Enapter

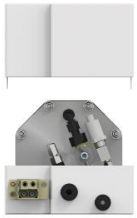
Green Hydrogen Production with AEM Electrolysers

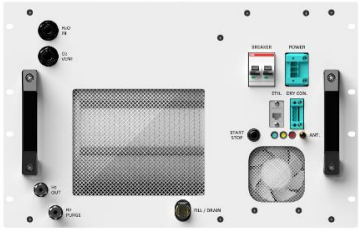
SMART. SIMPLE. SCALABLE.

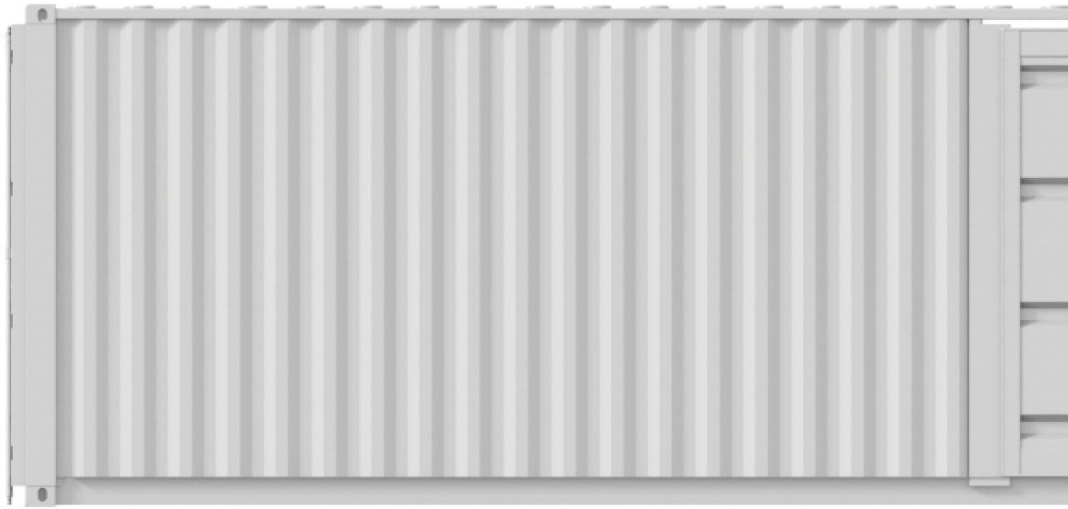
Swagelok H2-Thementag

Wasserstoff als Energieträger der Zukunft

Zeche Ewald, Herten
9. Juni 2022







OUR COMPANY

Enapter at a glance

Started in November 2017 by serial entrepreneur Sebastian-Justus Schmidt, with a vision to make hydrogen affordable for everyone. Built on a technology with >10-year track record at that time

Pioneer and commercial leader in AEM electrolysis, with a unique, patented technology breakthrough enabling massive cost reduction and distributed H_2 generation.

Changing the paradigm for electrolysers with a high-volume product focus, rather than projects. >90 partners integrate Enapter products into solutions of all sizes

Hardware, electronics and software in harmony for a next-generation experience. Drawing on Sebastian's background as a software entrepreneur. **Smart, Connected, Adaptable**

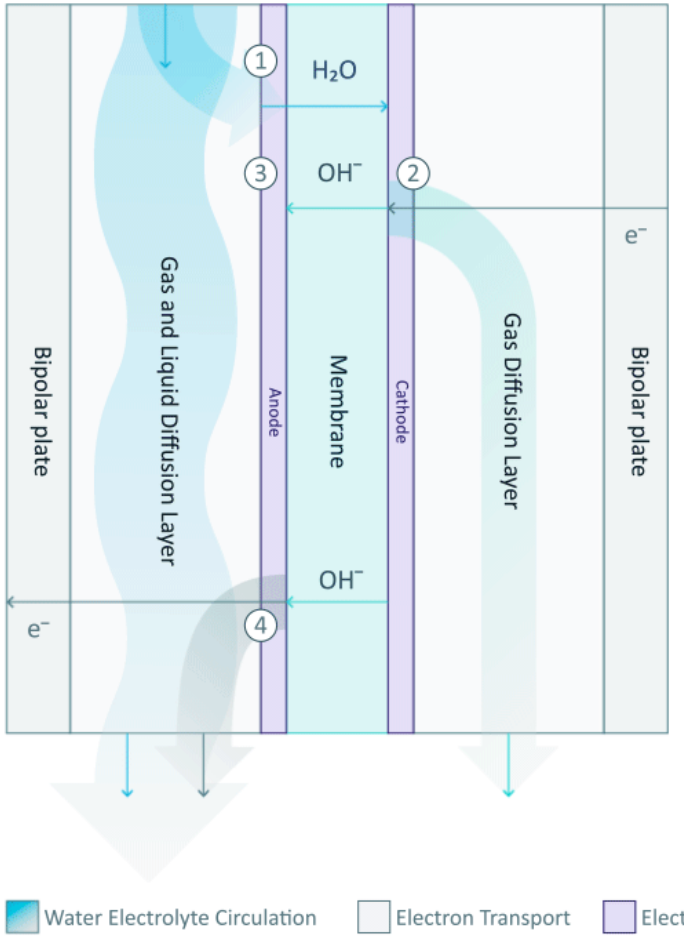
Scaling up for mass production from 100 units/month to >10,000 units/month in the coming years

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.

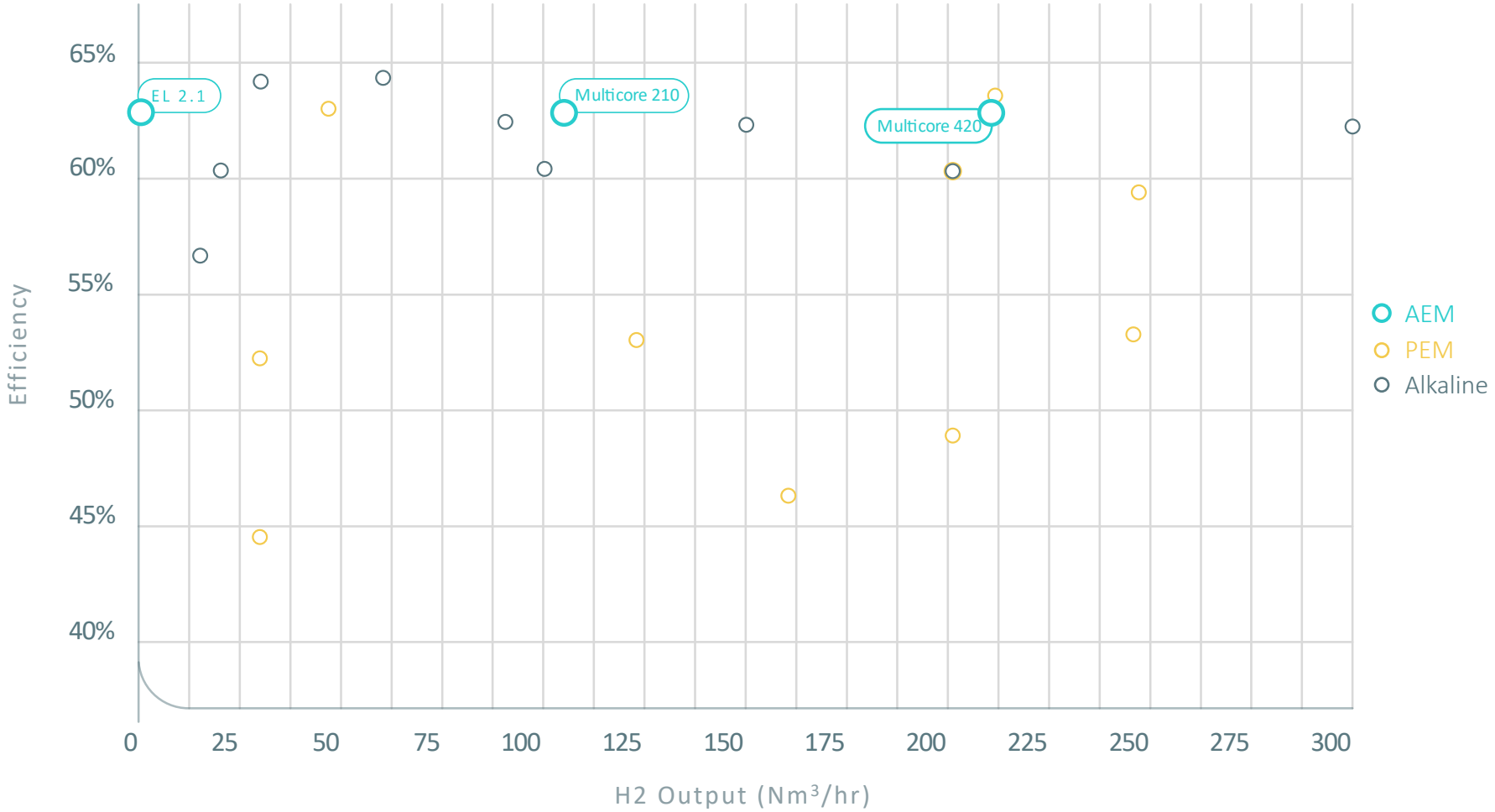
COMBINING THE BEST OF TWO WORLDS

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	✓	✗	✓

SYSTEM EFFICIENCY

How does AEM efficiency compare?



Efficiency values from 10 electrolyser manufacturers.

Values are calculated from publicly available information (datasheets & presentations) as of July 1st, 2021.

Efficiency values are based on LHV, nominal output, nominal power consumption at the system level.

(10% BOP power consumption are added for datasheets which only indicate values on the stack level).

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.

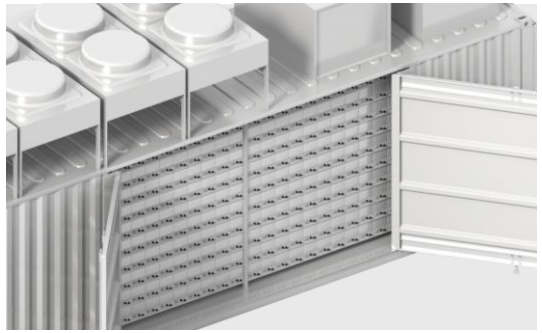
Deployment of increasingly-cheap modular solar at scale is undercutting and replacing fossil fuel energy generation.

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

PRODUCTION LINE

Pisa Expansion

We successfully moved from producing electrolysers at work stations…

…to a line production system where we are already trialing mass production.

In number this means we are moving from production capacities in the range of 20 units a month (2020) to 500+ units a month in Pisa in 2022.

WHERE WE ARE GOING

Planned mass production in Saerbeck

The Enapter Campus didbreak ground in September ’21

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

Production capacity to rise to >10k units / month in the coming years.

Saerbeck Construction Progress March 2022

Click here to see the video

[r]Evolution of the AEM Electrolyser

TODAY

EL 500
02.2018

Height: 10 Units

- Separate stack and control modules
- Significant onsite installation tasks
- All 4 sides of the module need to be accessible for air flow, electrical, gas connections

EL 2.0
01.2019

Height: 8 Units

- 9 cm smaller than predecessor
- Single module simplifies onsite installation
- Front-to-back airflow
- Integration into Enapter EMS allows mobile setup and remote monitoring
- New stack 40% smaller

EL 2.1
02.2020

Height: 7 Units

- 4.5 cm smaller than predecessor
- 5% less energy needed and low standby power
- Revised interface hot-swapping
- OTA capability for new features

EL 4.0
2022

Height: 6 Units

- 4.5 cm smaller
- 17kg lighter - 30%
- Longer lifetime
- Final assembly time 1 hour
- AC & DC
- Liquid-Cooled & Air-Cooled

EL Model T/X
~2023

- Longer lifetime
- Reduced footprint
- Reduced weight
- Higher hydrogen output

MEET THE AEM ELECTROLYZER EL 4.0

Click here to see the video

THE MODULAR AEM ELECTROLYSER

EL 4.0 Electrolyser

Hydrogen Production
500 NL/hr or 0.5 Nm^3/hr

Efficiency
4.8 kWh/1 Nm^3

Hydrogen Purity
99.9% or 99.999% *(with optional dryer)*

Power Consumption
2.4 kW

Water Input Conductivity
<20 µS/cm

Output Pressure
35 bar

Compact
Weighing 38kg and 6U high

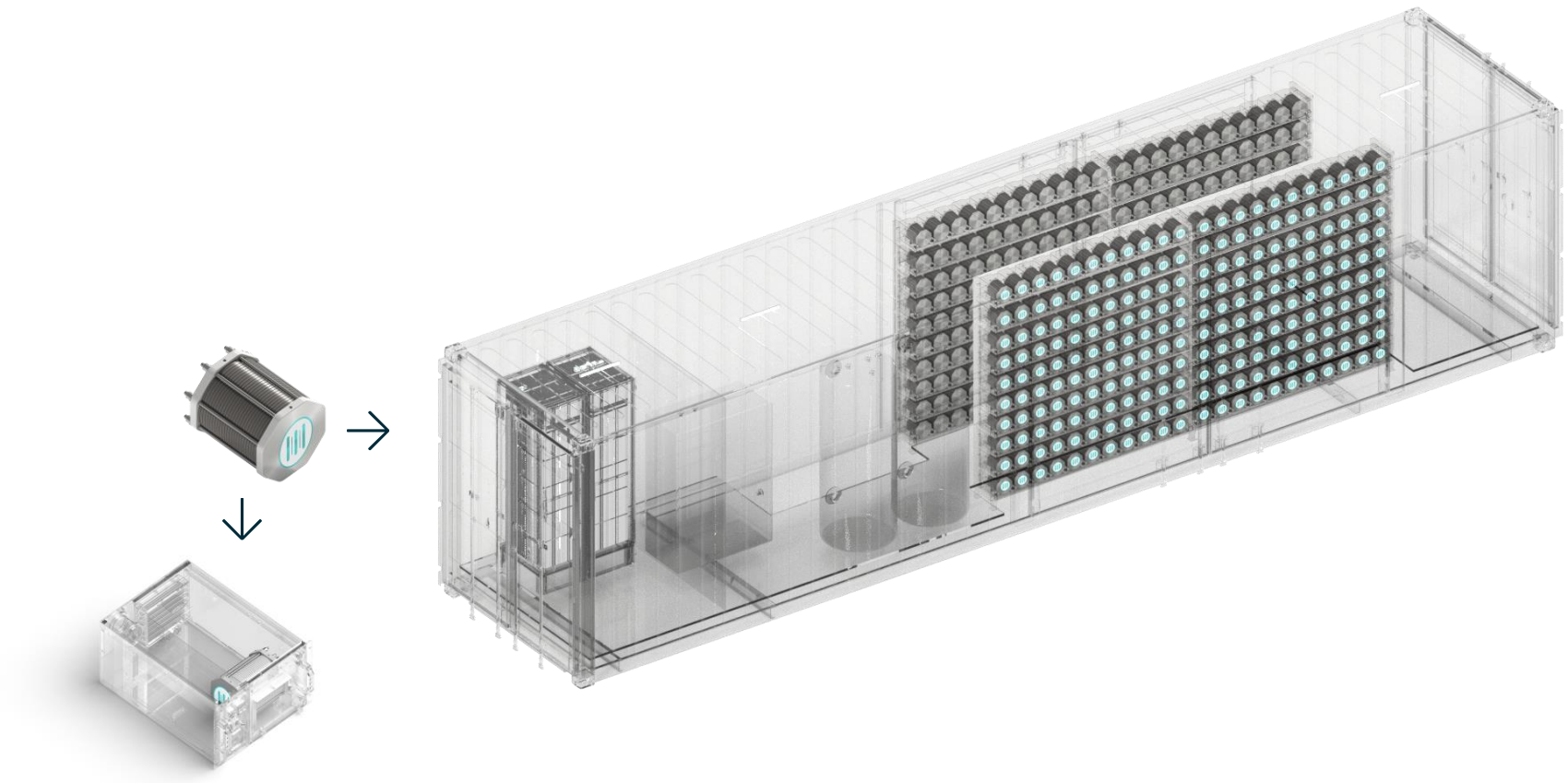
ISO 22734 ready
Ready for integration into an ISO 22734 compliant system

Enhanced hydrogen safety
Integrated hydrogen leak detection system and SIL1 rated safety instrumented system

Multiple versions
EL 4.0 AC (Air cooled / Liquid cooled)
EL 4.0 DC (Air cooled / Liquid cooled)

PLATFORM STRATEGY

Modular AEM cores: compact to scale



The "AEM stack" is the foundation or core of Enapter's product platform.

The AEM stacks can power a compact and modular single core AEM electrolyser. However, the same stacks will deliver megawatt-scale green hydrogen when 420 of them are deployed in our AEM Multicore system.

We are basing it all on one stack. This product platform approach allows us to increase our speed of product development, reduce development costs, and rapidly increase product variety.

AEM in MW

Hydrogen Production
210 Nm³/h

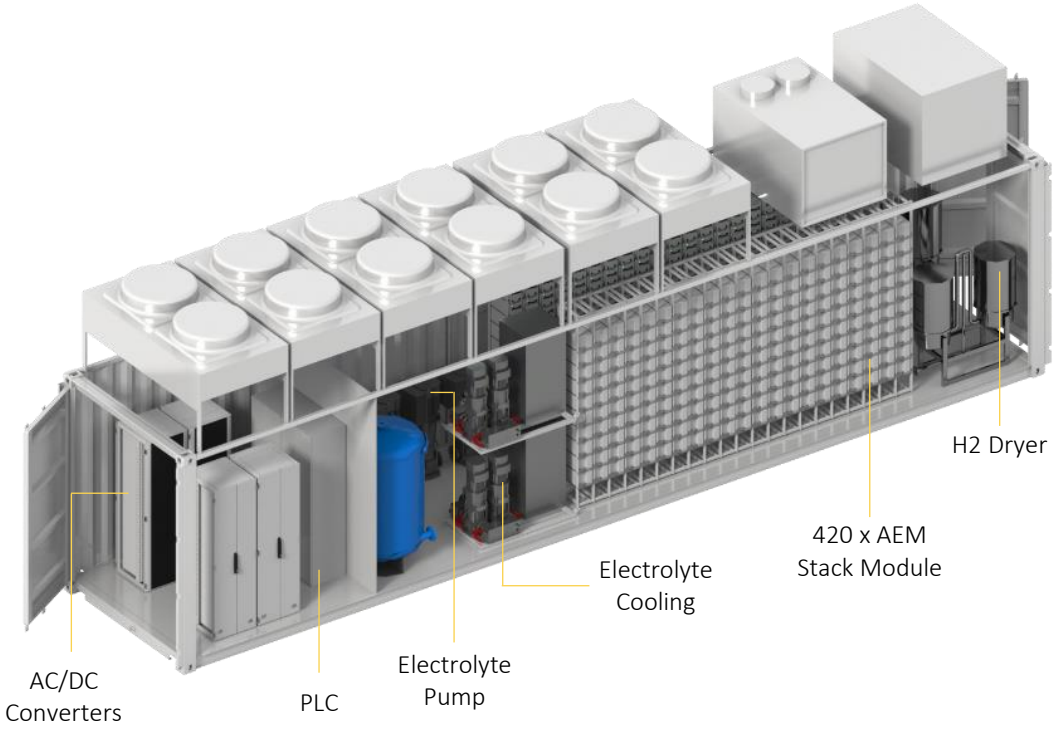
Hydrogen Purity
99.8%
99.999% (with optional dryer)

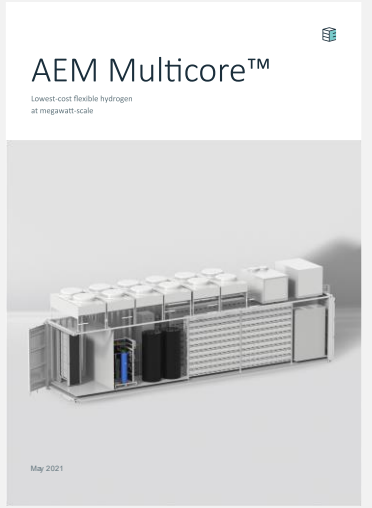
Flexibility
3% - 105%

Hot Startup time
0-100% within seconds

Power Consumption
4.8 kWh/Nm³

Output Pressure
Up to 35 bar

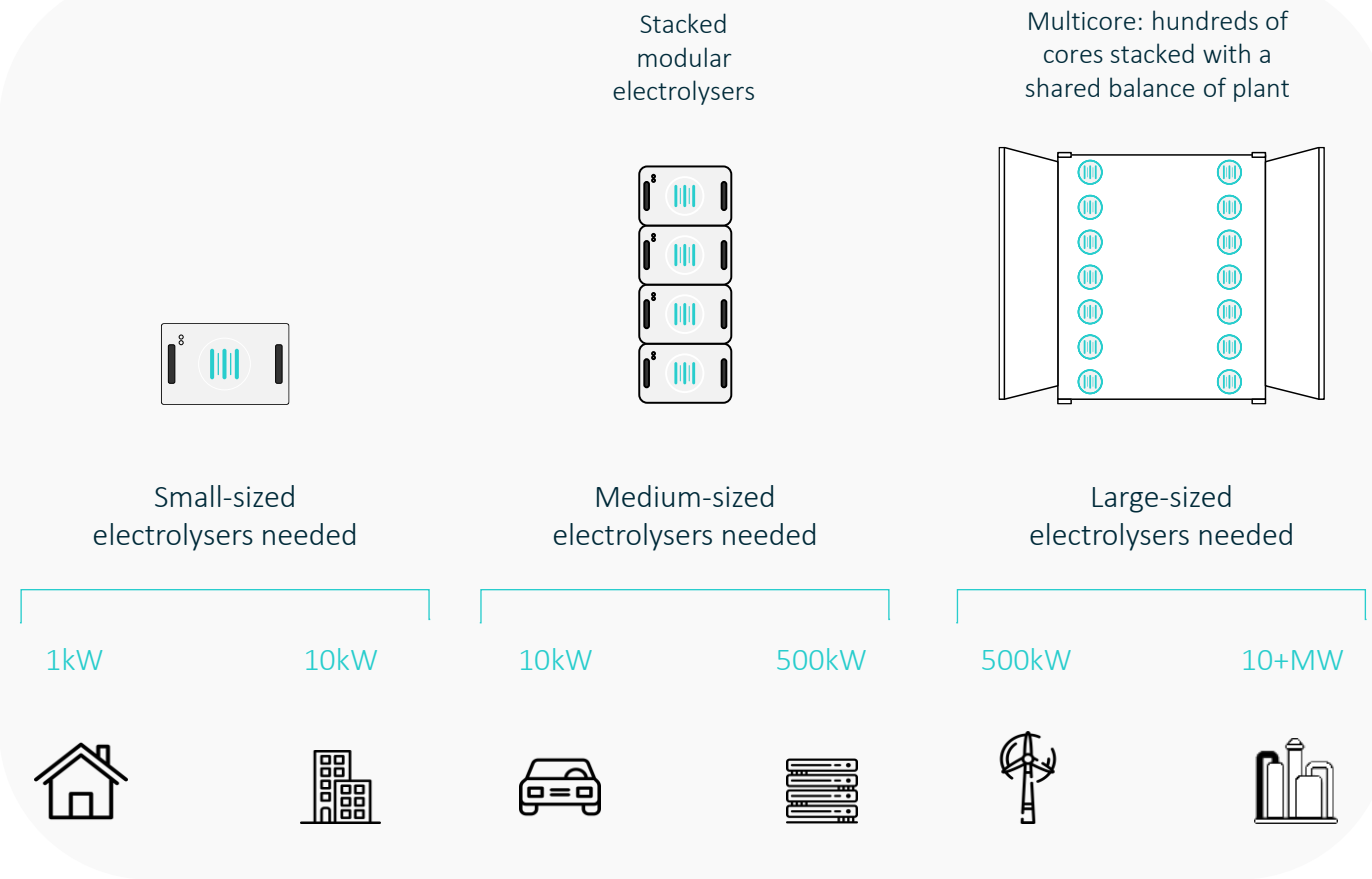




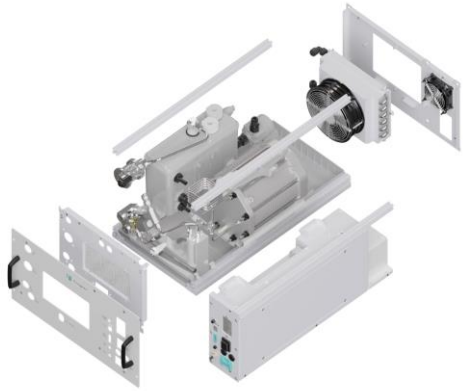
MODULAR AND STACKABLE TO SERVE BROADER MARKETS

Enapter provides building blocks, integrators create solutions

- Enapter is the only player enabling cost-effective systems for large industrial projects as well as small-to medium-size projects
- Mass-produced AEM electrolysers can be stacked to reach sizes from kW to MW – for applications ranging from residential and SME to large industrial
- The largest scales (MW) can be reached using multicore solutions, which stack several hundred cores around a balance of plant with built-in redundancy



Enapter x Swagelok



Where do we use Swagelok products?

- EL 4.0 and also planning to use it in our AEM Multicore
- We also use Swagelok products in our infrastructure and test stands for the engineering lab (already in Pisa today and soon in Saerbeck as well)

Why are we using Swagelok products?

- Amongst others: We required thigh leakage rates for our components and Swagelok products show very good tightness performance

Which type of Swagelok components are we utilizing?

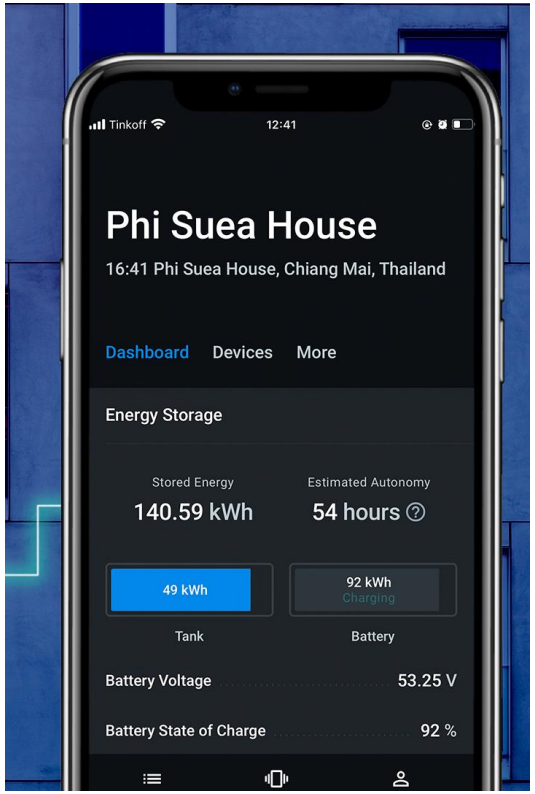
- For example: Adjustable Check Valves, Pressure Relief Valves, Proportional Relief Valve, Nuts & Ferrules, etc.

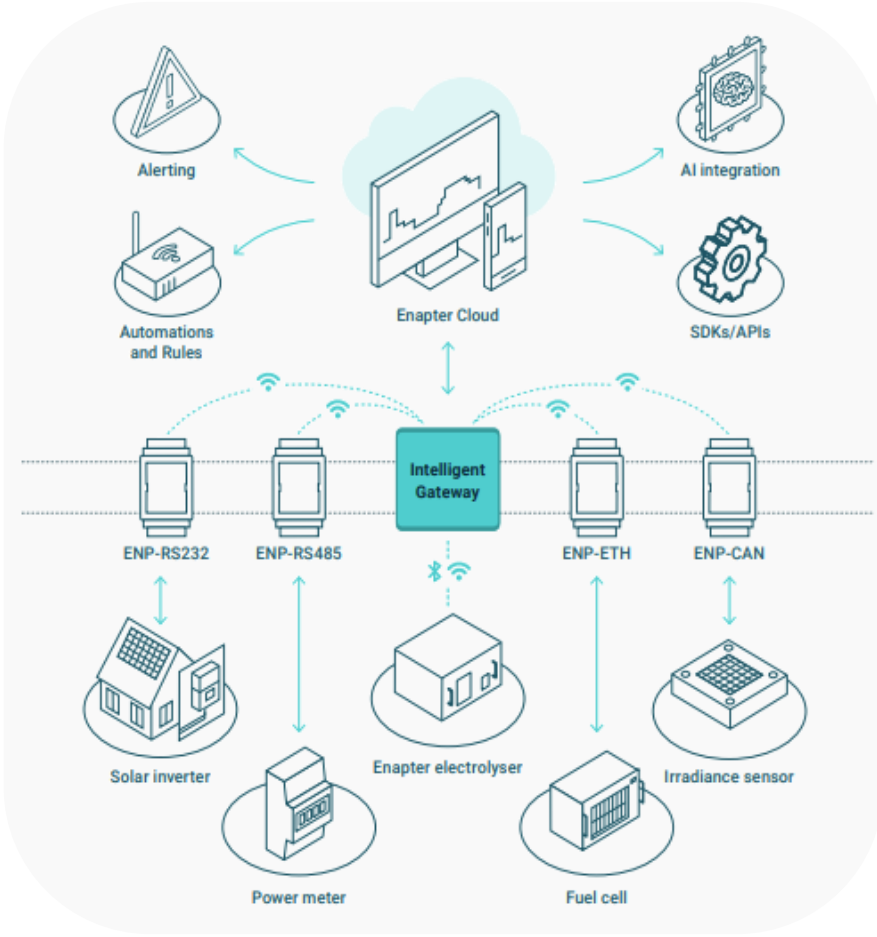
At which production sites do we use Swagelok solutions?

- Currently a lot in Pisa and in the future also in Saerbeck

Software enables the AEM Electrolyser

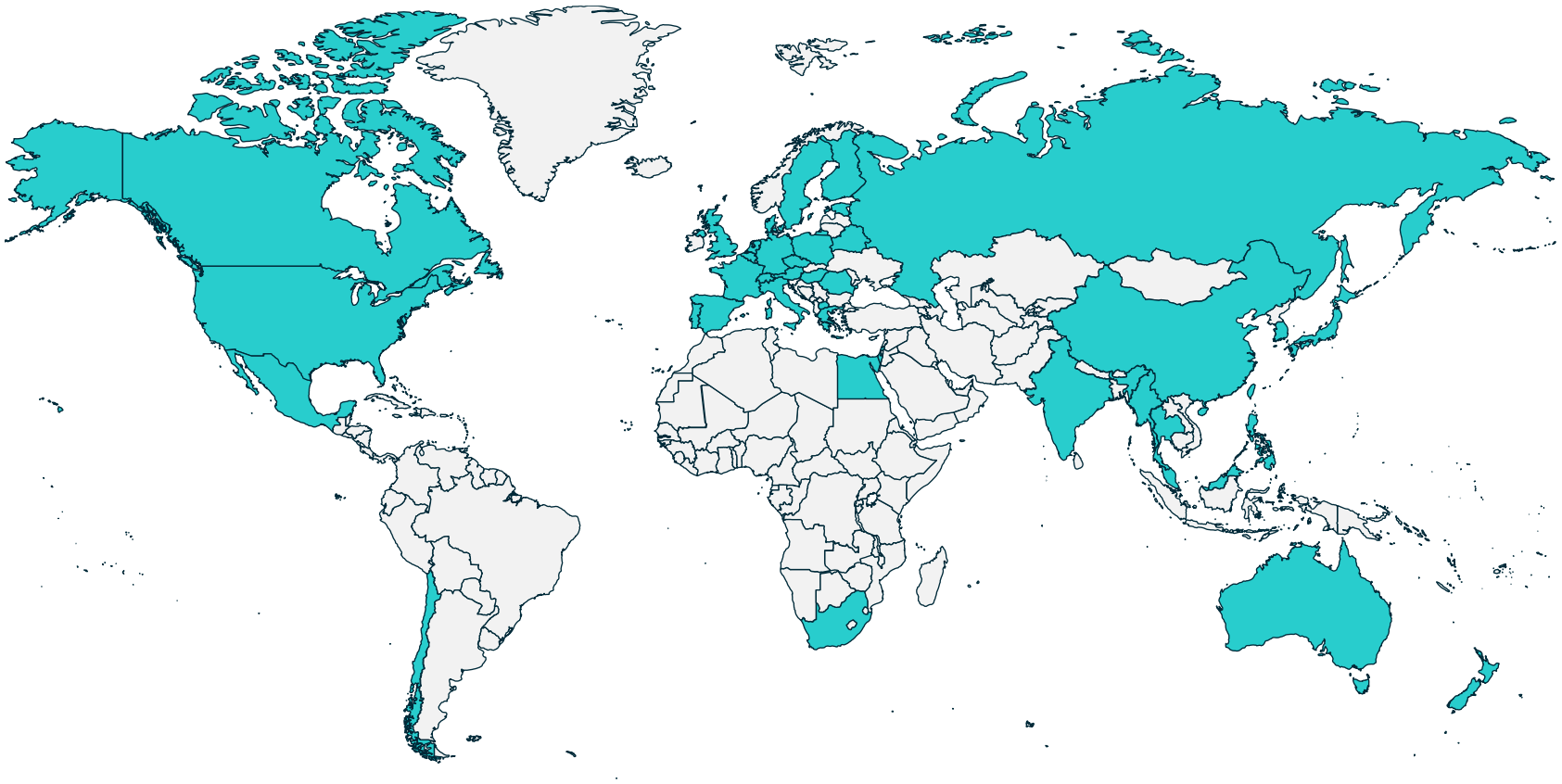
- Enapter provides a toolkit for energy monitoring and control
- Setup time in minutes
- Any energy device can be integrated
- Industry-grade security standards
- All protocols are supported
- Microgrid control
- Over-the-air (OTA) updates
- Rule-based engine
- Machine Learning ready





AEM ELECTROLYSER ROLLOUT

Enapter‘s global product traction



>244 customers across 49 countries so far

Data as of Jan 2022

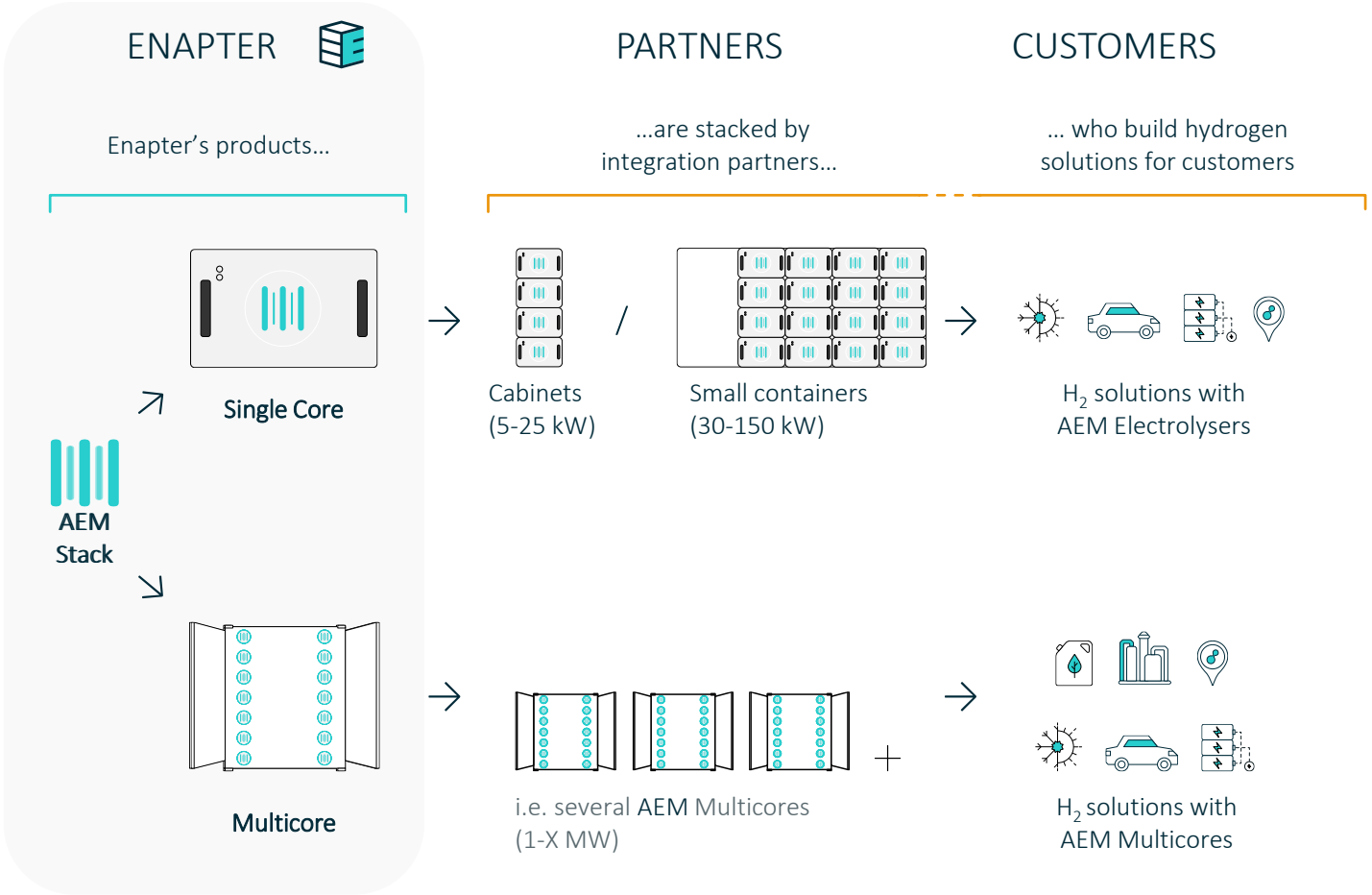
FOCUS ON PRODUCT, LEVERAGING PARTNERS FOR PROJECTS

Enapter makes the modules, integration partners stack them

- Enapter focuses purely on standardised modular products, leveraging partners to take on the project management work
- >100k system integrators worldwide could be enabled by Enapter to build competitive hydrogen solutions
- Commoditisation makes Enapter faster-to-market. Other players must develop new products for each use case / market, involving development time, component validation and technical risks
- Continuously increasing number of partners and certified partners:

>60
Partners

>30
Certified Partners



TRANSPORT

Fueling innovation

Protium Green Solutions ordered the largest AEM Electrolyser setup in the UK.

The 100-kW container produces green hydrogen for testing air and road mobility applications at an innovation center. Any excess hydrogen from the 30 electrolysers is used for energy storage.

Fuel Cell Systems (UK) integrated the liquid cooled electrolysers into the 20 ft container. They also use a hybrid energy monitoring system including Enapter's EMS toolkit

PROTIUM / FUEL CELL SYSTEMS– EXAMPLE OF CONTAINER INTEGRATION

Click here to see the video

TRANSPORT

Refueling road transport

A Hydrogen Refuelling Station (HRS) gathers the infrastructure for refilling fuel-cell vehicles with hydrogen that the fuel cell vehicle converts into electricity and water vapour.

Green hydrogen is stored until it’s needed for refuelling, at which point it usually goes through a compressor to start bringing it up to the pressure needed for the particular FCEV.

HRS for commercial fleets can also be seen as an enabler of other FCEV mobility such as trains, buses, forklifts.

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.

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.

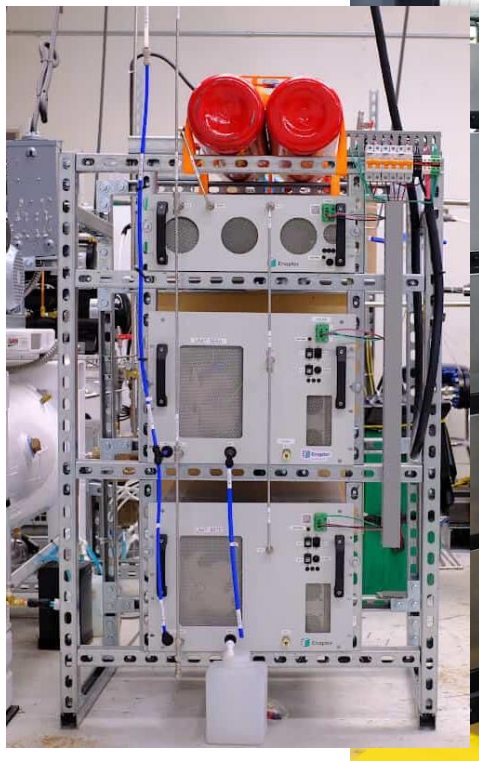
- Enapter deployed 8 AEM electrolysers, showcasing their unique modularity and flexibility.
- The produced hydrogen is safely transported to central boilers heating 25 apartments. 3 different hydrogen boilers are being tested in the setup.
- Since gas production in the Netherlands (Groningen) is winding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

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



Thanks for your attention!

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