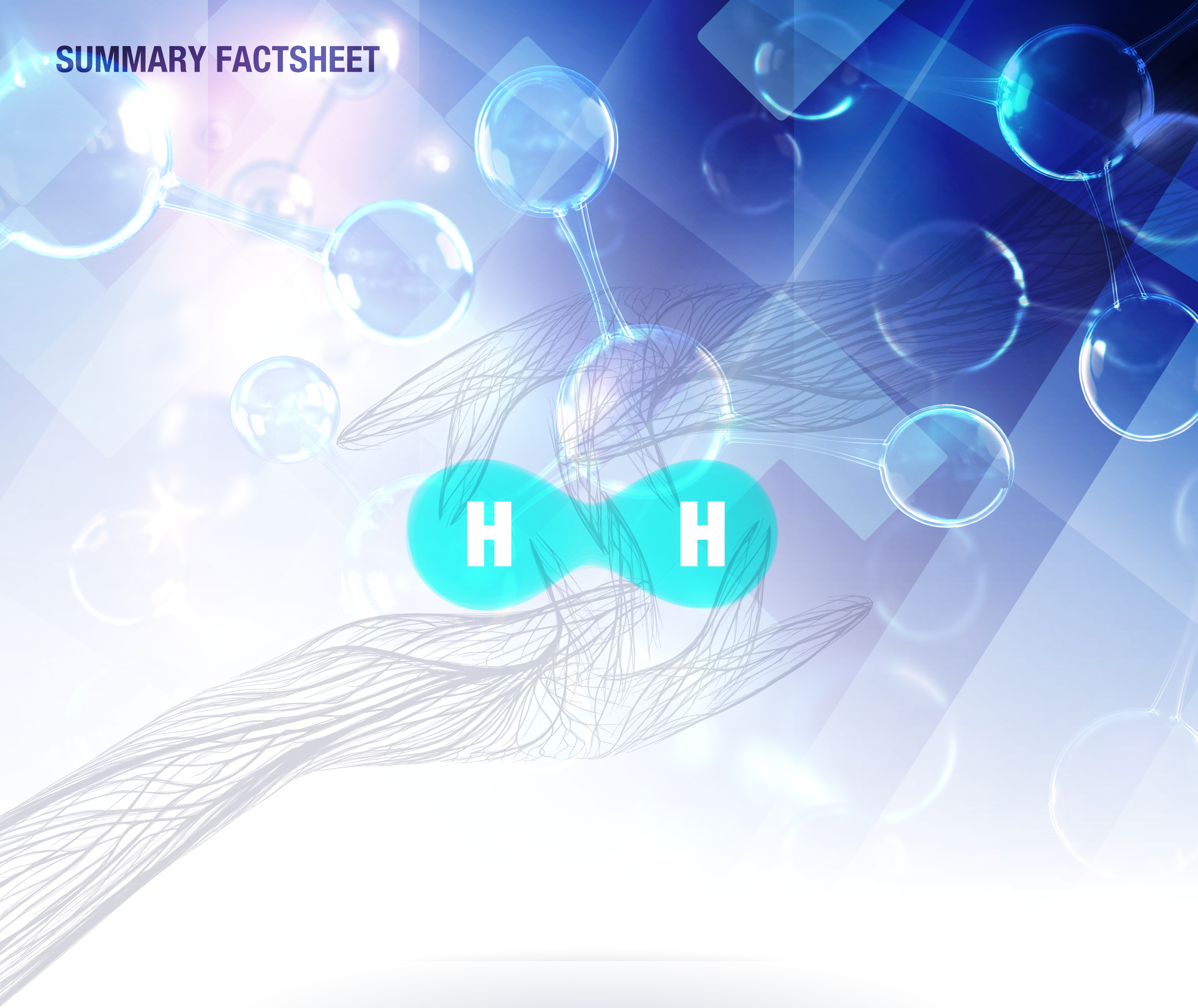
SUMMARY FACTSHEET



POWER TO HYDROGEN

EMERGING TECHNOLOGIES FOR THE RENEWABLE ENERGY SECTOR

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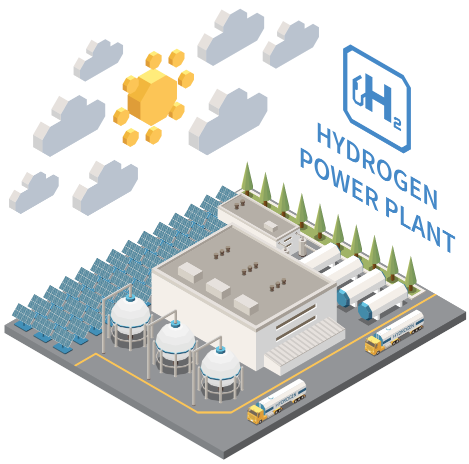
CONTENT

SUMMERY

1. What is power to Hydrogen?

Electrolysis, a method that employs electricity to divide water into hydrogen and oxygen, can be used to make hydrogen. When renewable energy is employed in this process, hydrogen becomes a complementary renewable energy carrier.

There are three main types of electrolyser: an alkaline electrolyser, a proton exchange membrane (PEM) electrolyser, and a solid oxide electrolyser (SOE).



	Type of electrolyser		
	Alkaline	PEM	SOE
Development status	Commercial	Commercial, small- and medium-scale applications (< 300 kW)	Undergoing research
Brief description	Transport of hydroxideion through electrolyte • Hydrogen generated at cathode • A l liquid alkaline s solution of sodium or potassium hydroxide used as an electrolyte	Water reacts at the anode to form oxygen and hydrogenions (protons) • Electrons flow through an external circuit, and hydrogen ions selectively move across the PEM to the cathode • Electrolyte is a solid specialty plastic material	Water at the cathode combines with electrons from the external circuit to form hydrogen gas and negatively charged oxygen-ions • The oxygen ions pass through the solid ceramic membrane and react at the anode to form oxygen gas and generate electrons for the external circuit • A solid ceramic material used as the electrolyte
Operating temperature	100–150 °C	70–90 °C	700–800 °C

Table 1: Brief description of electrolysers, Bertuccioli et al., 2014

The hydrogen produced during the electrolysis process can be utilized as an energy storage medium and for purposes such as producing heat for buildings, refueling fuel cell cars, and as a source of feedstock for industries. Hydrogen can be stored and transferred using the existing natural gas infrastructure. Adapting natural gas infrastructure to transport hydrogen requires little investment.

2. The Role of power to hydrogen in The Power Sector

Power to Hydrogen can help regulate the variability in power supply from wind and solar photovoltaic (PV) technologies by providing grid balancing services and long-term storage. Power to Hydrogen can also enable the use of clean hydrogen produced from renewable energy sources as a feedstock in industrial processes, hence aiding in the decarbonization of other sectors.

3. Applications of power to hydrogen in The Energy Sector

- **Reducing VRE curtailment**

When renewable energy cannot be fed into the electricity grid due to network constraints or low demand, it can be sent to electrolysers for electrolysis to produce hydrogen. Obtaining excess renewable energy can significantly improve hydrogen production economics.

- **Long-term energy storage**

While daily imbalances resulting from VRE generation may be better addressed with batteries, seasonal changes necessitate long-term storage options such as power to hydrogen. Hydrogen can be used as a long-term storage medium, holding energy for several months. Currently, storing energy in the form of hydrogen is not economically feasible.

- **Providing grid-balancing services via the electrolyser**

As a flexible load, the electrolyser systems used to produce hydrogen may be rapidly cycled up and down, offering grid functions such as frequency regulation. The experiment demonstrates that electrolysers may swiftly modify their load point in response to grid needs while also accelerating recovery in the event of a frequency deviation (Gardiner, 2014).

- **Using clean H_2 as fuel and feedstock in other sectors**

Hydrogen can be used as feedstock in the chemical industry; such as the production of ammonia, synthetic fuels, various types of fertilizer, methane production, synthetic liquid fuels from biomass, and it can be used to replace fossil fuels and act as a reducing agent in heavy industries.

Hydrogen can be utilized directly as a fuel in the transportation sector or to generate electricity using fuel cells. It can also be utilized as fuel by blending it with natural gas in existing pipelines.

- **Transporting renewable power over long distances as H_2**

Transporting energy in the form of hydrogen can allow renewable energy to be delivered to areas where renewable energy supplies are scarce (Hydrogen Council, 2017). A gas pipeline network or vessels can be used to transport hydrogen. Transporting renewable energy in the form of hydrogen over large distances could be an economically appealing option in the long run, particularly in circumstances where the electricity grid is underutilized or where building new infrastructure would be unfeasible or expensive.

4. Challenges and Enabling Factors

- **Lowering production costs and increasing income streams**

Electrolysers have long been utilized in a variety of sectors. They are considered "mature" technology for industrial applications. Their potential in energy applications, however, is still developing. To accommodate the potential of power to hydrogen, existing legislative and market frameworks must be changed or reinvented, while technology and infrastructure costs must be continually reduced.

- **Develop a hydrogen infrastructure**

Hydrogen-related infrastructure must be developed in such a way that promotes the construction of a hydrogen ecosystem for power to hydrogen to contribute to power sector reform.
This would allow all of the necessary stages to continue to develop: production, transmission, storage, and consumption.

- **Promote policies that encourage the use of renewable hydrogen.**

The deployment of hydrogen infrastructure necessitates collaboration among numerous stakeholders. Furthermore, the financial feasibility of many hydrogen infrastructure expenditures is dependent on a 10- to 20-year time commitment. To reduce the risks and reap the benefits of hydrogen deployment, a comprehensive road map is required. Governments may want to consider developing national/regional action plans for the sector, with specific targets in mind to encourage the deployment of renewable hydrogen infrastructure.

A stable and supportive policy environment is required to attract appropriate private investments and achieve rapid scale-up. This holds true throughout the supply chain (equipment, manufacturers, infrastructure operators, car manufacturers, and so on).

- **Develop and enforce regulations related to safety**

The hydrogen gas is extremely flammable. While there are adequate safety regulations for traditional uses of hydrogen, there is a lack of safety regulations for upcoming uses of hydrogen (such as cartridge-based storage solutions for road vehicles) which might act as a barrier to commercialisation.

5. Projects and Services

GRHYD demonstration project

In France, a consortium led by ENGIE is exhibiting the GRHYD hydrogen energy storage project. The GRHYD project intends to transform surplus energy generated from renewable energy sources into hydrogen, with France aiming to fulfill 23 percent of its total end-user energy consumption from renewable sources by 2020. The hydrogen is mixed with natural gas to make Hythane(1), which is then utilised within the current infrastructure (ENGIE, 2018).

H2Future (FCH JU) project

Siemens installed a 6 MW electrolyser at the Voestalpine Linz steel production site in Austria as part of the H2Future FCH JU project. The goal of the project is to investigate using electrolysers to supply grid balancing services including primary, secondary, and tertiary reserve, as well as providing hydrogen to the steel factory. To take advantage of time-of-use power pricing, hydrogen is created utilizing electricity during off-peak hours (European Commission, 2018).

Stone Edge Farm Micro-grid

The Stone Edge Farm microgrid in California was unable to economically export excess renewable energy to the California Independent System Operator (CAISO) market.

One of the obstacles in exporting power was meeting CAISO's standards for onsite weather forecasts and complying with the 0.5 MW minimum threshold. The microgrid developer is now exporting power using hydrogen. It has installed an onsite electrolyser bank that converts extra electricity to hydrogen. This hydrogen is then utilised in electric vehicles with fuel cells. When needed, hydrogen is also used to generate electricity via fuel cells (Forni, 2017).

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