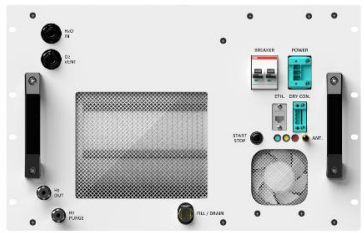
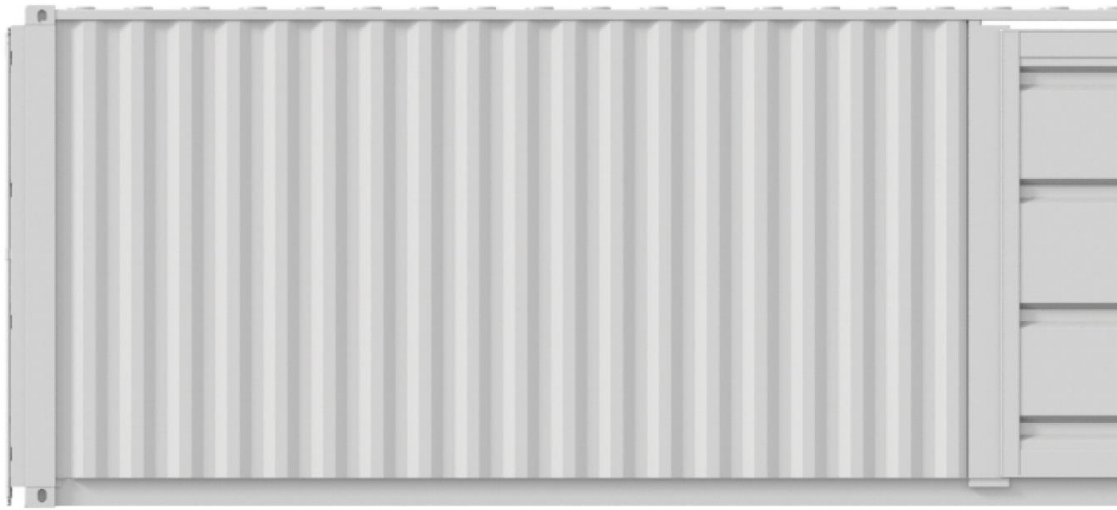
Enapter

AEM Electrolysers

SMART. SIMPLE. SCALABLE.





About Enapter

OUR COMPANY

Enapter at a glance

Enapter is a rapidly-growing energy technology company. We leverage Anion Exchange Membrane (AEM) tech and its unique advantages. It allows for the mass production of electrolysers as products, not projects.

Based on our projections, we expect hydrogen from AEM electrolysers to be cheaper than from any other source.

Serial entrepreneur Sebastian-Justus Schmidt started Enapter in November 2017. We have since made big strides in developing product and growing to 165 employees by May 2021.

Enapter accessed the capital markets in August 2020 via a reverse merger. We're on the regulated market of the Frankfurt and Hamburg Exchanges (ISIN DE000A255G02).

Next up: scaling our production and mass producing our AEM electrolysers.

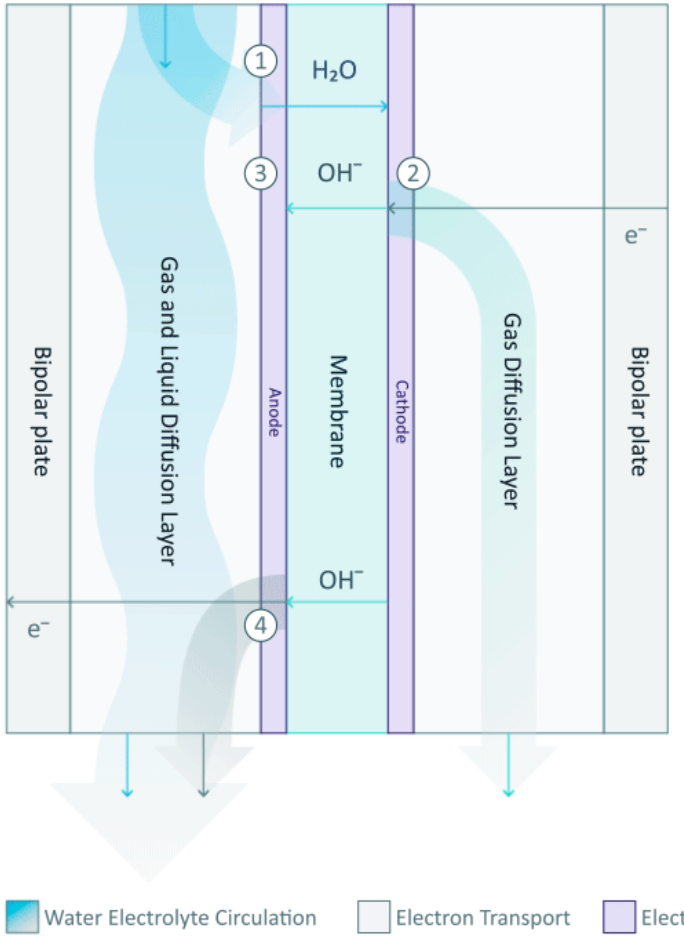
AEM Electrolysis

PATENTED AEM TECHNOLOGY

Our secret sauce

The strengths of our AEM Electrolysers:

- Combining the best of trad. Alkaline and PEM technology
- Low-cost materials and setup
- Top efficiency
- Easy to install and handle
- Low OPEX
- Strong patents granted, more pending



1. Water travels from the anode half-cell through the membrane.
2. Hydrogen is produced at the dry cathode and released via the gas diffusion layer.
3. OH- moves back to the anode via the membrane.
4. Oxygen is produced from OH- at the anode and released via the gas and liquid diffusion layer.

COMBINING THE BEST OF TWO WORLDS

AEM technology advantages

	PEM	Alkaline	Enapter AEM
High H_2 Purity	✓	✗	✓
Output Pressure	30 bar	atm	35 bar
Consumption (kWh/Nm^3 H_2)	5.1	4.9	4.8
No caustic electrolyte	✓	✗	✓
No costly components	✗	✓	✓
Fast ramp time	✓	✗	✓
Compactness	✓	✗	✓

Scaling production

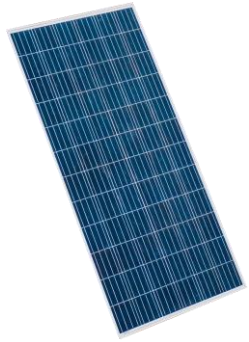
STANDARDISATION AND MASS PRODUCTION

Massive price reduction through commodification at scale

1981

today

2000



today

Throughout economic history, nothing has seen faster growth and cost reductions than mass-produced commodities.

PCs replaced mainframes and, in turn, stripped-down, standardized, and mass-produced blade computers now scale computing capacity to ever lower prices.

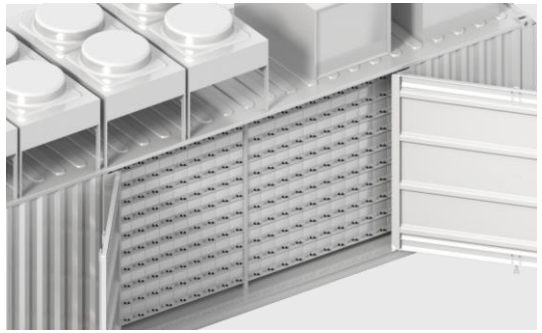
Deployment of increasingly-cheap modular solar at scale is undercutting and replacing fossil fuel energy generation.

It's green hydrogen's turn.

STANDARDISATION AND MASS PRODUCTION

Massive price reduction through commodification at scale

2019



2023

Instead of designing electrolysers as individual engineering projects, Enapter is mimicking the introduction of the PC or the solar panel by making a product that is compact, modular and scalable.

Enapter's approach is unique for green hydrogen production – we are standardising and mass-producing electrolysers and their cores, which we believe will yield larger cost reductions faster.

Mass produced AEM stacks and electrolysers can be stacked to reach any size from kilowatts to megawatts sizes – for any use.

WHERE WE ARE TODAY

Enapter's rapid growth

2017 – Our first building in Pisa. We renovated it in 2018, now exclusively used for R&D

2019 – Additional building commissioned for serial production

2020 – Further building acquired in Sep 2020 for R&D extension with 8 new laboratories, new testing area and an ISO cleanroom

2021 – Building acquired in December 2020 to scale up chemical and stack production

WHERE WE ARE GOING

Planned mass production in Saerbeck

The Enapter Campus will break ground in September ‘21 with the construction company Goldbeck.

The factory in the climate community of Saerbeck will be 100% powered by locally produced renewable energy from day 1.

Planned production capacity starting at the end of 2022: 10,000 units/month.

AEM Electrolysers

THE MODULAR AEM ELECTROLYSER

EL 2.1 Electrolyser

Hydrogen Production
500 NL/hr or 0.5 Nm³/hr

Efficiency
4.8 kWh for 1 Nm³ of H2

Hydrogen Purity
~99.9%

Power Consumption
2.4 kW

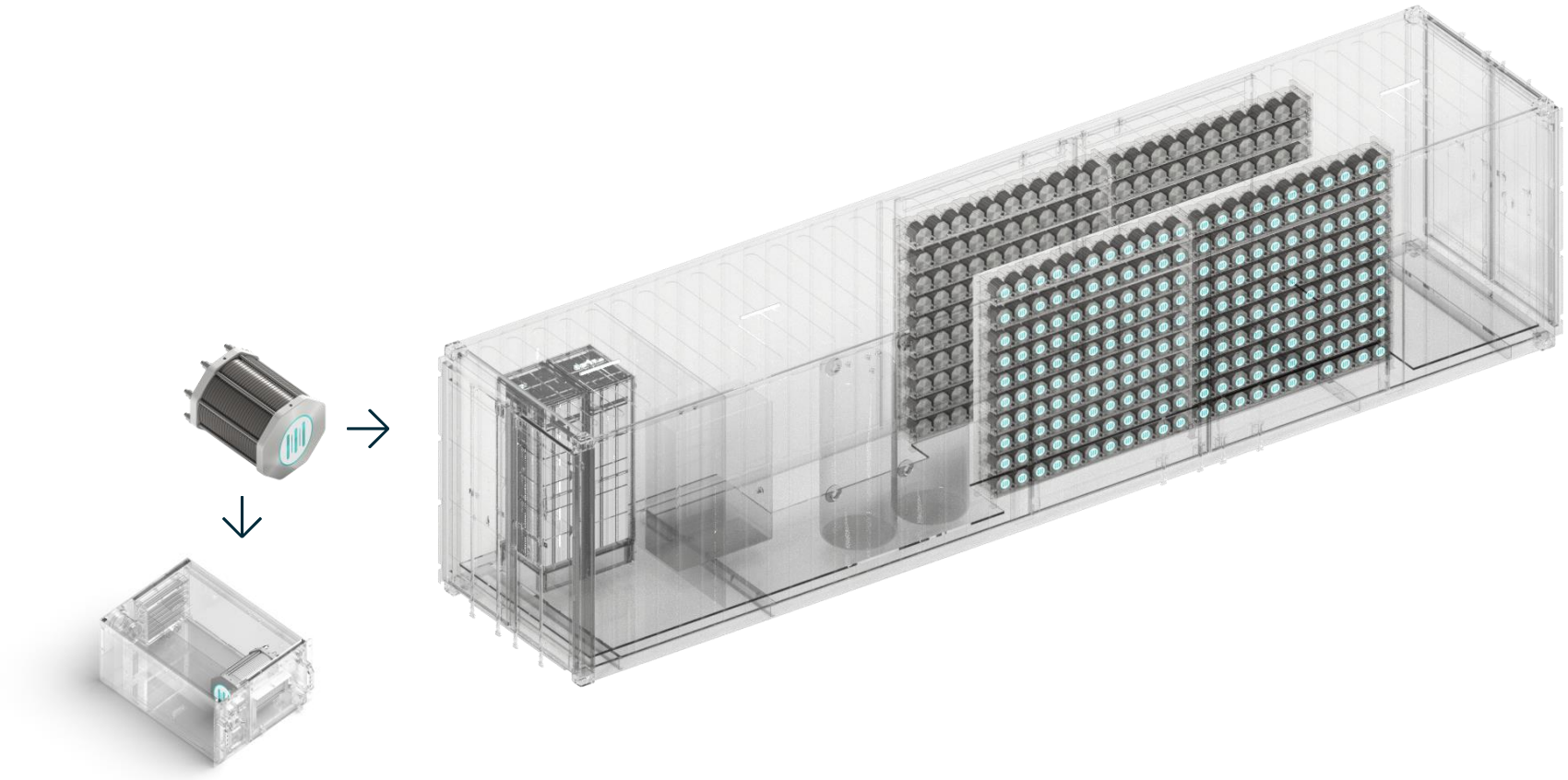
Input Water Purity
<20 µS/cm

Output Pressure
35 bar

EL 2.1
Serial Production started in March 2020

PLATFORM STRATEGY

Modular AEM cores: compact to scale



The "AEM stack" module – a single AEM electrolyser core – is the foundation of Enapter's product platform.

Our mass-produced AEM stack forms the heart of our compact, modular AEM electrolyser, the EL 2.1. But it also delivers megawatt-scale green hydrogen when 420 of them are deployed in our ready-made AEM Multicore system.

This product platform approach allows us to increase our speed of product development, reduce development costs, and rapidly increase product variety.

MEGAWATT CLASS

AEM Multicore™

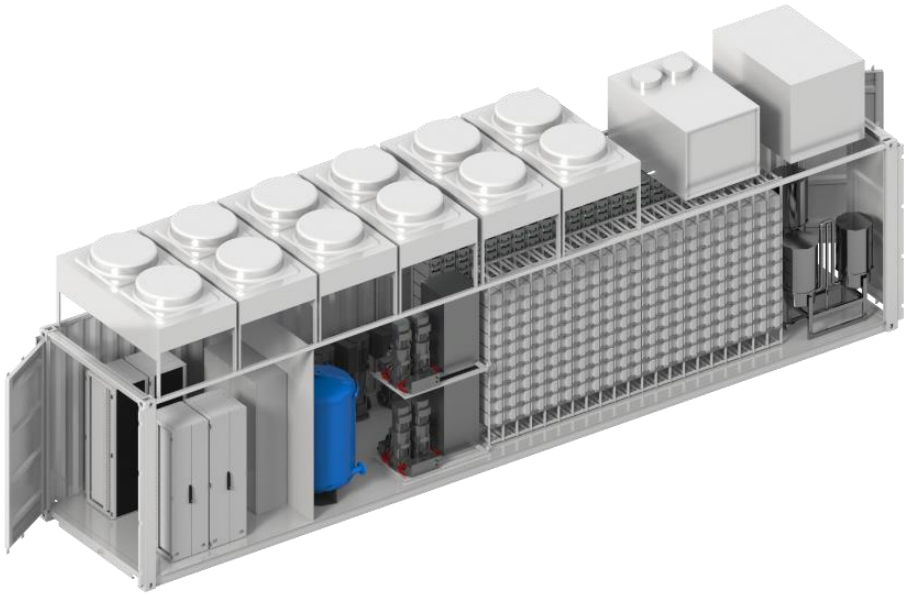
Hydrogen Production
210 Nm³/hr

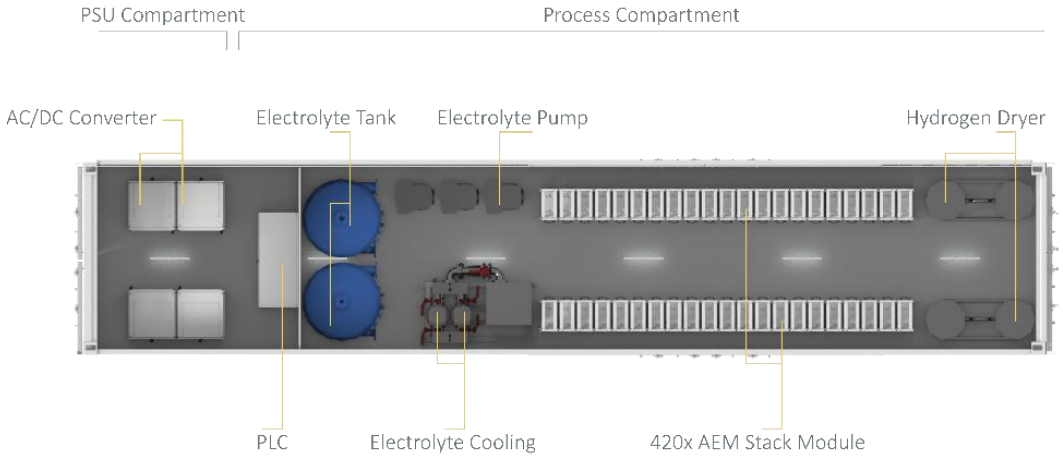
Hydrogen Purity
~99.8%, 99.999% with optional dryer

Power Consumption
1,008 kW

Efficiency
4.8 kWh/Nm³

Output Pressure
Up to 35 bar





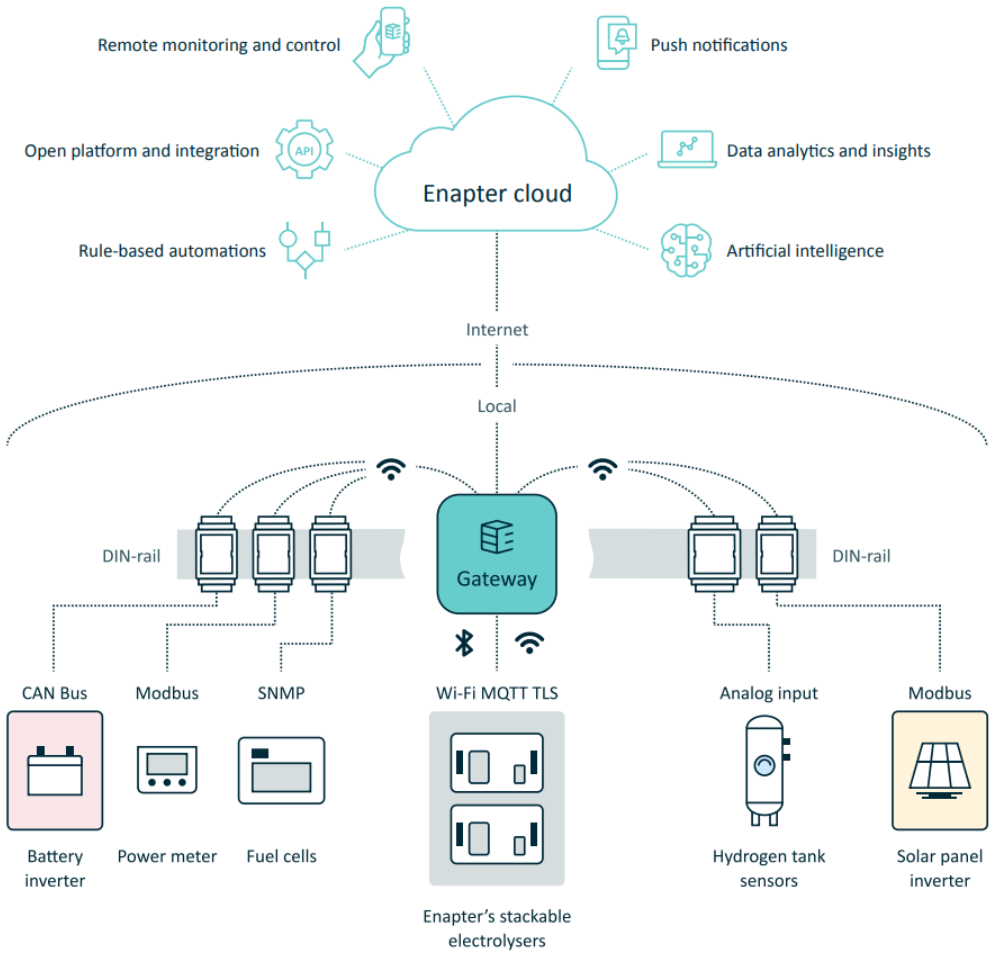
AEM Multicore
Serial Production planned in 2022

- 40-foot modular container
- Self-contained with:
  - Power distribution
  - H2 safety
- Fully automatic with Enapter's EMS, Modbus

Energy Management System

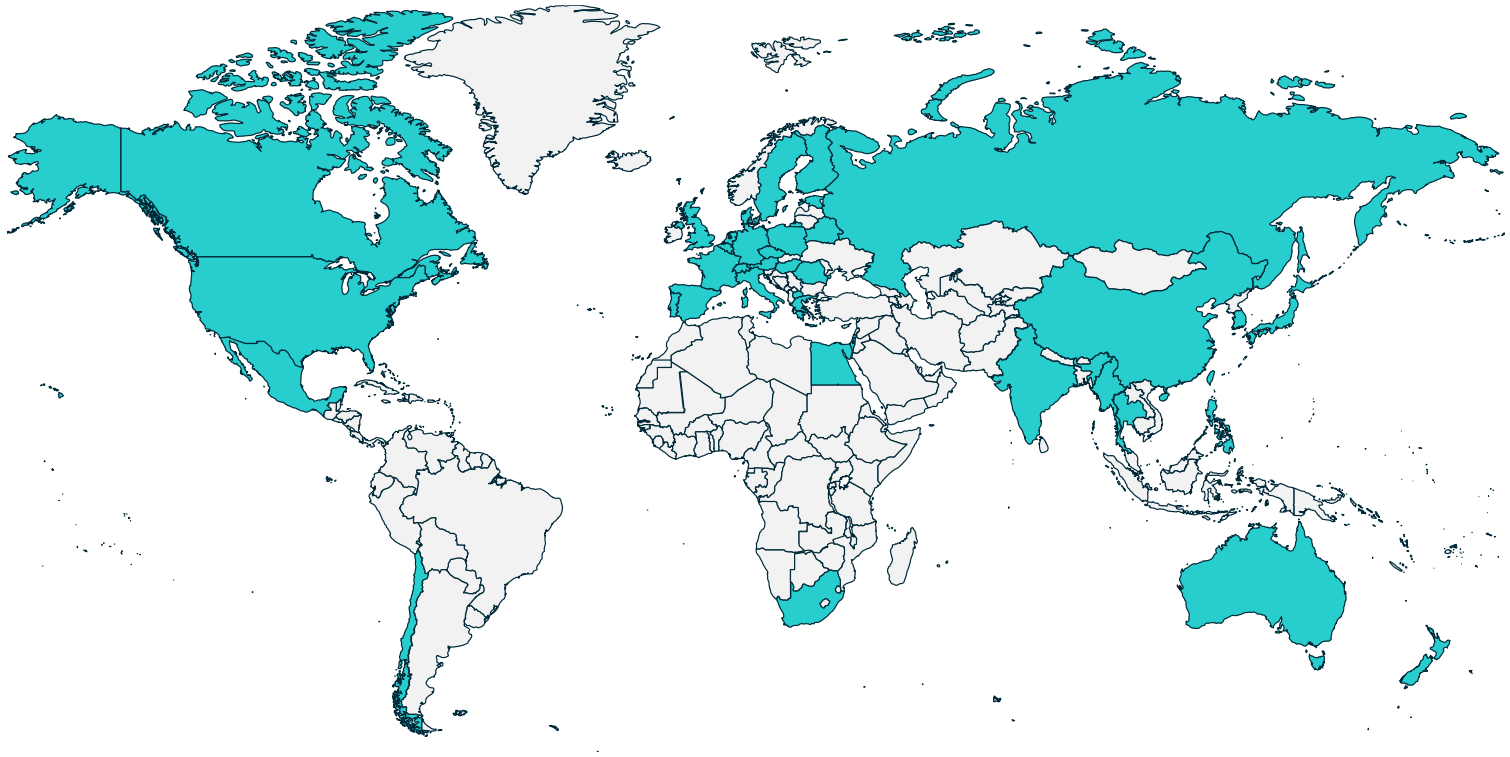
SYSTEM ARCHITECTURE

Creating your Energy Management System



Use Cases and Enapter`s global traction

Enapter‘s global product traction



So far, we have shipped electrolysers to 166 customers in 40 countries.

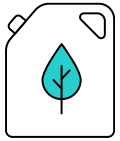
Data as of May 2021

Hydrogen use cases are endless

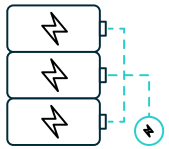
Traditional H2 Market

industrial feedstocks: ammonia, refineries, methanol, other

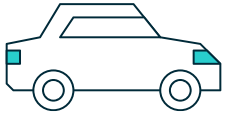
New Green H2 Market



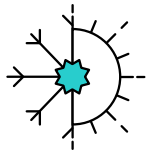
synthetic fuels



electricity storage



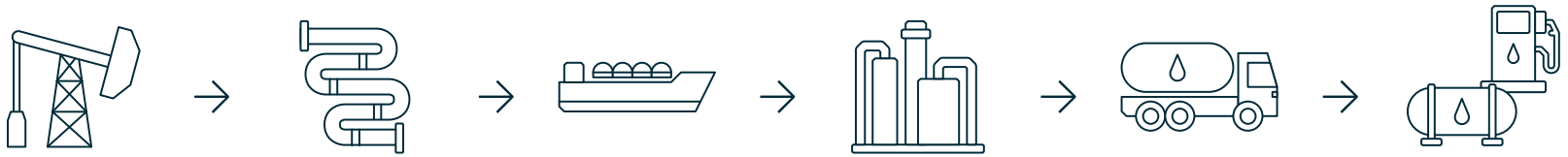
transport



heating/cooling

new use cases

Disrupt and decentralise



Cheap renewable electricity has disrupted fossil fuel power generation and enabled decentralised green power.

Low-cost, modular green hydrogen will do the same for other applications that rely on liquid or gaseous fossil fuels.

Energy centralisation has peaked. With a modular electrolyser, fully decentralised green energy solutions are now possible.

THE HYDROGEN LEGO GAME

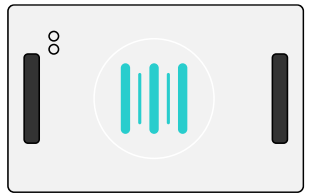
We provide building blocks, integrators create solutions

Enapter's products…

…are stacked by integration partners…

… who build hydrogen solutions for customers.

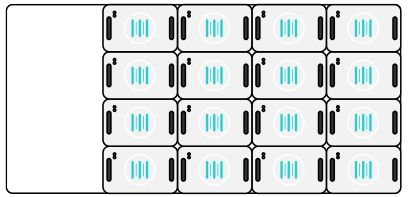
AEM Stack



AEM Electrolyser

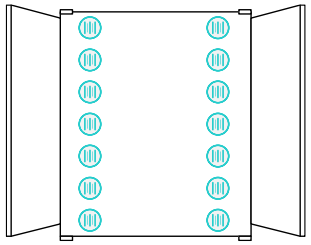
Cabinets (5-25 kW)

/

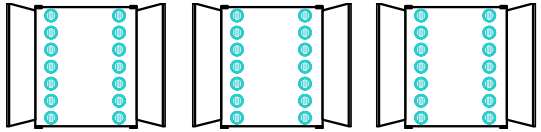


Small containers (30-150 kW)

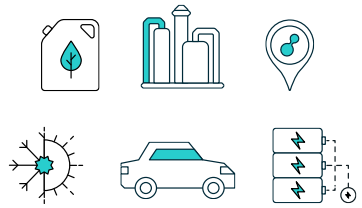
H2 solutions with AEM Electrolysers



AEM Multicore



i.e. several AEM Multicores (1-X MW)



H2 solutions with AEM Multicores

Partners

Our system integration around the world can support with offering turnkey solutions

More Information about our partners and our partner programme:
https://www.enapter.com/partners

ELECTRICITY STORAGE

The Phi Suea House

The Phi Suea House (Home of the Butterflies) is the world's first solar-hydrogen multi-house:

- Off-grid since 2015 in Thailand, it is a showcase for sustainable living
- Sunshine and rain cover all energy and water needs on the premises, facilitated by Enapter electrolysers.
- In simple terms, the energy of the sun is transformed via solar panels into electricity. Any excess power will be converted and stored as hydrogen. When the sun doesn't shine, the stored hydrogen gas in tanks generates electricity by using fuel cells.
- Selected as a "Hydrogen Valley" on the Mission Innovation Platform. It is one of the world's most advanced H2 projects, and is the only one in Southeast Asia. Read more.

ELECTRICITY STORAGE

Lavo Hydrogen Battery

Lavo develops next generation green energy metal-hydride hydrogen storage.

- It's the world's first integrated hybrid hydrogen battery that combines with rooftop solar to deliver sustainable, reliable and renewable green energy to homes and businesses.
- Developed in partnership with UNSW, Sydney, Australia and Design + Industry, LAVO™ is a hydrogen hybrid battery that stores over 40kWh of electricity – enough to power the average Australian home for 2 days.
- Enapter provides the fitted AEM electrolyser. Together with Lavo, they work at the same speed and ambition to make a real dent in climate change.

ELECTRICITY STORAGE

Microgrid

Electrification of rural community with 100% renewable-based microgrid with hydrogen storage.

- PESTECH electrifies 100 community members in Malaysia using PV coupled with hydrogen energy storage system (ESS)
- AEM electrolyser produces hydrogen from excess PV during the daytime
- Hydrogen is stored and electricity is produced with a fuel cell to supply nighttime demand
- Read more about the economics of hydrogen microgrid here

ELECTRIVITY STORAGE

Peak Shaving with Hydrogen

Delta Green is the first energy-independent office building in France, with energy production exceeding user consumption.

- The aim of Delta Green is to showcase complete energy autonomy.
- The energy mix is made up of PV, geothermal and hydrogen storage; with PowiDian integrating the hydrogen solution. Instead of using batteries, the tertiary building uses 2 Enapter electrolysers to store hydrogen for peak shaving.
- The commercial benefit is that hydrogen is converted into electricity to fulfil demand and avoid demand spikes that would result in a higher electricity tariff

POWER TO HEAT

H2 Heating Solutions

In June 2019, the first hydrogen project for residential heating was officially opened in Rozenburg near Rotterdam in the Netherlands, planned by DNVGL.

- Enapter deployed 8 AEM electrolysers, showcasing their unique modularity and flexibility.
- The produced hydrogen is safely transported to central boilers heating 25 apartments. 3 different hydrogen boilers are being tested in the setup.
- Since gas production in the Netherlands (Groningen) is winding down, the country has ambitious hydrogen plans to replace natural gas.

ONSITE REFUELING

H2 Mobility Solutions: Cars

Hydrogen vehicles are quickly gaining ground around the globle.

- On-site refueling for fuel cell drones, cars, planes or other vehicles is another use case for decentralized hydrogen production.
- Enapter is working with Hyperion Motors in the United States to supply the Hypercar with the clean fuel it needs for power.

ONSITE REFUELING

H2 Mobility Solutions: Cars

- Another H2 refueling station with on-site production of hydrogen by two units of Enapter`s AEM electrolyser EL 2.1 was recently commissioned in the “Milford Haven: Energy Kingdom” project in Wales (UK)
- Objectives of this projects are to provide an example and roadmap to decarbonization using decentrally produced green hydrogen, stimulate local growth and investment as well as education and job creation

ONSITE REFUELING

H2 Mobility Solutions: Airplanes

- The HyFlyer project aims to decarbonise medium range passenger aircrafts using hydrogen.
- The Hydrogen used for the test flights in UK are produced by Enapter electrolysers, which are integrated into a refueling container and provide on-site hydrogen production

ONSITE REFUELING

H2 Mobility Solutions: Drones

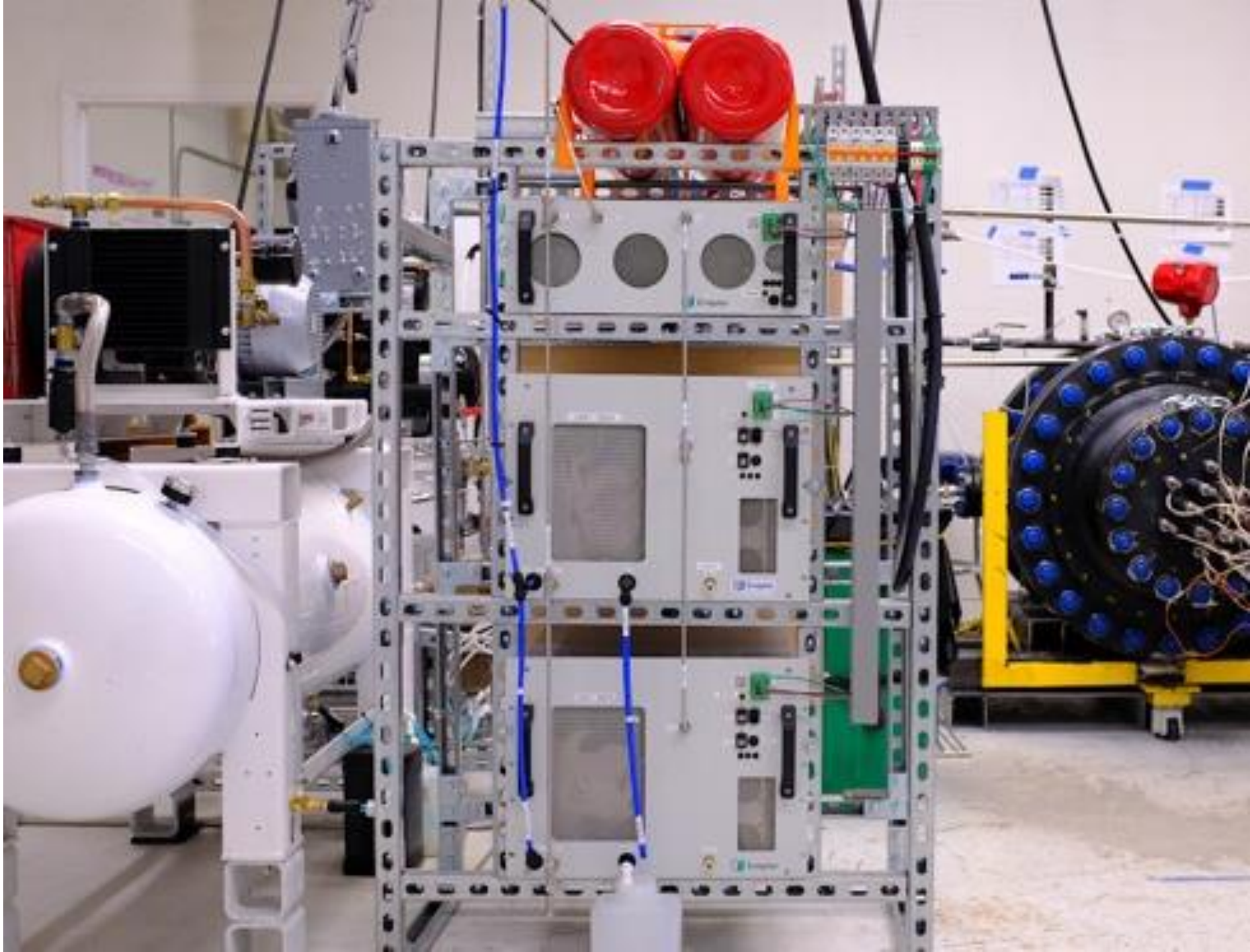
- Hydrogen Fuel Cell drones are getting more and more popular due to longer flight durations and heaver loads they can carry
- Several partners integrated our electrolyser into small refueling station for hydrogen powered drones
- ORCA 2 is refueling station developed in China by B-Shark. And includes a 0.5 nm3/hr to produce on-site hydrogen

POWER-TO-X

Ammonia Production

Starfire Energy is developing modular systems to produce carbon-free Ammonia (NH3) (read more here)

- Ammonia has a high energy density and stores and transports cheaply using well-developed technologies, codes, and standards
- 10 kg/day is first of several iterations, the goal for them is to have a modular NH3 system with a production capacity of 50 tonnes/day
- Modular systems reduce business risk for the customer, which is 100% in line with Enapter's approach



RESEARCH

Biocatalytic Power-to-Methane

- Electricity from solar energy is converted into hydrogen by electrolysis.
- Hydrogen is then converted into natural gas by biocatalysis using carbon dioxide.
- The produced methane can be stored in the existing infrastructure.
- Carbon dioxide is produced during alcoholic fermentation, for example in the production of spirits or beer, but also in the production of bioethanol, which is added to the fuel.

INDUSTRIAL

Nitrogen Purification

- Nitrogen gas is commonly generated by pressure swing adsorption (PSA). Depending on the size of the System, there will be a certain amount of impurities
- In Portugal our electrolysers as integrated together on-site at a factory with a PSA system. The Hydrogen is then used to purify the nitrogen

Thanks for your attention!

Jens Bischoff
jens@enapter.com

WWW.ENAPTER.COM