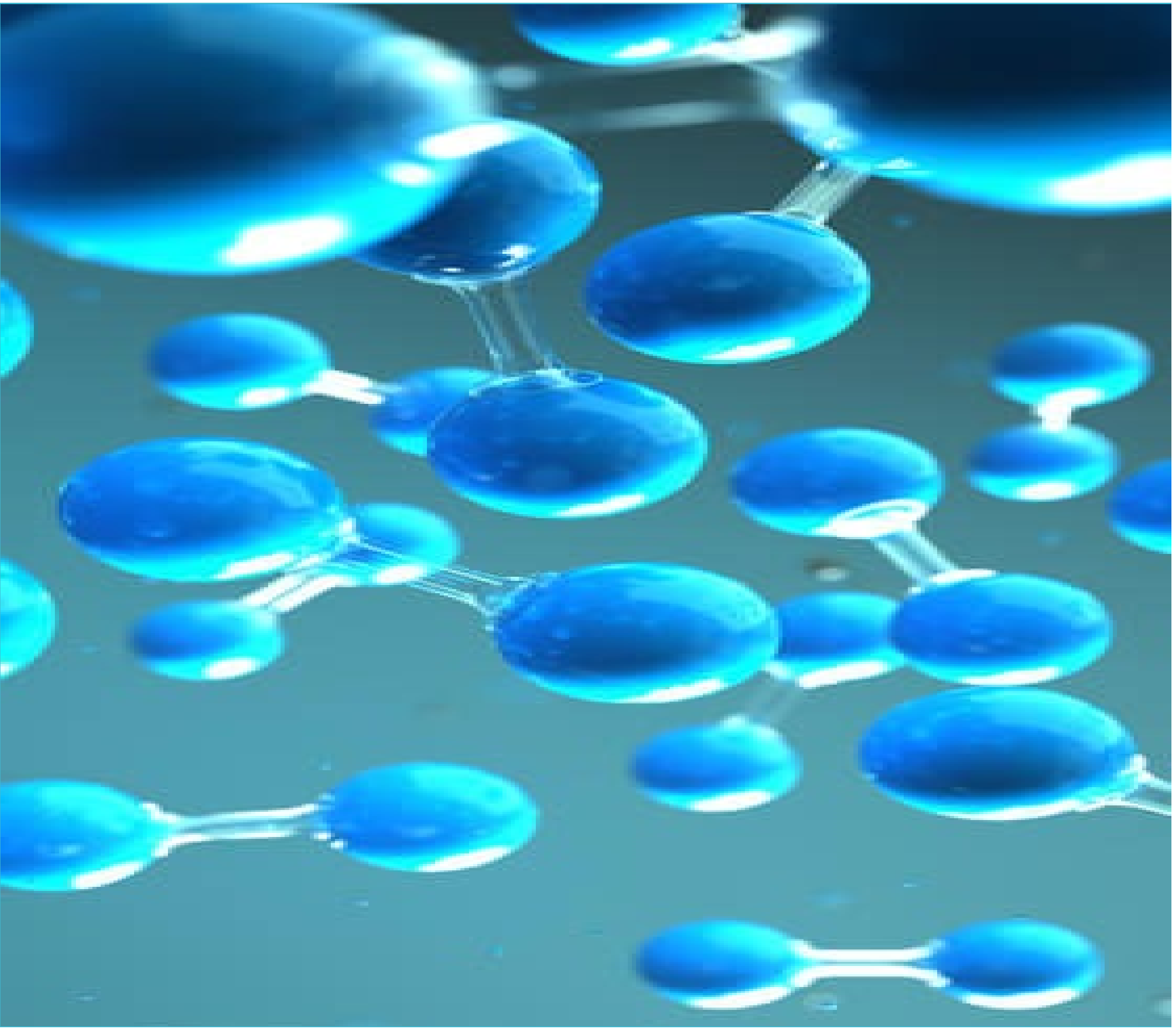
H_2 Energy srl

Solutions for a transition towards green energy and a sustainable World …



About us

H2E produce and commercialize industrial electrolysis systems.

With over 20 years of experience in the sector of its managers, engineers, researchers, we are able to supply CE certified PEM and AWL systems, as well as AEM, with innovative solutions that characterize our history ans our track record.

We are convinced that electrolysis technology, developed on a large scale, nowadays can already be competitive, thanks to the continuous development of the stacks and the rationalization of the solutions adopted.

As H2E, together our partners, we are active in R&D developing high temperature and pressure electrolysis systems:

- **SOEC proton conducting ceramic electrolytes** at 500 ° C.
- High temperature and pressure AWL, working 200/350 °C

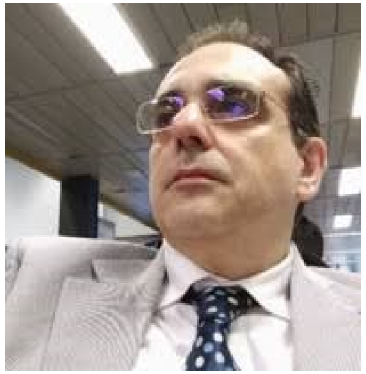
H2E provides turnkey solutions of systems for the use of hydrogen in the natural gas network, but also as an energy carrier in energy storage.

We are developing integrated systems to be used in railways and automotive transportation systems, to be applied also in steel production solutions and for various uses such as industrial and domestic.

We study, together with Clients advanced solutions and applications, carrying out feasibility studies and with the relevant design and coordination of the related systems..

The people

The team is made up of people with different specializations, all with international experience and with the same vision: imagine a world that bases its economy on hydrogen, definitively abandoning fossil fuels.



SARO CAPOZZOLI
Co-founder and Director, responsible for the domestic and international business development. China Market expert with technical background and complex project management.

RICCARDO DUCOLI
Co-Fouder and Director Responsible for finance and investments. He is an expert in special project development, . operating as renewable energy producer in the past 30 years.

CLAUDIO MASCIALINO
Co-Founder and President of the Board,. Researcher, with a demonstrated history of working in the automotive industry, Innovation Management. busiiness development focused on Sustainable business

EZIO TEDOLDI
Production Director R&D and Project coordinator. He is responsible for the developing of integrated system for hydrogen and oxygen in new applications in different scenario, in agriculture, sustainability, etc.

MARIO DRAGONI
R&D Director and Technical Director, responsible for the R/D and development of new products and stack systems.
More than 20 years of experience in the sector.

MATTEO DRAGONI
Technical project coordinator and Product Manager in Gas field application and project development. Expert in the validation and certification process.

Selected projects

With over 50 plants built around the world, H2E boasts, thanks to the contribution of its managers and engineers, an important experience that will find more and more feedback as the use of the hydrogen produced, but let's not forget also the oxygen, will always find applications wider

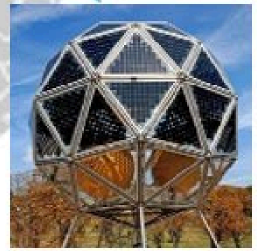
Application: HRS
Nominal Power: 50kW
H2 production: 10Nm³/h
AEM

Application: integrated battery electrolysis system
Nominal Power: 15kWx2
H2 production: 6Nm³/h
Client design

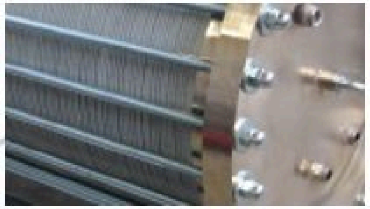
Application: Research
High pressure PEM electrolyzer prototype for DENERG Department of Energy Politecnico di Torino

Application: R&D
Nominal Power: 25W Test Bench
H2 Production: 5Nm³/h
AWL

Application: Power to gas
Nominal Power: 5MW
H2 Production: 1000Nm³/h
AWL



Application: E-Bike Mobility
Nominal Power: 50kW
H2 production: 10Nm³/h
AWL

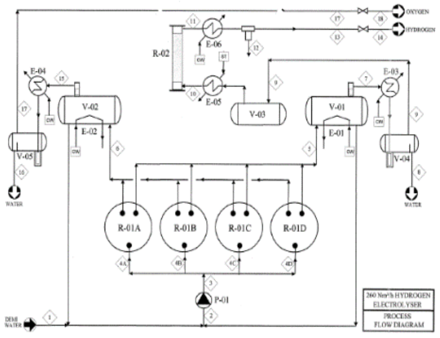


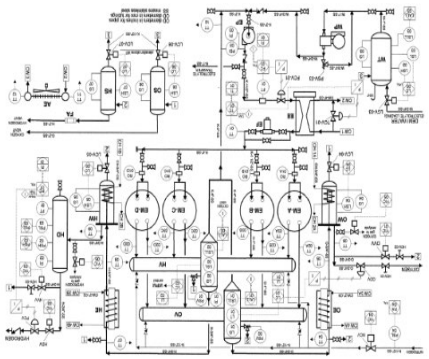
Application: Power cooling
Nominal Power: 100 kW
H2 production: 20Nm³/h
AWL

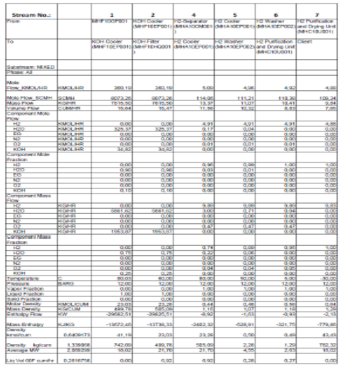
BOP engineering process, Project Management

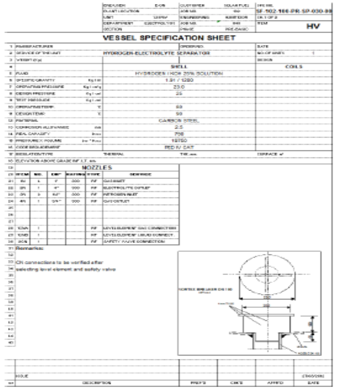
Our process of developing a project: from process and detailed engineering, to the realization of our turn-key systems, following a rigorous process of time, certifications and quality control.

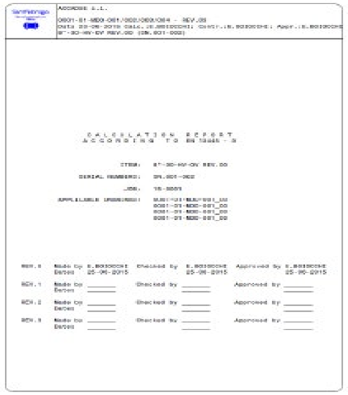
PFD Process flow diagram → P&ID → MASS & HEAT BALANCE → SIZING & DESIGN → CE CERTIFICATION

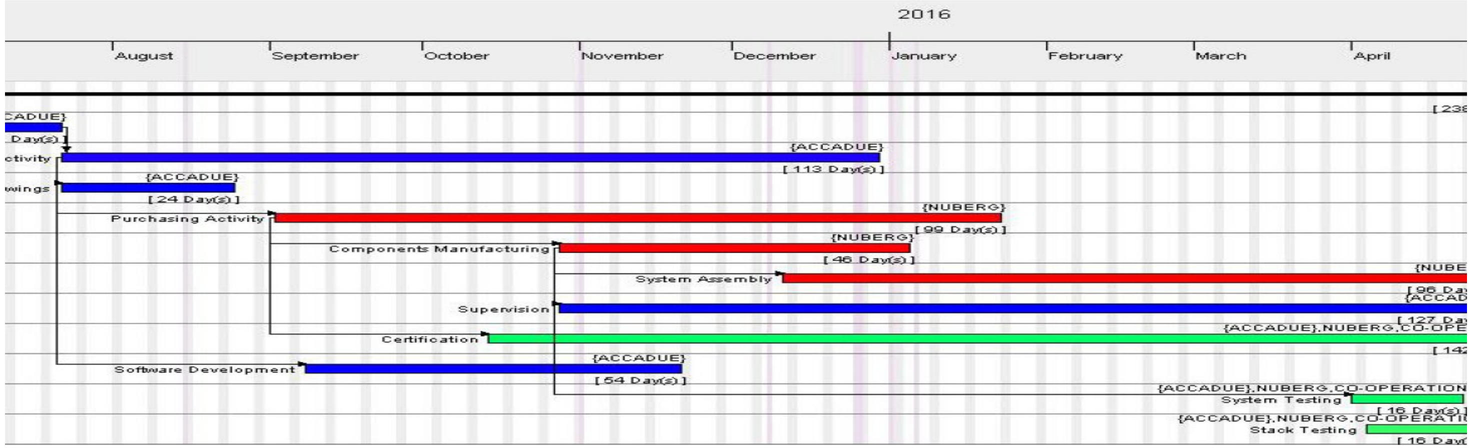












Electrolyser Engineering Process

Specifications → Mechanical design → Cell components sourcing and cost analysis → Cells manufacturing → FEM, CF, mal distribution Analysis → Mono Cell testing and validation → Molding Cell and testing → Electrolyzer System Assembly → Testing → Delivery

The development process of the stacks and ancillary systems, to optimize and to allow the control and management of hydrogen production, follows a rigorous pattern that has been refined over the years.

Product portfolio and perfomances

Nominal Power [kW]	25	50	100	250	300	500	750	1000	5000
Hydrogen Production [Nm3/h]	5	10	20	40	60	100	150	200	1000
Hydrogen Production [kg/h]	0.45	0.90	1.80	3.60	5.40	8.99	13.50	17.97	899.85
Oxygen Production [Nm3/h]	2.50	5	10	20	30	50	75	100	500
Stack comsuption [kWh/Nm3]	4,4	4,4	4,4	4,4	4,4	4,4	4,4	4,4	4,4
System Consumption [kWh/Nm3]	5,5	5,3	5,2	5,1	4,9	4,8	4,8	4,7	4,6
Container size	1x20ft	1x20ft	1x20ft	1x20ft	1x40ft	1x40ft	1x40ft	1x40ft	30x30m
AEM	Actual		Ready in 6 Months		Ready in 12 months in progress				
PEM	Actual Capability								
AWL	Actual Capability								

Technology: overview

H2E pressurised water electrolysers are designed for the efficient generation of hydrogen and oxygen under pressure, without the aid of mechanical compressions, therefore with maximum energy efficiency.

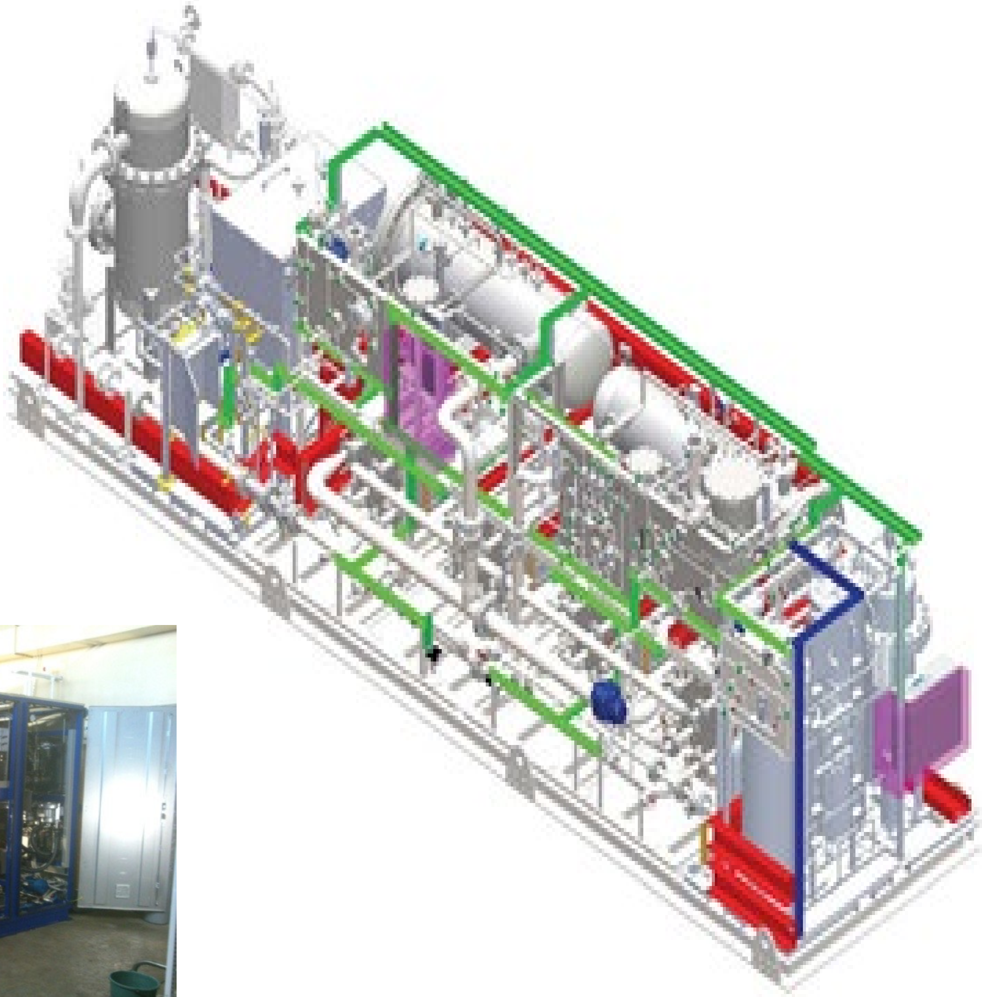
The electrolyser is supplied with integration of systems based on energy treatment, resources powered by renewable or other kind of energies.

The system is designed to maximize the automaticity of "fail-safe" operations.

This is based on two main components: the process unit and the power unit.

The process unit contains all the equipment, piping and instrumentation needed to perform the electrolysis process.

The monitoring and control system, based on a programmable logic controller (PLC), is integrated with the power unit. The unit is fully assembled and tested before delivery.



STACK TECHNOLOGIES: AWL – PEM - AEM

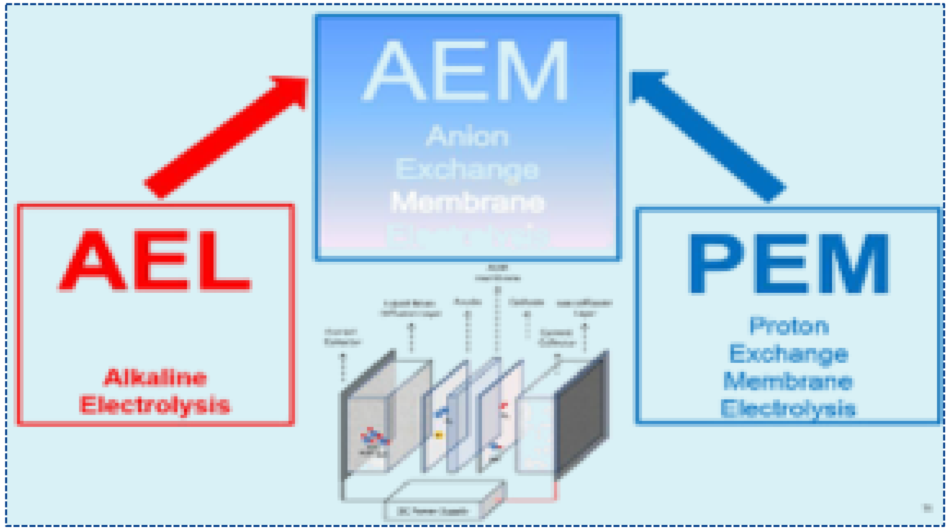
AWL: Alkaline Water Electrolysis

- Alkaline water electrolysis (AWL) is the most mature and durable water electrolysis technology which has been used widely for decades.
- AWL uses non-Platinum Group Metals (non-PGM) such as nickel as electrocatalysts.
- However, due to large Ohmic losses incurred across the liquid electrolyte and the porous diaphragm, AWL performance is normally at low current density with poses a challenge for the emerging renewable energy markets and requires a bulky stack design at MW scales. AWL stack operates at high KOH concentration.
- Due to this reason, the AWL system requires corrosion resistant material in the electrolyte management system and piping.

PEM: Proton Exchange Membrane Electrolysis

- PEM water electrolysis has great advantages such as compact design, high current density , high efficiency, fast response, small footprint, it operates under lower temperatures and produces ultrapure hydrogen and oxygen as a byproduct.
- The state-of-the-art electrocatalysts for PEM electrolysis are high activity of noble metals such as
- Pt/Pd and IrO2/RuO2 which makes the more expensive than alkaline water electrolysis.
- Therefore, one of the main challenges in PEM water electrolysis is to reduce the production cost and to maintain the high efficiency.

AEM: Anion Exchange Membrane Water Electrolysis



AEM can combine and improve upon advantages of both **Alkaline** and **PEM** systems.

Compared to PEM systems, they operate in dilute liquid electrolyte instead of pure deionized water, providing tolerance to impurities, flexible electrode design, and an advantage in large systems. AEM eltrolysers can operate at high current densities and high differential pressures while using low to zero PGM (Platinum grade materials) in the stack. In addition, particularly with dilute KOH concentrations shunt currents are substantially reduced for added efficiency and the Balance of Plant (BOP) can be simplified over existing AWL technology with fewer safety concerns and improved material compatibility for supporting equipment.

As a result, AEM is an extremely promising technology to reduce the capital cost of electrolysis systems.

The AEM technology implements no noble metals, new applications and licences in order to produce blue and green hydrogens at a lower costs.

The sector has enormous growth potential in the coming years, since 1975 it has more than tripled its value and continues to grow.

Technology comparison

	AWL	PEM	AEM
• **ADVANTAGES**	• Mature technology • Non-PGM catalyst • Long term stability • Low cost • Megawatt rage • Cost effective	• High current densities • Higher voltage efficiencies • Good partial load • Rapid system response • Compact cell design • Dynamic operation	• Non-noble metal catalyst • Noncorrosive electrolyte • Compact cell design • Lower cost • Absence of leaking • High operating pressure
• **DISADVANTAGES**	• Low current densities • Crossover of gas • Low dynamic • Low operating pressure • Corrosive liquid electrolyte	• High cost of components • Acidic corrosive components • Possible low durability • Noble metal catalyst	• Medium current densities • Maturity • Not existing yet in large scale

Technology comparison

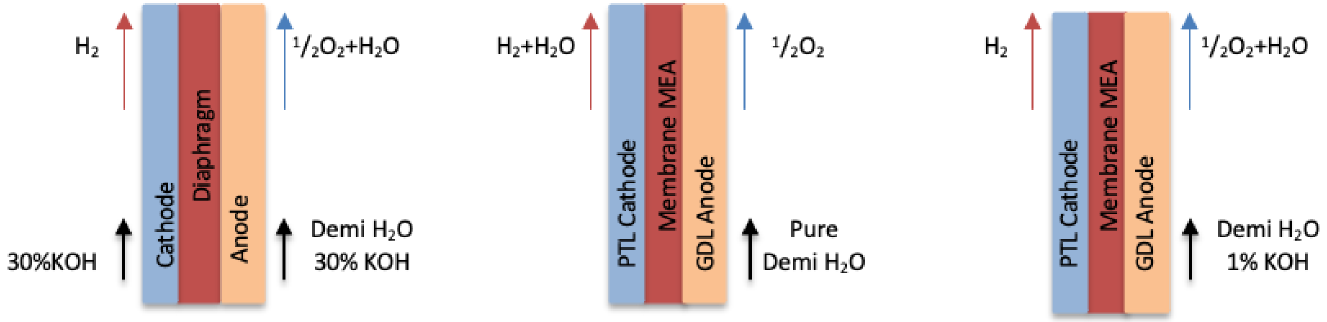
The technological features of the three types of water electrolysis systems

	AWL	PEM	AEM
Electrolyte	20-30% KOH	PFSA	QAPS
Temperature range	65-100	60-80	60-70
Typical discharge H2 pressure [bar]	15-30	30-80	30-80
Current density (mA/cm2)	400-1000	800-2500	500-1200
Demonstrated durability h	100 000	50 000 - 100 000	NA
Pressure H2	30 bar	30 bar	30 bar
Typical current efficiency	50-70,8	48,5-65,6	39,7
Rated production Nm3/h	Up to 5000	Up to 1000	Up to 1000
Specific energy consumption (kWh/Nm3)	4.5 - 7.5	5.8 - 7.3	5.2 - 4.8

Materials comparison

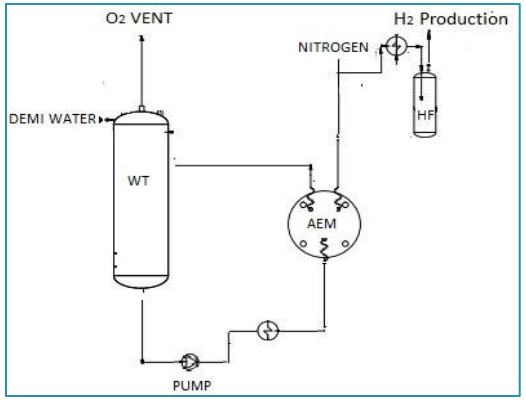
The graphic lists components and materials in the cell stack for three types of water electrolysis systems: Membrane, Anodic and cathodic catalyst, PTL and GDL material and Bipolar plate.

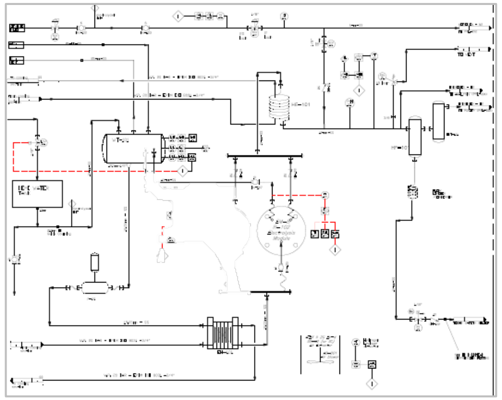
Component	AWL	PEM	AEM
PTL material	-	Ti 30% porosity/Pt	Ni foam/ Ni wool
Catalyst Cathode	Ni based 21$/m2	50% Pt/C (Platinum grade) 195$/m2	NiCrMo (e.g) 100 $/m2
Membrane	Diaphragm	PFSA (e.g. Nafion ™)	Aenemion
Catalyst anode	Ni based 21$/m2	75%IrO2 1238 $/m2	NiMo (e.g) 100 $/m2
GDL material	-	Carbon cloth	Carbon cloth
Bipolar plate	Stainless steel Ni coated	Titanium	Stainless steel Ni coated



BOP comparison

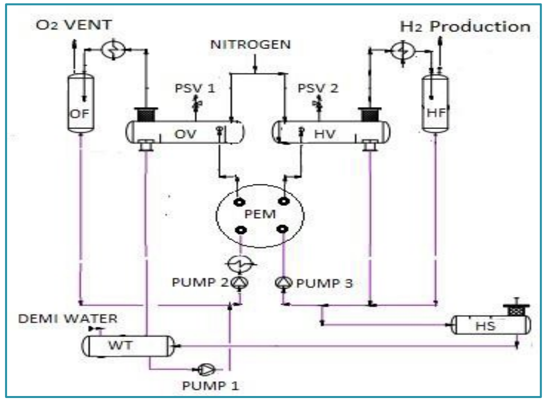
AEM

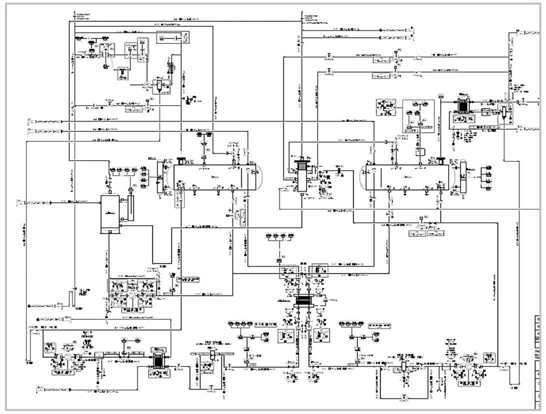




AEM allows cost reduction and saving in space, maintenance, etc

PEM

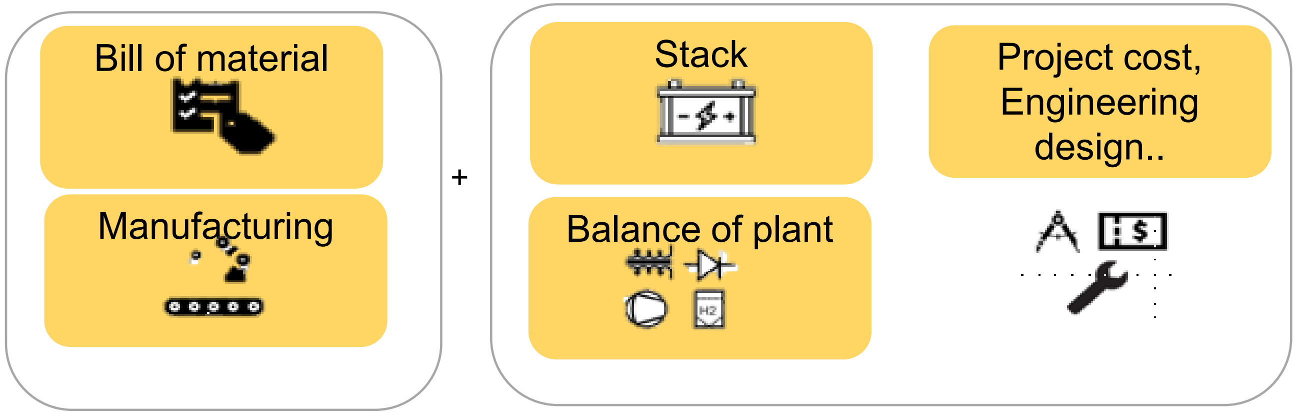


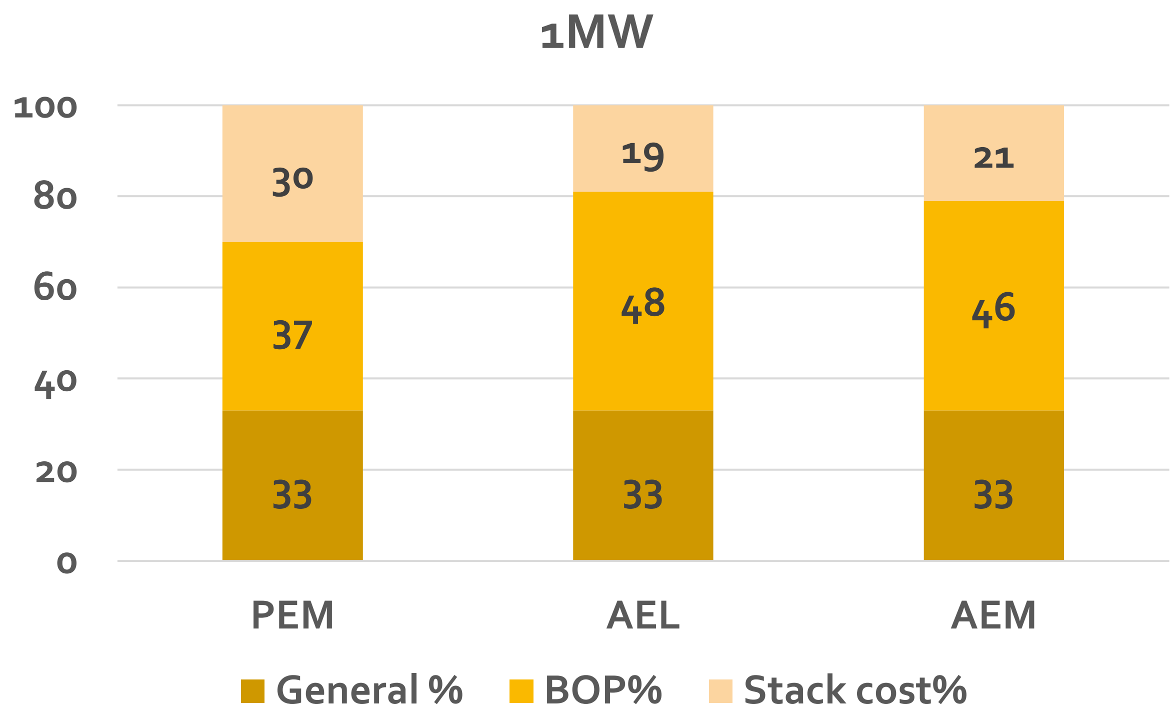


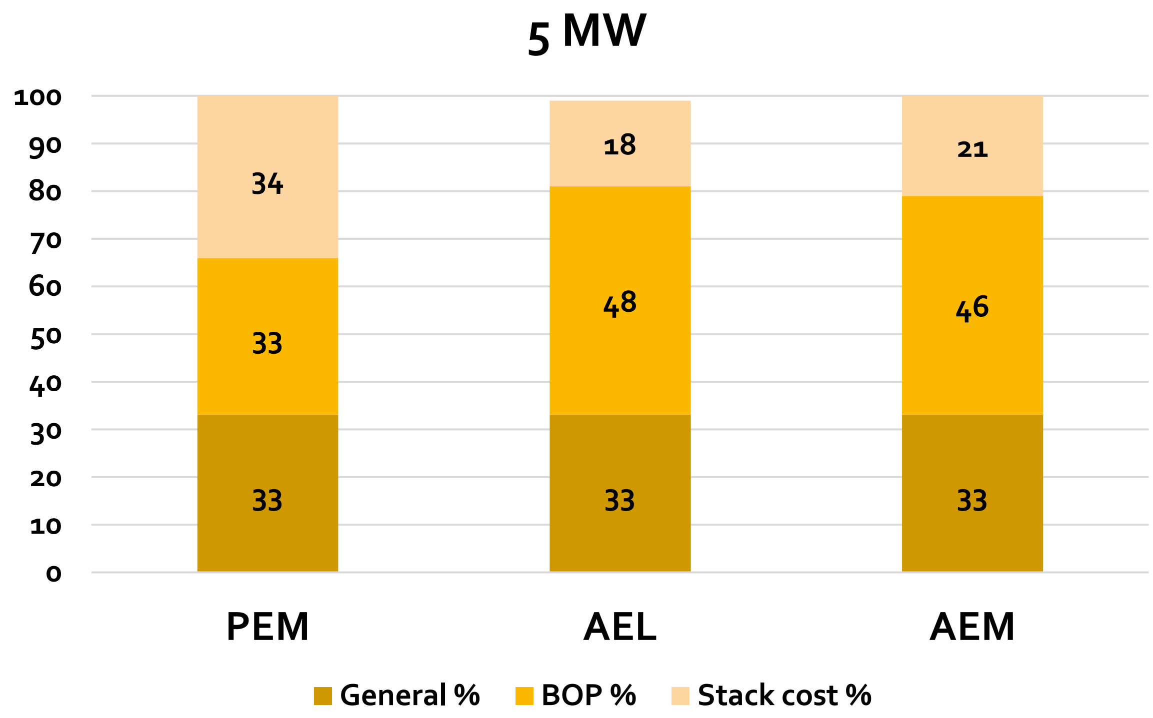
PEM Existing Traditional system

The **AEM** technology significantly simplifies BOP and therefore has the lowest BOP investment cost compared to other electrolysis systems

Investment cost and cost breakdown







R&D AWL-AEM-PEM STACK Roadmap

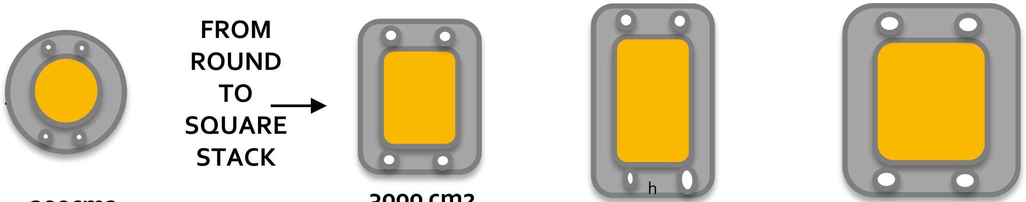
Key target achievements: Better overall performance, enhanced functionalities, cost reduction (production& maintenance),

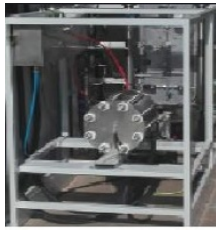
Cell design evolution

Simplification of overall design

Increase of stack size

Increase of BoP size





10 kW Stack Complete → 50kW Stack Complete → 250kW Stack 6 month → 1MW Stack 10 month → 10MW Stack 18 month

We continuously develop new patents and applications, some shared, others proprietary, but what matters is knowing how to do things, the know how to make things done!

Some Patents

N°3 Co-Inventor in Patents concerning AWL stack design

N°1 Co-Inventor in Patents concerning Power Control

N°1 Pending Patent on AEM Cathode osmosis control

N°1 coming soon Pending Patent on AWL High Pressure & Temperature

Research and development

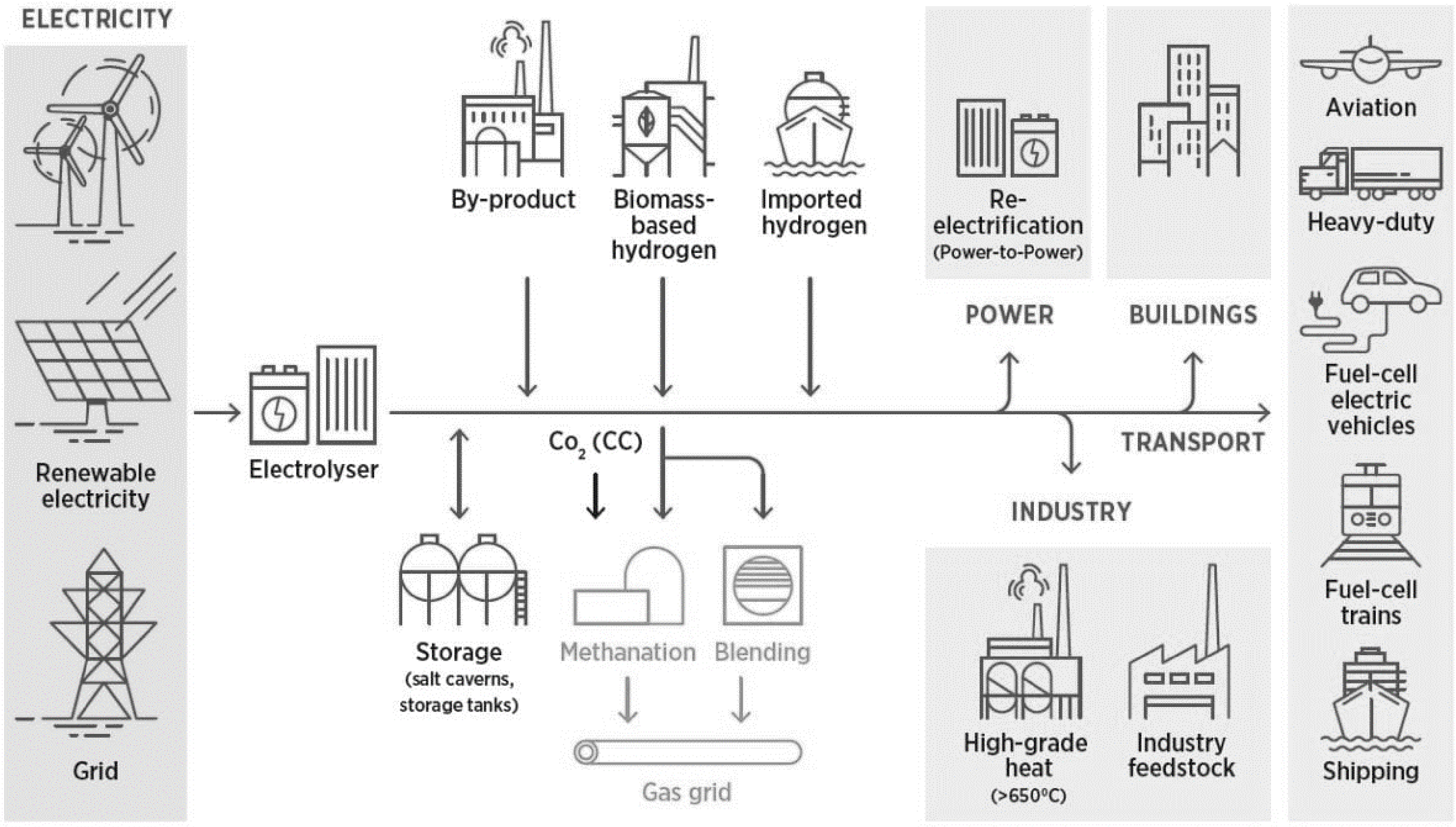
We are continuing researching and developing new kind of stacks and systems to optimize the electrolysis process. In many industrial processes is available thermal energy, with temperatures higher than 200°C, to use SOEC or AWL-HTP, can be the efficient solutions for Hydrogen production. Protonic ceramic electrolysis cells as energy conversion systems are a promising technology, capable of combining high efficiency, flexibility under diverse working conditions and excellent performance.

SOEC-Proton Conductor Membranes for use in Steam Electrolysis, has been demonstrated to be an efficient and viable method to produce high purity hydrogen using ceramics proton-conducting electrolytes (PCE) at the medium-high temperature 500°C. This class of electrolytes is particularly favored for their relatively high ionic conductivity with low activation energy for proton conduction.

AWL-HTP is a new alkaline electrolytic cells approach, designed to work at medium-high temperature, in a range between 200°C to 350°C, the water splitting into H2 and O2 takes place with an important Thermal Energy contribution, with a consequent increase of Voltage Efficiency. It allows to increase also the gases high Pressure production.

Applications

Power-to-Hydrogen describes the process of converting renewable energy to gaseous energy carriers such as hydrogen or methane via water electrolysis. The hydrogen can be used directly or fed into an assortment of processes.



Applications

Applications

Storage

Ammonia can be co-fired to reduce CO_2 emissions. Hydrogen will be used for seasonal storage.

Transport

Hydrogen fuel cell vehicles can reduce air pollution, Shipping and aviation are other fields were the energy can be employed.

Buildings

Can be used for high-temperature heating pumps or fuel cells, especially in commercial buildings located in densely populated cities.

Energy intensive Industry

Can be used in oil refining, ammonia production, than urea production, steel production industries as feedstock.

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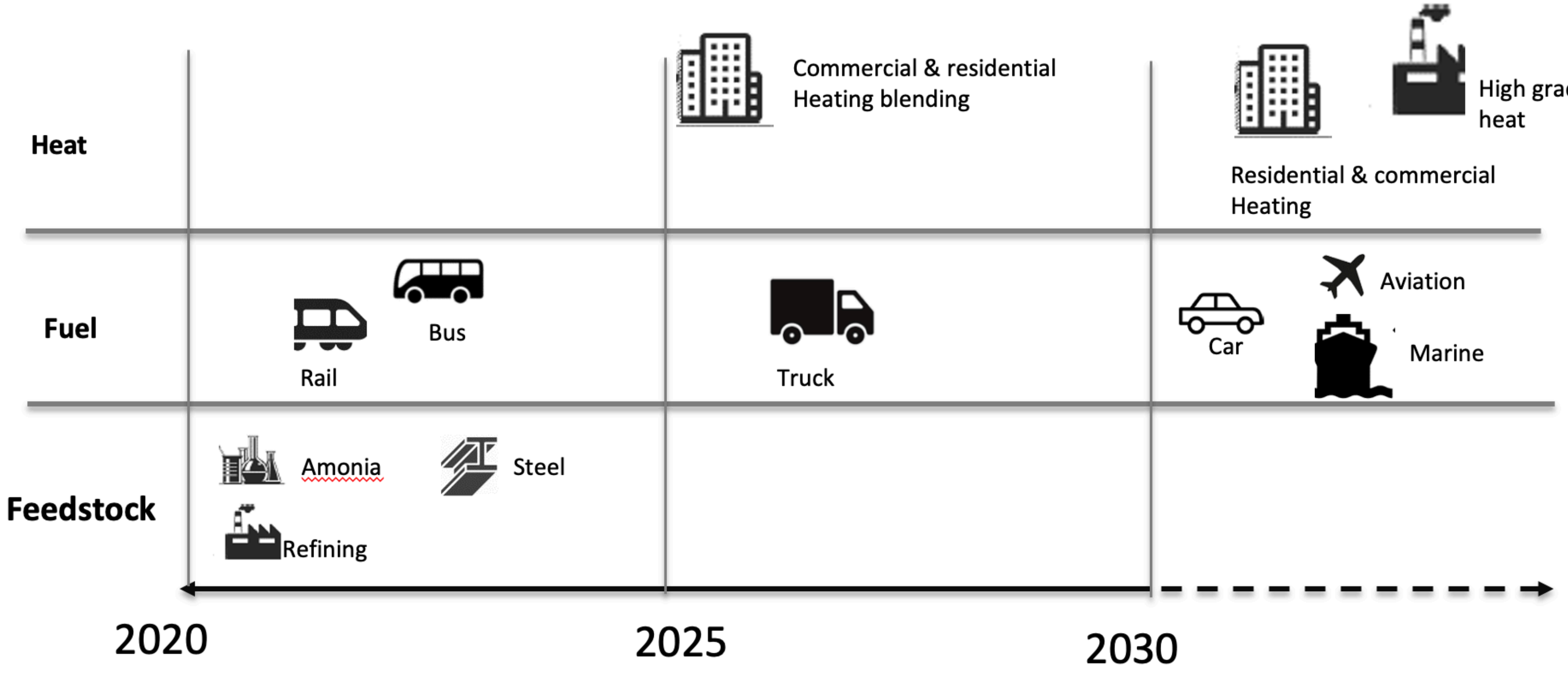
Market development

Analysis of demand evolution by segment over time :



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