SIQENS

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Electrochemical Hydrogen Separation

Hydrogen purification, extraction, and recovery

Electrochemical hydrogen separation addresses key challenges in low-cost hydrogen infrastructure, on-site hydrogen production, or by tapping unused resources of hydrogen.

INTRODUCTION

Purity matters

Hydrogen is the most abundant element in the universe, but rarely found in its pure form on earth. In nature, hydrogen tends to combine with other elements to form compounds. Predominantly, the production of hydrogen relies on splitting up these compounds, yielding a hydrogen-rich gas stream. Based on the feedstock, the gas stream contains impurities like carbon, sulfur, nitrogen and other contaminants. These impurities can impact the quality and properties of the hydrogen gas, causing damage to downstream equipment. To prevent harm to equipment and machinery that use hydrogen as a fuel, such as low temperature fuel cells, the gas stream has to be purified and contaminants need to be removed.

Separating hydrogen from other gases or impurities can be challenging, particularly if they have similar physical or chemical properties. In addition, impurities can form solid deposits on the surface of purification equipment, leading to clogging and reduced efficiency. For conventional purification methods, an extensive amount of pressure and energy is required. Such means of purification are only limited viable for small scale, decentralized plant designs. Furthermore, the recovery of lower volume shares of hydrogen, such as from industrial off-gases or natural gas blends, tends to be not economical.

SIQENS Electrochemical hydrogen separation units (EHS) are designed for the separation and purification of hydrogen from various gas streams. Extracting and recovering high-purity hydrogen where it is needed – and upgrading hydrogen for direct local use, storage, or merchant sales.

HOW IT WORKS

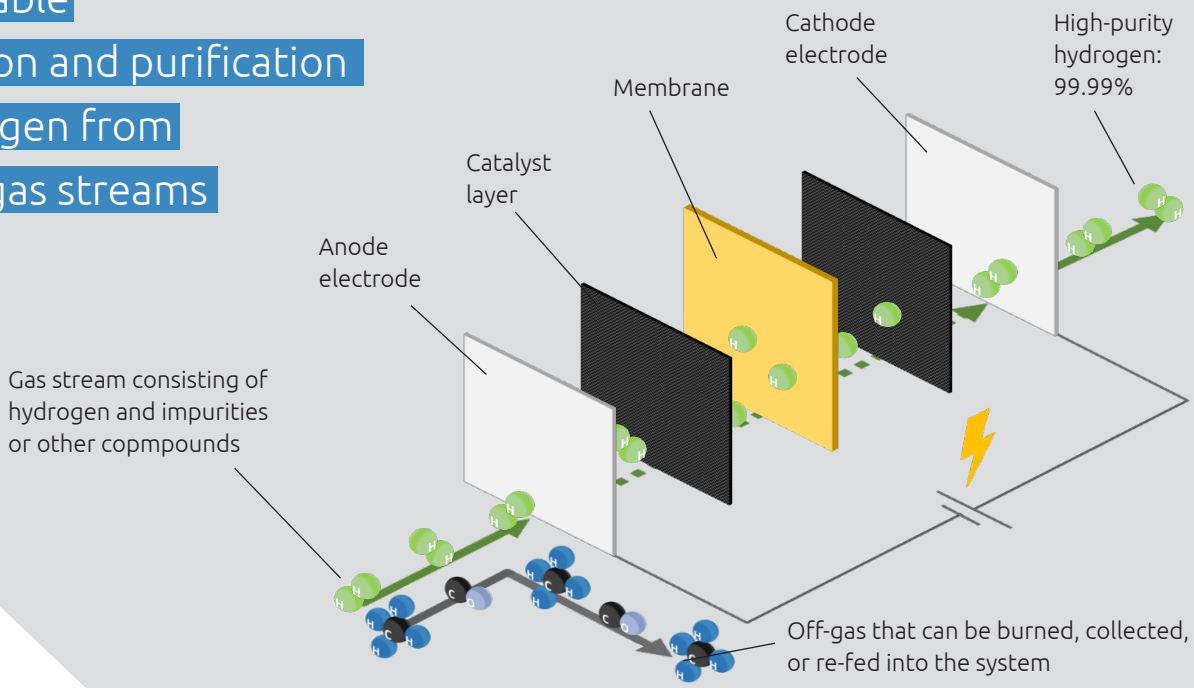
The separation process

The SIQENS EHS technology is built around the SIQENS HT-PEM stack (high temperature polymer membrane), which is serially included in the SIQENS Ecoport methanol fuel cell product range. As such, the stack has been in commercial operation for several years. Opposed to being used for power generation within the fuel cell systems, the stack allows for separation and purification of hydrogen in various gas streams.

Energy-efficient and scalable separation and purification of hydrogen from various gas streams

On the stack membrane, a specially developed catalyst identifies and attracts hydrogen molecules in hydrogen-containing gas streams. Introduction of a small amount of electricity splits the hydrogen molecules into single hydrogen protons and free electrons.

The membrane is designed to allow only hydrogen protons to pass through. By re-joining on the other side, they combine to hydrogen molecules. The process yields high purity hydrogen, capable of being used in industrial processes, the chemical industry, for network decarbonization projects, or in fuel cell electric vehicles.



Advantages

Electrochemical hydrogen separation is an attractive alternative to other hydrogen purification technologies, such as pressure swing adsorption or membrane separation, as it requires relatively low energy consumption and has a high selectivity for hydrogen. Additionally, it is a flexible and scalable technology that can be adapted to a wide range of feed gases, making it a key component of the hydrogen economy.

High purity

Purifies hydrogen to fuel cell grade:
> 99.97%
ISO 14687:2019
SAE J2719-202003

Efficient

Hydrogen purifictaion and recovery at low electricity consumption:
1 – 6 $kWh_{el}/kg\ H_2$

Versatile

Extraction from feed gases with a wide range of hydrogen content:
3 – 99%

Modular

Purifies hydrogen economically even at small scale:
2 – 1,000 kg/day

DATA SHEET

Technical parameters

Technical specification is based on demonstrator systems with a separation rate of 5 kg/day H_2 that are operated at research facilities and industrial partners. Application-specific requirements regarding inlet and output pressure or costumization for operation in different environments can be adressed via the system design and peripheral components.

SIQENS EHS - Technical parameters	
H_2 content in feed gas	2% – 100%
H_2 recovery rate[1]	up to 90%
Operating temperature stack	140 – 160°C
CO tolerance	10 vol%
Sulfur tolerance (H_2S)	100 ppmv
Inlet pressure[2]	2 – 15 bar
Inlet gas temperature[2]	1 – 60 °C
Ambient temperature[2]	1 – 45 °C
Energy consumption[1]	1 – 6 kWh/kg H_2
Output pressure[2]	0 – 0.5 bar(g)
Purity[3]	99.99 %

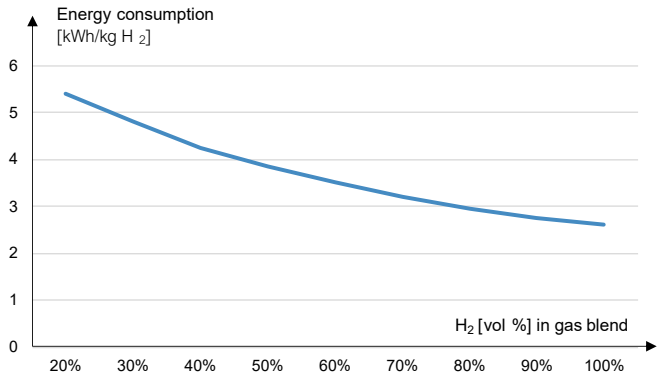
[1] Depending on the medium

[2] Can be addressed via additional compression stage, housing, and overall system design

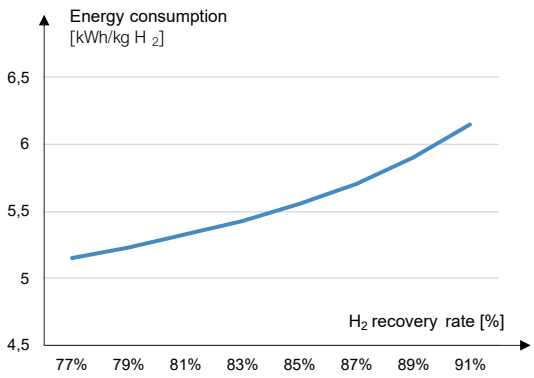
[3] Depending on the medium; several stages possible to achieve even higher purity rate

Example: Hydrogen separation from a blend of hydrogen and natural gas

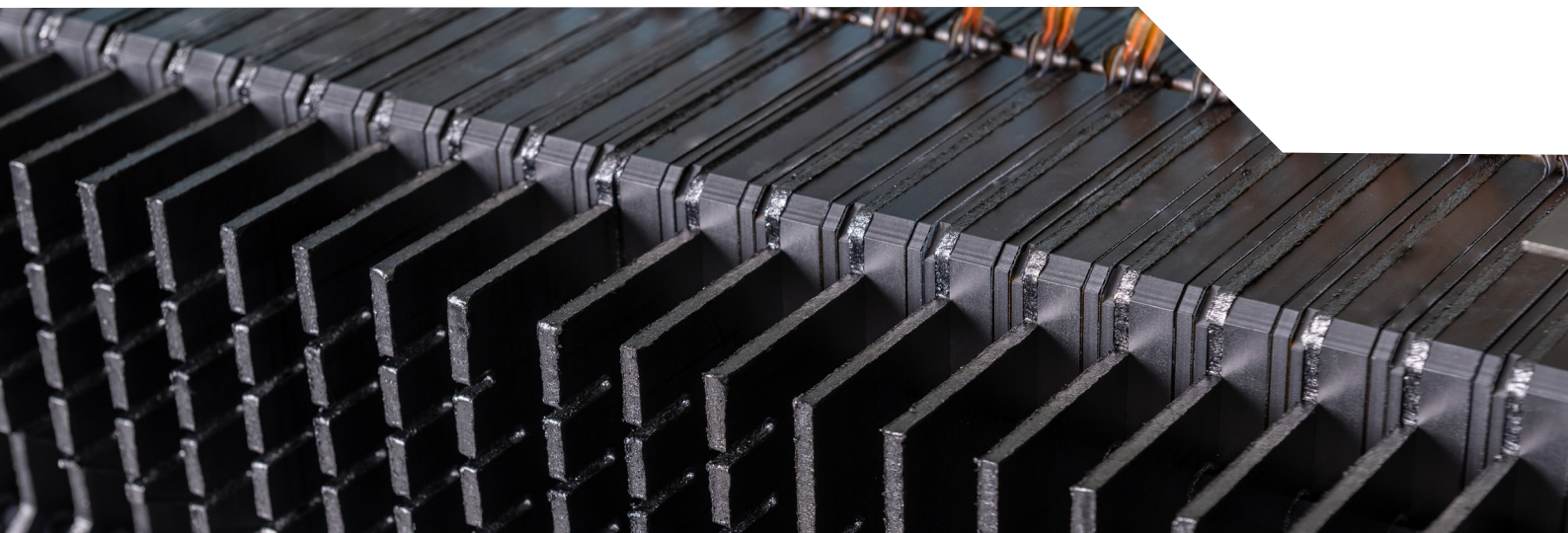
Energy consumption based on hydrogen content [vol %]



Energy consumption based on recovery rate [%]



The power consumption depends on the hydrogen content in the feedgas and the desired recovery rate. Generally, power consumption will decrease with an increase in the hydrogen content of the feed gas and increase to achieve a higher recovery rate.



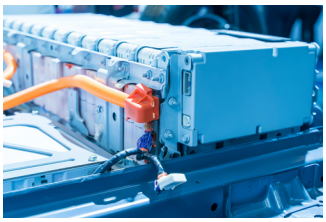
WHERE HIGH-PURITY HYDROGEN IS NEEDED

End use applications that rely on high-purity hydrogen

Industrial processes and fuel cells rely on high-purity hydrogen. Electrochemical hydrogen separation enables on-site generation, low-cost distribution, and recovery of hydrogen across a variety of areas:

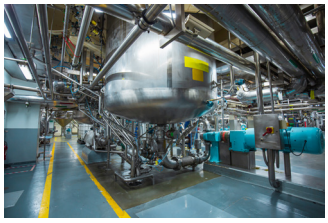
Hydrogen refuelling

Hydrogen has the potential to become an essential component in the decarbonization of heavy-duty transportation



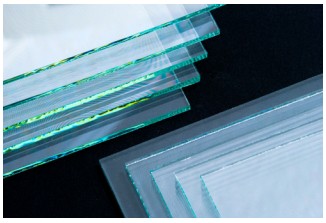
Stationary fuel cells

In stationary fuel cells, hydrogen offers a simple means of replacing diesel in remote and backup power supply.



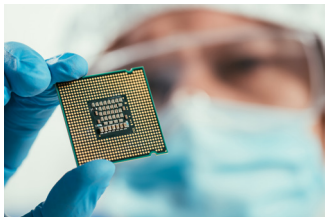
Food industry

Hydrogen is used as a process gas for the production process of oil and fat such as margarine & vegetable oils.



Glass production

Hydrogen is used as a process gas during the float process of flat gass production.



Electronics industry

Hydrogen is used as a forming, carrier, and scavenger gas in semi-conductor production.

Refineries

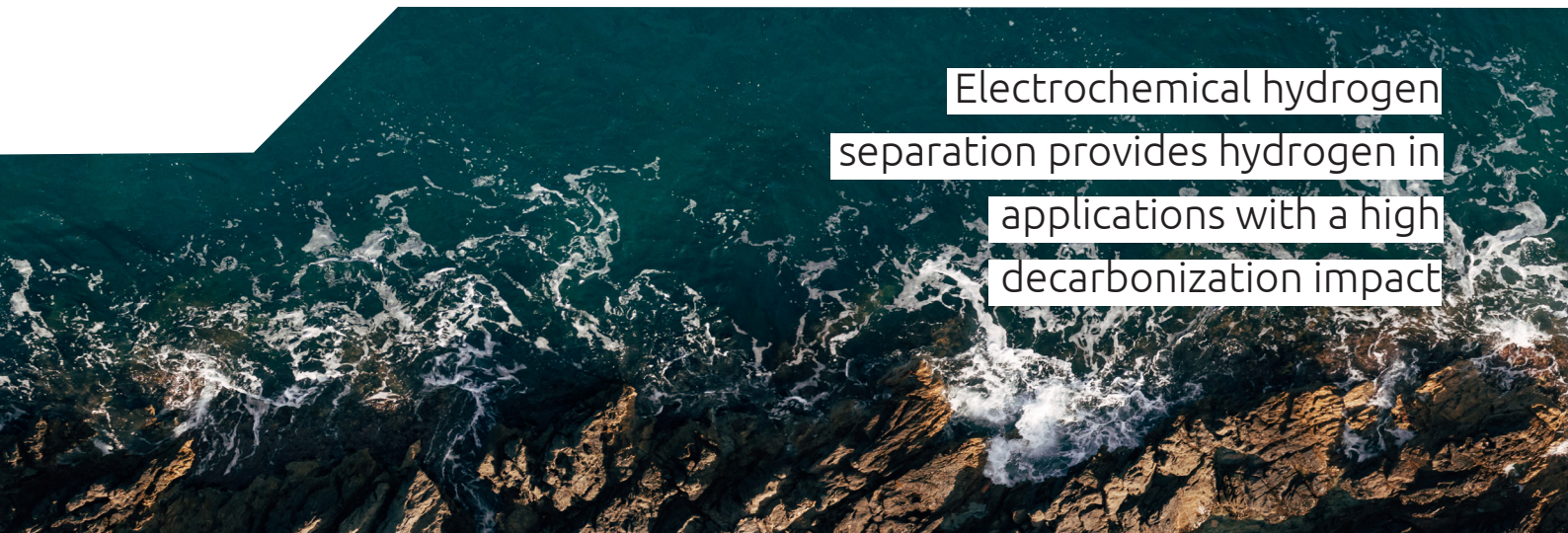
Among others, hydrogen is required to complete the reactivation of catalysts used in the petrochemical industry.

Chemical industry

Hydrogen is needed for the production of fine chemicals such as sorbitol or fatty acids.

Metallurgy

Hydrogen is used to mantain a highly controlled temperature and atmosphere during heat treatment processes.



Electrochemical hydrogen separation provides hydrogen in applications with a high decarbonization impact

WHERE IT ADDS VALUE

Use cases for electrochemical hydrogen separation

EHS enables the simple and wide-spread usage of hydrogen in high-value and decentral applications, addressing key challenges in low-cost hydrogen infrastructure, on-site hydrogen production, or by tapping unused resources of hydrogen.

HYDROGEN PRODUCTION

On-site hydrogen generation

Hydrogen can be obtained from various feedstock such as methanol, methane, or biogas. Such hydorgen carriers can be split up locally via steam reformation. The resulting gas contains free hydrogen molecules, other components, and impurities. The modular design of EHS provides a significant value-add even at low production quantities and makes high-purity hydrogen available on-site.

HYDROGEN DISTRIBUTION

Low-cost transportation

Low-cost hydrogen transportation remain a major challenge in the ramp up of the hydrogen economy. On-site separation and purification leverage the benefits of existing pipeline infrastructure or enable transportation via hydrogen carriers:

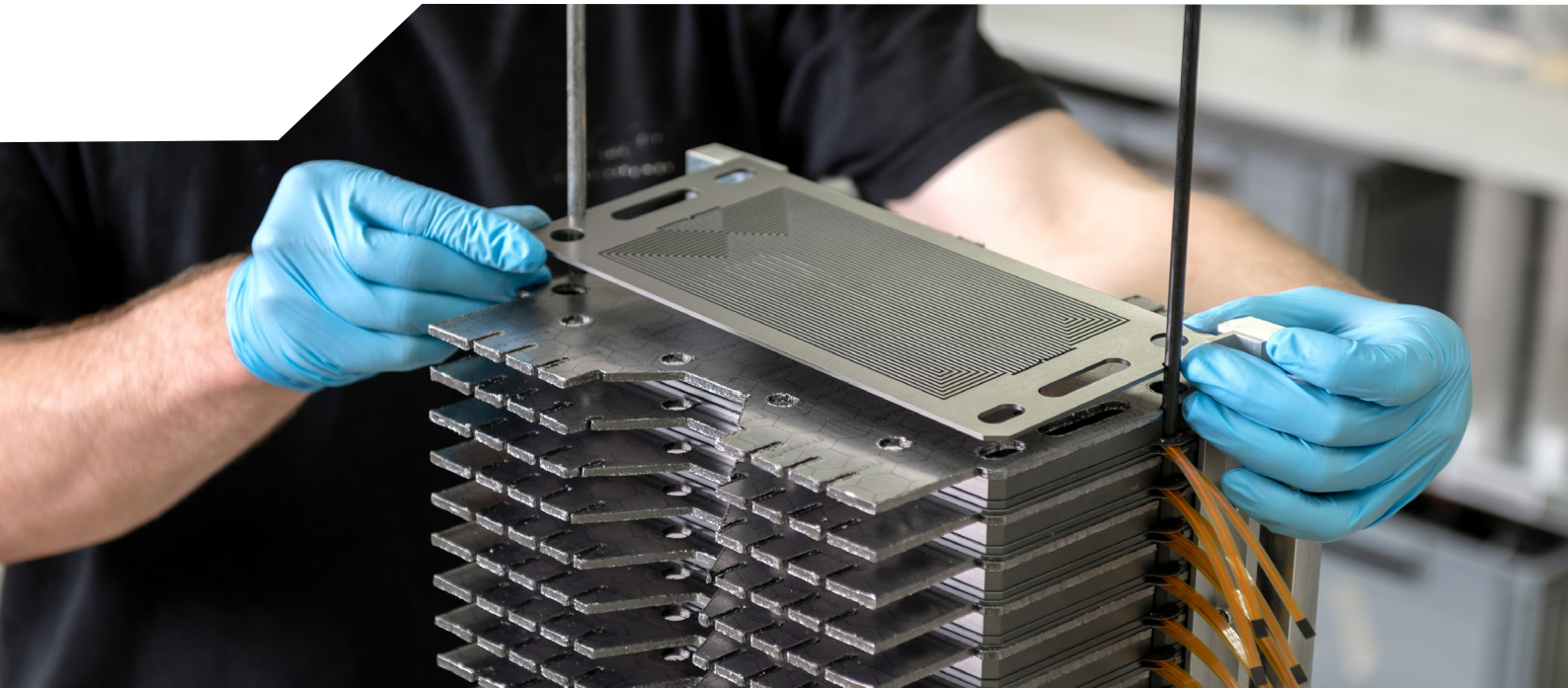
- Hydrogen deblending
  Local separation from blends within the natural gas grid
- Town gas networks
  Extraction of high-purity hydrogen from town gas networks
- Hydrogen pipelines
  Purification of hydrogen after long-distance transportation
- LOHC and other carriers
  Purification after dehydrogenation or reconversion

HYDROGEN RECOVERY AND USE

Purification of crude gas

Various crude gas streams or off-gases from industrial processes contain hydrogen that cannot be separated economically by conventional means. EHS allows for recovery of high-purity hydrogen in areas such as:

- Extraction from natural reservoirs
- Helium production
- Recovery from off-gases
  e.g. the semi-conductor industry



WORK WITH US

Hydrogen for end users

As an industrial user, electrochemical hydrogen separation has the potential to provide you with high-purity hydrogen at low-cost, tapping existing resources such as off-gas streams from your production processes. We listen carefully and collaborate closely to meet your needs. Through our partner network, we can offer turn-key solutions for on-site hydrogen supply.

As a network operator, EHS helps you in future-proofing your network. Enabling the transition to high-value green gases by allowing for downstream extraction and meeting purity requirements of different users alongside your network.

OEMs and solution partners

At SIQENS, our goal is to develop products with a focus on end-use application. Strong and long-lasting partnerships with industrial pioneers is part of our DNA.

Electrochemical hydrogen separation offers a modular and highly efficient alternative to pressure swing adsorption and other purification technologies in on-site hydrogen production systems, such as containerized steam methane reformers. We offer technical support and components to enhance your product portfolio, providing you with the toolkit to serve your customers.

Contact us

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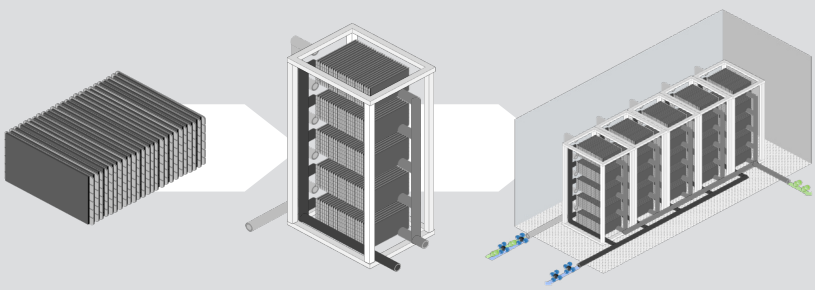
Scaling towards your requirements

Similar to large scale battery energy storage systems, the modular design of the EHS stacks are designed to be operated in parallel or series to address higher separation quantities.



Solutions for
gas stream purification
starting at
5 kg of hydrogen
per day

About us

At SIQENS, we are committed to develop regenerative energy and hydrogen solutions based on fuel cells and electrochemical technology. Our goal: accelerating the decarbonization of decentralized power generation and driving down the cost of hydrogen production and distribution.

While hydrogen is an ideal fuel, it is extremely difficult to transport and store. We believe that ramping up the hydrogen economy is only possible with economical solutions for local generation and low-cost infrastructure.

SIQENS Ecoport methanol fuel cell modules generate clean power from methanol – a globally-traded, hydrogen-rich fuel. Today, businesses and authorities worldwide rely on our fuel cells when generating power at the most remote locations or to shield-guard their critical infrastructure.

Built on our patented high-temperature polymer electrolyte membrane (HT-PEM) technology portfolio, SIQENS Electrochemical Hydrogen Separation can be used to separate, recover, and purify hydrogen from various gas streams. Enabling the simple and wide-spread usage of hydrogen in high-value and decentral applications, by addressing key challenges in pipeline infrastructure, on-site hydrogen production, or by tapping unused resources of hydrogen.

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