons of hydrogen per year — almost three quarters of which would be in the form of ammonia. Together, hydrogen and ammonia would account for just over 60% of the shipping industry's energy consumption. Biofuels will contribute a further 20%, with fossil oil still making up about 15%.

"Due to a lack of available low-carbon options on the market and the long lifetime of vessels (typically 25-35 years), shipping is one of the few transport modes that does not achieve zero emissions by 2050 in the NZE," the report says.

Aviation

The aviation industry would require about 50 million tons of hydrogen per year — almost 99% of which would be combined with captured CO_2 to produce carbon-neutral synthetic jet fuel.

This synthetic fuel would meet about 30% of total fuel consumption from aviation in 2050, with 45% coming from biofuels. Battery-powered planes would account for less than 2% of fuel consumption, with fossil oil still contributing 10%. The role for hydrogen-powered planes, which are being developed by Airbus, would be negligible.

Power-to-X describes methods for converting electrical energy into liquid or gaseous chemical energy sources through electrolysis and further synthesis processes. Using electrical current, water is split into oxygen and hydrogen – a 100% CO_2 emission-free process. Being a key technology for the energy transition, Hydrogen can be easily stored and further used or processed in many way.

Mobility: Power-to-X produces synthetic fuels for immediate application: e-Methane, e-Methanol, e-Diesel, e-Gasoline or e-Jet fuel – ready for instant use. They can be blended gradually with fossil fuels until they fully replace fossil fuels as a primary energy source. Existing infrastructure such as gas pipelines, gas stations, or storage facilities can be used as well as existing and low-cost consumer applications, powered by e-Fuels.

Power generation: Modern gas turbines can be operated with a mix of hydrogen and natural gas, with a hydrogen share of 5 to 100%. Hydrogen can be cached, transported in gas grids and re-electrified in gas turbines, combined cycles or fuel cell power plants.

Industry: Large heat demand; H_2 enables CO_2-free metal production; Green hydrogen as feedstock for production of ammonia and other products.

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Japan Planning to Burn 3 million tpy of Ammonia by 2030

Yara International ASA,and JERA Co., Inc, Japan's largest power generation company, have signed a Memorandum of Understanding to collaborate on the production, delivery and supply chain development for blue and green ammonia, to enable zero-emission thermal power generation in Japan.

Japan recently announced plans to introduce ammonia into the fuel mix for thermal power generation, as part of its measures to cut CO_2 emissions and reach carbon neutrality by 2050. As part of its Green Growth Strategy, the government targets ammonia imports of 3 million tons by 2030.

"This ground-breaking collaboration aims to decarbonize JERA's power production and provide Yara with a footprint in the strategically important Japanese market. Building blue and green ammonia value chains is critical to enabling the hydrogen economy and collaborating with a key player like JERA marks a milestone in leveraging Yara's global capabilities," says Svein Tore Holsether, President and Chief Executive Officer of Yara.

JERA Corporate Vice President Yukio Kani says: "We are pleased to conclude this MOU with Yara, a leading global ammonia producer, which shares our aspiration to develop a clean ammonia value chain. We believe that this cross-sector collaboration will not only expand business opportunities for both companies but also accelerate the transition to a decarbonized society."

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Ammonia does not emit carbon dioxide during combustion and is seen as an effective future energy source. Blue ammonia is derived from a carbon capture and storage process (CCS), while green ammonia is produced carbon free by using hydrogen sourced from renewable energy as feedstock. The term clean ammonia comprises both blue and green ammonia.
Under the MoU, Yara and JERA are targeting collaboration in the following areas:

- Supply and development of new ammonia demand in Japan including power generation purpose
- Sequestration of already captured CO_2 (CCS) at Yara's ammonia plant in Pilbara, Australia, enabling the production and supply of blue ammonia to JERA
- New clean (blue and green) ammonia project development
- Optimization of ammonia logistics to Japan

JERA is the largest power generation company in Japan, producing about 30% of Japan's electricity. The Tokyo-based company is committed to establishing green fuel supply chains to achieve zero CO_2 emissions from its operations in Japan and overseas by 2050.

Yara is a world leader in ammonia, with long experience and leading positions within global ammonia production, logistics and trade. The Oslo-based company produces roughly 8.5 million tons of ammonia annually. Yara employs a fleet of 11 ammonia carriers, including 5 fully owned ships, and owns 18 marine ammonia terminals with 580 kt of storage capacity – enabling it to produce and deliver ammonia across the globe. Yara recently established a new Clean Ammonia unit to capture growth opportunities in emission-free fuel for shipping and power, carbon-free fertilizer and ammonia for industrial applications.

Ammonia Co-Firing in Japan

Japan is seeking a significant role for ammonia co-firing in its domestic coal-fired power plants as it seeks a path towards its 2050 net zero emissions target.

Originally aiming for a 20% ammonia co-firing rate at the nation's coal-fired power plants by 2030 with the aim of expanding beyond 50% thereafter, the government has now brought forward its target and wants to see a demonstration of 50% co-firing by 2030.

Japan's biggest power generator JERA is currently testing ammonia co-firing at its 1,000-megawatt (MW) Hekinan coal-fired power plant with the intention to reach 20% ammonia co-firing by 2024.

Japan's early focus on green hydrogen produced via renewables seems to have been diluted to include blue hydrogen produced from coal and gas with carbon supposedly captured. Japan's Green Ammonia Consortium has recently rebranded to become the Clean Fuel Ammonia Association, reflecting this change in focus.

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Current Activity

August 13, 2021 - Utility E-Alert

Howden Supplying Compressors to Everfuel for Green Hydrogen

Howden Supplying Compressors for Haru Oni efuel Plant

1600 MW Hamburg Plant could be Purposed to Wind Based Green Hydrogen

Shell Starts Up 10 MW Electrolyzer in Wesseling

SSAB to Make Sponge Iron Using Hydrogen and Not Coal in Lulea

GE Supplying 316 MW Hydrogen Capable Turbine to NSW.

Plug Power will Produce Green Hydrogen in GA

BP Could Export Green Hydrogen from Australia

JM to Manufacture Components for Green Hydrogen

Haldor Topsoe SynCOR to be Used by Air Products in Blue Hydrogen Production

Doosan Developing Ammonia/Hydrogen Turbines

Cummins and Chevron Pursing Hydrogen for Transportation

Linde Starts Up Fifth Hydrogen Plant in the U.S.

Mitsui & Co., Inc. and CF Industries to Jointly Explore Development of Blue Ammonia Projects in the United States

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August 6, 2021 - Utility E-Alert

HydrogenNext Conference to be Held in San Antonio in October

Trillium Successes to be Covered at the Conference

Largest Transit Hydrogen Fueling Station in Santa Anna California

1.2 GW Dedicated Hydrogen-Fired Power Plant Starts Taking Shape in Texas

Washington Utility Provider Douglas PUD Turns to Renewable Hydrogen for Backup Power

Mitsubishi Making Turbine Plants Hydrogen Ready

Sundyne's Pumps & Compressors Offer Functionality Specifically Suited to Hydrogen Applications

The Strengths of the PPI Compressor Line Address the Key Requirements for Hydrogen Applications

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July 2021 - Utility E-Alerts

July 30

Johnson Matthey Acquires Assets to Accelerate Green Hydrogen Scale-Up

Kansai Electric Power Will Study Ways of Producing CO_2-Free Hydrogen in Japan

GCL to Make Ammonia and Hydrogen in Ethiopia

BP Expects Hydrogen to Account for 16% of Worlds Energy by 2050

July 23

Tallgrass Energy Awarded U.S. Department of Energy Funding to Advance Next Generation Clean Hydrogen Technologies

Saudi Arabia, Oman, and Australia Have Big Hydrogen Plans

Air Products Chooses Haldor Topsoe's SynCOR Technology For World-Scale Blue Hydrogen Energy Complex in Canada

Heliogen and Bloom Energy (BE) Announced a Partnership to Produce "Green Hydrogen"

July 1

Howden to Supply Hydrogen Storage Compressors to Steel Producer

Howden Supplying Compressors For Everfuel Green Hydrogen Plant in Denmark

MHI Using Hydrogen as an Effective Form of Renewable Power Storage

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Deliverables

Databases and Weekly Hydrogen Activity Updates

The weekly Utility E-Alert is 20-30 pages with a comprehensive hydrogen section as shown above under “current activity”

http://home.mcilvainecompany.com/index.php/databases/41f-utility-e-alert

Details on gas turbine plants around the world are included

http://home.mcilvainecompany.com/index.php/markets/air/gas-turbine-and-reciprocating-engine-supplier-program

Details on coal fired plants are included
http://home.mcilvainecompany.com/index.php/databases/42ei-utility-tracking-system

Package price for all of the above is $3800/year plus $200/year each for additional subscribers.

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Customized Forecasts for Hydrogen Opportunities

- Millions of forecasts for hydrogen opportunities are available with the following segmentation
- Product: Options include pumps, valves, compressors, combustion and treatment systems, filters, chemicals, scrubbers
- Energy sources: Any or all the energy sources listed on slide 5
- Uses: Any or all uses from electricity generation to transport
- Countries: 80 countries and sub regions
- Forecast period: Any number of years into the future
- Technology analysis
- Projected market share based on cost of ownership advantages
- Price: quoted after specific scope is determined

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