THE SWISS EXPERT FOR INDUSTRIAL SOLUTION MANAGEMENT

H2 Educator

EasyEnergy is a **Swiss Engineering & Consulting company** with worldwide references.

Combining knowledge and experience in the field of **power**, **heat**, **gas**, hydrogen and **special fluids**, we support customers in their hydrogen projects as **system integrator**.

Thanks to our cooperation with leading partners we design and manufacture customized products such as **hydrogen production systems**, **auxiliaries for turbines**, gas and liquid filtration unit, **compressor skid**.

EASYENERGY
CONSULTING & TECHNOLOGY

Davide Hanselmann
Easy Energy Companies & Consulting SA
CEO

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AGENDA

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System Walkthrough
AEM Electrolyzer Technology
Hydrogen Production Process
Water Circuit - Instrumentation

Safety System

Hydrogen the Ninja Element S
afety Implications
Fire Triangle Approach
H2 Educator Safety Systems

Economics

Modular Scaling Demonstration
Business Case Development.

Applications

Examples
Brainstorming Session

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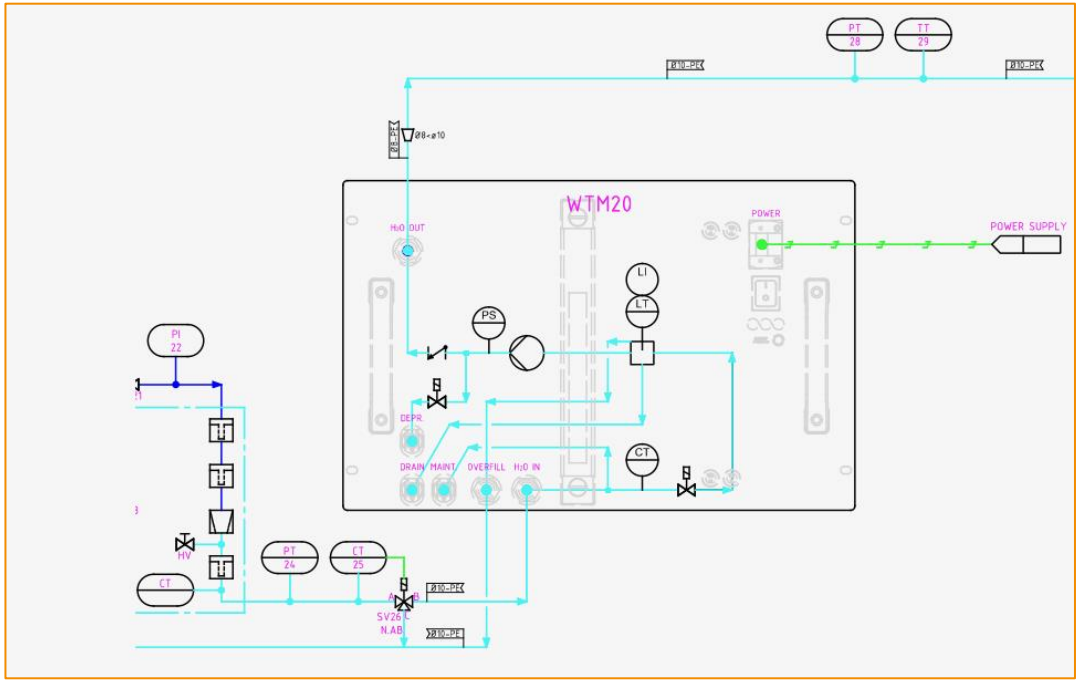
How it works

We realized and operate a H_2 EDUCATOR to **test**, **verify** and **validate performance** of production system under different loads with **Enapter AEM electrolyser**.

WATER CIRCUIT

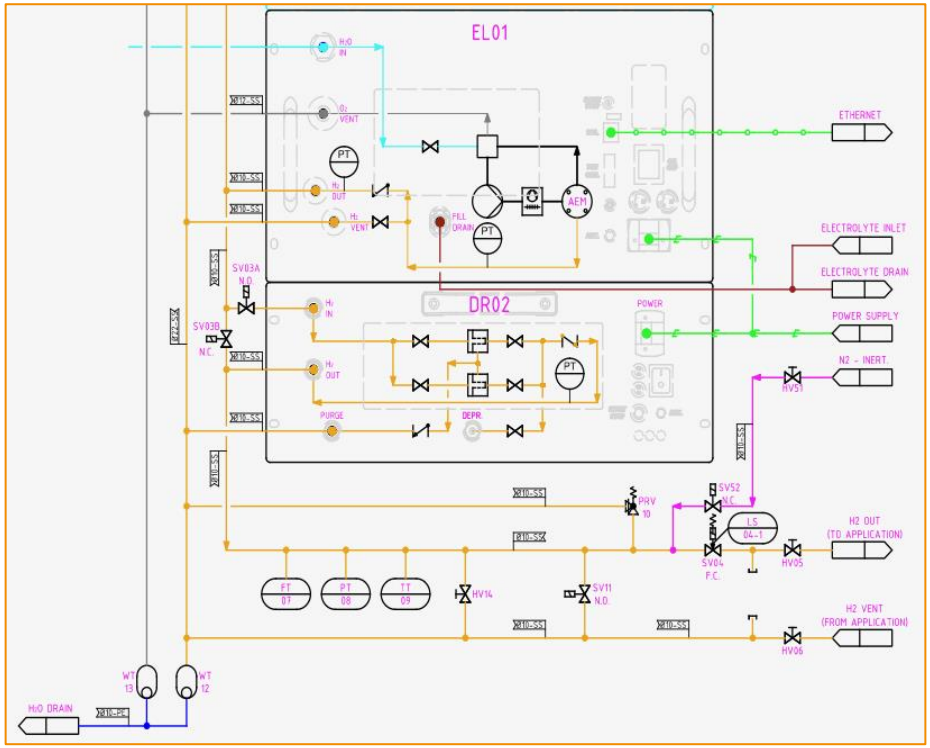
- Tap water
- Water treatment system with osmosis filter
- Water conductivity check
- Demi Water tank
- Demi Water supply to electrolyzers



HYDROGEN CIRCUIT

- Demi water from tank
- Hydrogen out to dryer module 99.999% p urity
- Hydrogen from dryer to application
- Hydrogen could be vented if needed
- Oxygen vented outside, need to be separa te from Hydrogen
- Water trap for draining condensate

H_2 up to 35 bar
99.999% pure
2 kg/day



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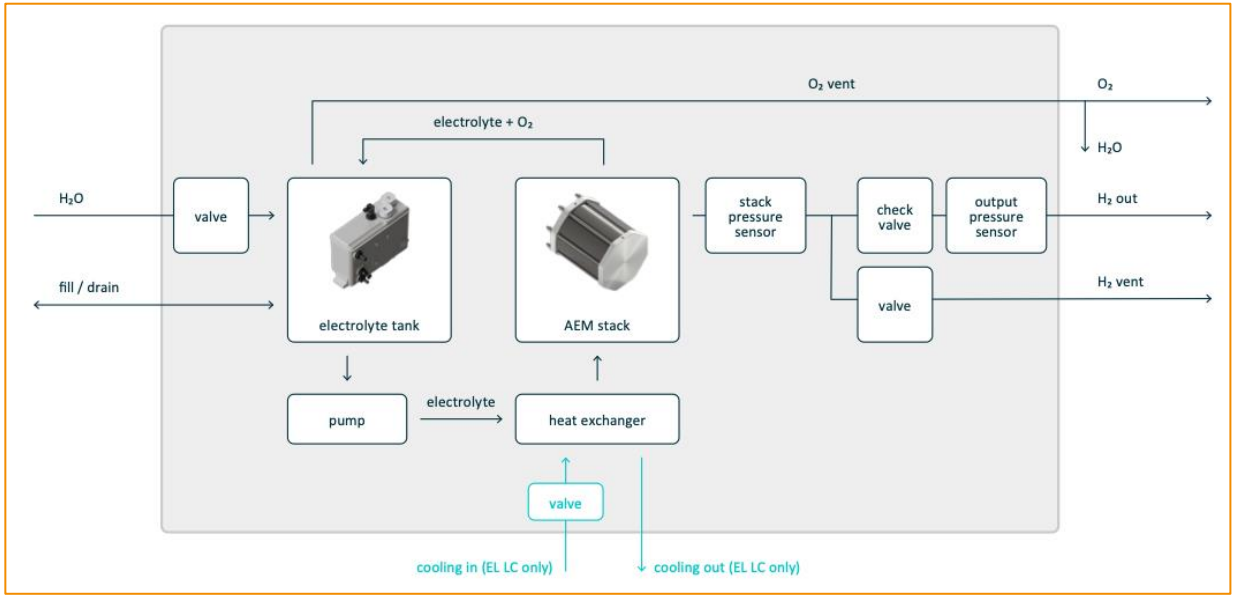
Electrolyzer



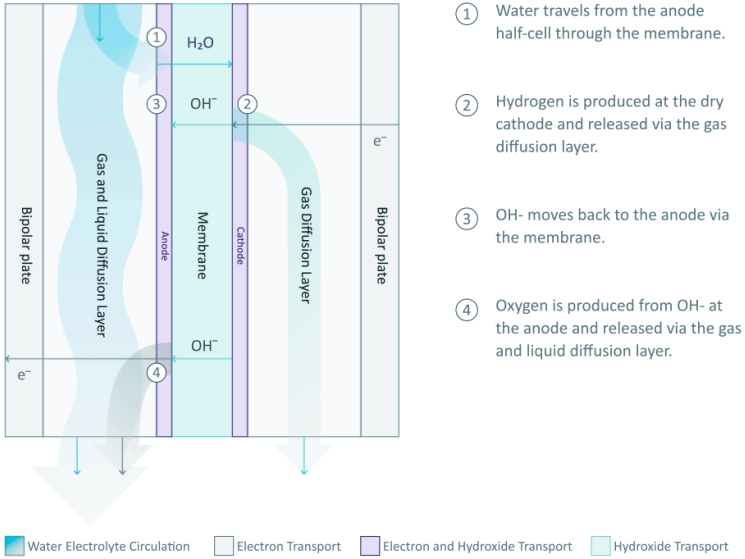
Electrolyzer - Stack Working Principle

ANION EXCHANGE MEMBRANE ELECTROLYZER

Anion Exchange Membrane (AEM) Electrolysers unlock on-site hydrogen production **for any use, at any scale.**

Electrolysis with anion exchange membranes has **clear benefits** compared with other electrolytic processes such as conventional alkaline electrolysis using diaphragms (AEL) or the more recent method of proton exchange membrane electrolysis (PEM) which is highly dependent on raw materials such as precious metals.

The innovative AEM concept **reduces investment costs** because the cells used for electrolysis in alkaline conditions do not require precious metals. Therefore, far less expensive materials can be used. Other attributes of this AEM electrolysis platform are **high current density**, **very good efficiency**, and **high flexibility**.



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.

Emerson reliability, precision, complete range of product (more focused on bigger projects)

MEASUREMENT & FLOW

LIQUID & GAS ANALYTICAL

FLOW CONTROL VALVES

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Control & Monitoring - Safety

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VIDEO

https://youtu.be/fnWwKhIvKdc?si=0l5BrO21a58hF-Ep

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Hydrogen- The Ninja Element

It's colourless, odourless, tasteless, non-toxic, highly combustible and explosive.

14 times lighter than air → H_2 leakage even with small holes

Very reactive with O_2 and air → Separate O_2 from H_2

Avoid ignition source → Ex area

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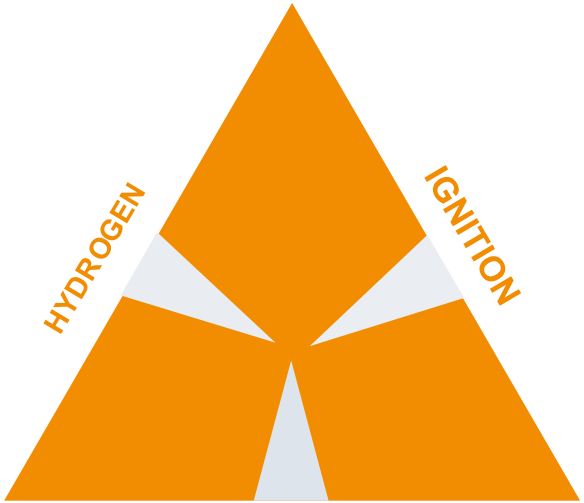
Safety – Fire Triangle For Hydrogen

AVOID

Unintentional m ixing:
Use only hydrogen compatible materi als and consider d esign and safety f actors to prevent l eaks



ANTICIPATE

Ignition mecha nisms: Control m echanisms that ca n ignite hydrogen -oxidizer mixtures

ADOPT

Best practices: Implement safe practices wit h inspection, assembly, operation, maintenanc e and safety systems

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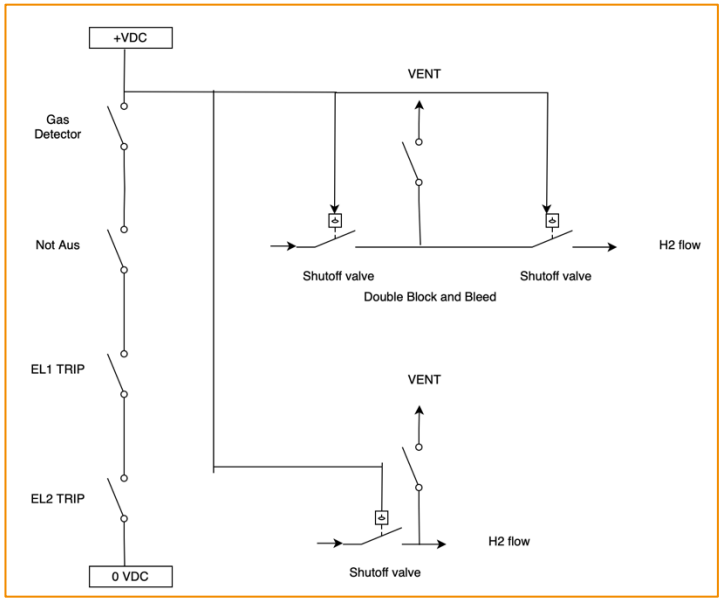
Safety Concept

- N2 injection line to purge all piping
- Safety system with spring return, limit switch for close position, manual venting



Consequence of failure rank	Consequence of failure ranges				MTTF rank		
					1	2	3
					MTTF		
	Personnel health and safety (S)	Environmental (E) degradation	Impact on production (P) and operation	Cost (Economy) (C)	25 < MTTF (years)	5 < MTTF < 25 (years)	MTTF < 5 (years)
1	Minor injuries. No potential for fire. No effect on safety systems.	A small spill has been detected: Volume < 0.01 m³ (10 liters) to sea or spilled on installation.	Brief stop of production less than 3 hours. Failure of subsea equipment with negligible impact on production.	Repairs can be performed while being on topside.	N	L	M
2	Personnel injuries requiring medical treatment. Potential for fire, but not in classified area (e.g. possible failure to isolate section from the platform). Limited effect on safety systems.	Moderate spill to sea: Any oil > 0.01 m³ (10 liters) Any red chemicals > 0,01 m³ (10 liters) Any yellow chemicals > 0,1 m³ (100 liters) Any green chemicals > 10 m³ (1000 liters)	Shutdown or reduced rate of production between 3 to 12 hrs. Failure of subsea equipment with limited impact on production (e.g. retrievable modules or components forming part of the water injection system).	Subsea intervention with need of a small to medium sized vessel.			
3	Serious personnel injuries. Potential for fire in classified area (e.g. possible failure to isolate the section from platform). Render safety systems inoperable.	Major spill to sea: Any oil > 16 m³ (100 bbl) Any quantity of black chemicals.	Shutdown or significant reduced rate of production for more than 12 hours.	Major subsea interventions with the necessity of rig or large vessel.			

RISK ANALYSYS

Degree of serious-ness	Injury		Work related illness (WRI)		Uncontrolled discharge/emissions		Oil-/gas/flammable liquids leakages		Fire/explosion		Failure in safety/security functions and barriers		Reputation	
	Actual	Potent.	Actual	Potent.	Actual	Potent.	Actual	Potent.	Actual	Potent.	Actual	Potent.	Actual	Potent.
1	Fatality		Work related illness that result in death		Single spill with long term effect on the environment. Release to air > yearly expected emission of component		>10 kg/s or brief leakages >100 kg		Whole facility/plant exposed		Threaten whole facility/plant		Great international negativ exposure in mass media and among organisations	
2	Serious lost time injury/serious injury		Serious work related illness		Single spill with medium term effect on the environment. Release to air > monthly expected emission of component		1–10 kg/s or brief leakages >10 kg		Large part of facility/plant exposed		Threaten large part of facility/plant		Medium international negativ exposure in mass media and among organisations	
3	Other lost time injury or injury involving substitute work		Work related illness that results in short term absence or restricted/ alternative work		Single spill with short term effect on the environment. Release to air > weekly expected emission of component		0,1–1 kg/s or brief leakages >1 kg		Parts of facility/plant exposed		Threaten parts of facility/plant		National negativ exposure in mass media, from authorities on national level	
4	Medical treatment injury		Work related illness that results in treatment from authorised health care personnel		Single spill with minor effect on the environment. Release to air < weekly expected emission of component		<0.1 kg/s		Local area of facility/plant exposed		Threaten local area		Local/regional negativ exposure in mass media, from authorities and customers	
5	First aid injury		Other work related illnesses		Single spill or release to air with negligible effect on the environment		<<0.1 kg/s (significantly less than 0.1 kg/s)		Negligible risk for facility/plant		Negligible risk for facility/plant		Limited to a few persons or a single customer	

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Training

Due to high interest in the scaling hydrogen economy more and more companies and therefore employees need to be trained in all parts of the hydrogen value chain, but **training** outside the companies' offices result in additional travel costs, likely leading to limited or no real training related to hydrogen topics.

In addition to that, hydrogen trainings from official notified bodies or training centres are very expensive. Safety topics, correct handling of hydrogen assets and the automation of hydrogen production processes need to be trained by service personnel, engineers, and new hires.

Our H2 Educator helps to **increase the knowledge regarding hydrogen production**, measurement, and control in a simple, small and mobile Device.
It allows us to train our own team, and stakeholders teams effectively and on-site. It is ever evolving and dynamic.

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AEM Technology - Benefits

COMPARISON OF THE ELECTROLYZERS			
Technical Differences	**AEL Electrolysers**	**PEM Electrolysers**	**AEM Electrolysers**
Electrolyte	Potassium hydroxide solution	Polymer membrane	Anion or cation exchange membrane
Operating temperature	50 – 90°C	< 100°C	< 60°C
Efficiency	70 – 80%	70%	80%
Maximum current density	0.5 – 1 A/cm^2	1 – 2 A/cm^2	2 – 4 A/cm^2
Catalyst material	Nickel or Raney nickel	Platinum	Non-noble metals
Maintenance	Requires frequent maintenance	Requires regular maintenance	Requires less maintenance than PEM

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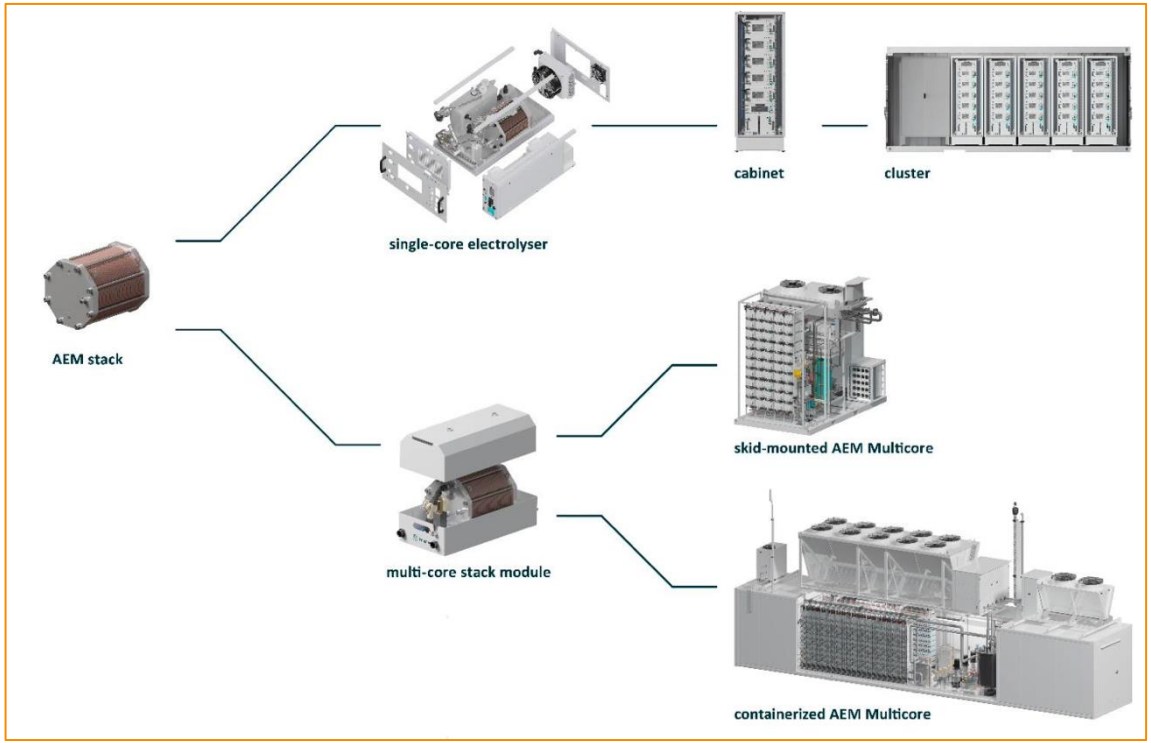
Modular Approach



Flexible H_2 production / Electricity consumption to follow renewable intermittent energy.

From small to bigger project, **same concept.**

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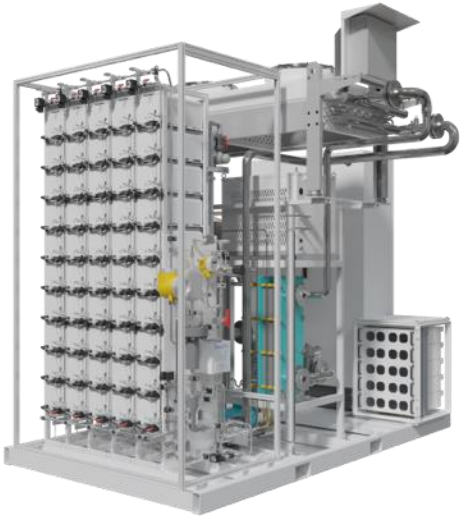
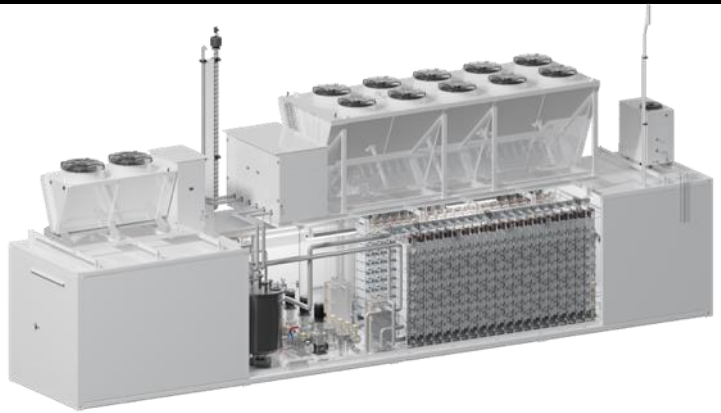
Cost / Performance

Expected life : 30’000 h

CAPEX - 40’000 € **PERFORMANCE** - 5 kW = 2 kg/day
H_2 COST - 20 €/kg



CAPEX - 400’000 €
PERFORMANCE - 120 kW = 53 kg/day
H_2 COST - 6 €/kg



CAPEX - 1’500’000 €
PERFORMANCE - 1 MW = 445 kg/day
H_2 COST - 2.7 €/kg

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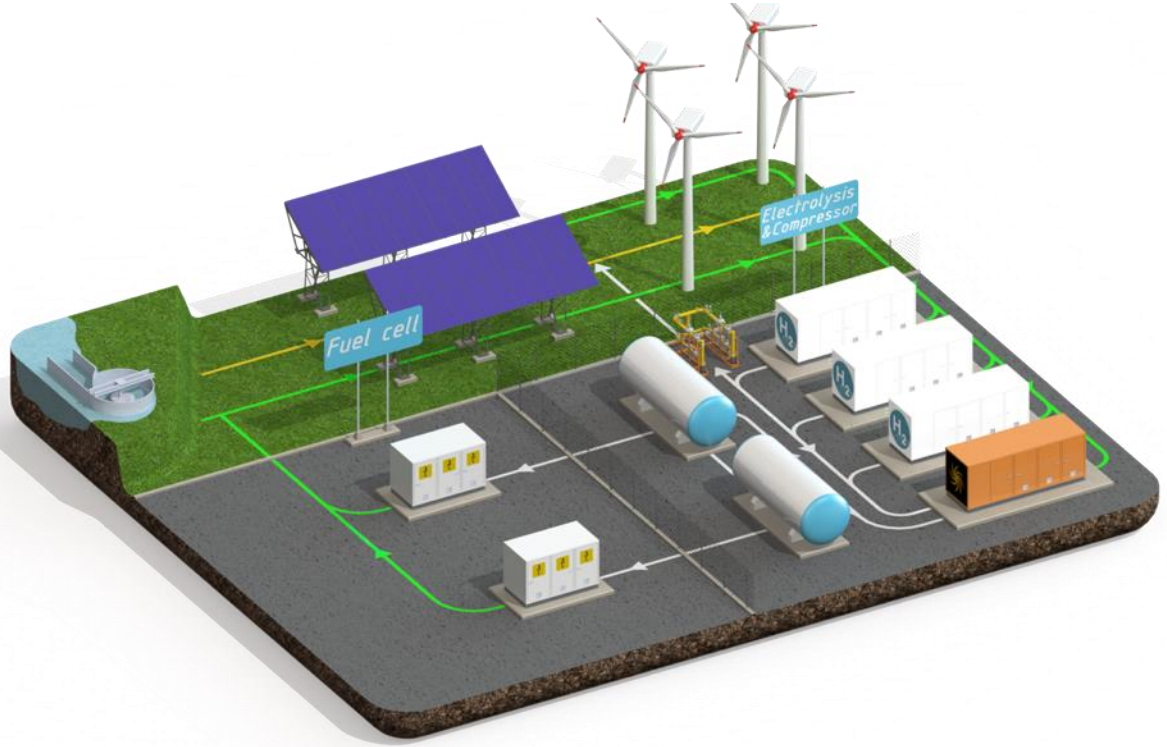
Hydrogen – Backup Power

Hydrogen backup power system is the cleane st way to provide uninterrupted and decentralize d supply of electricity.

Thanks to high **energy density**, **long lifetime**, **fast response time for start-up** and **power m odulation**, fuel cell system can offer reliable and efficient source of electricity for critical loads such data center, antenna's, hospitals, banks, and other critical infrastructure.



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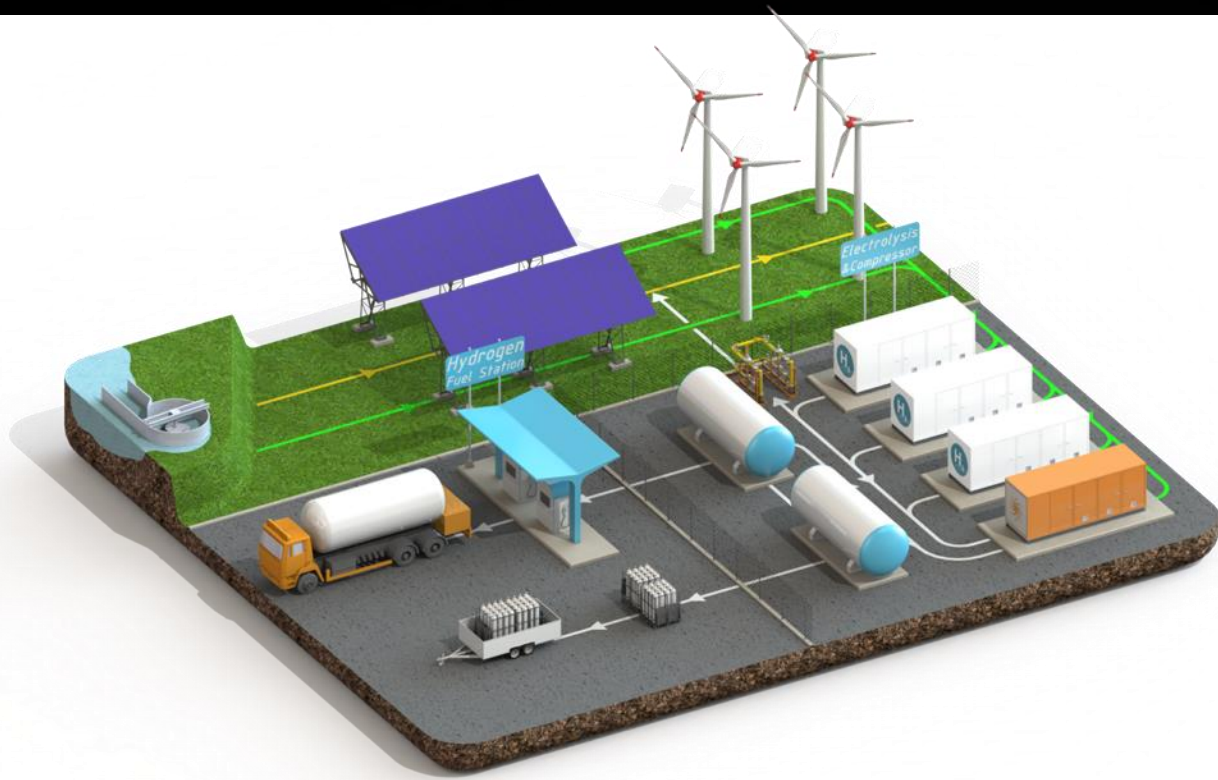
Hydrogen Mobility

Hydrogen is one of the best solutions for **achieving carbon neutrality in the heavy mobility sector.**

Hydrogen trucks have the same **benefits** of electrical vehicles without the constraints of battery weight or recharging time.

Hydrogen enables **energy storage** from renewable sources to produce no emission fuel for transportation and logistics sectors.



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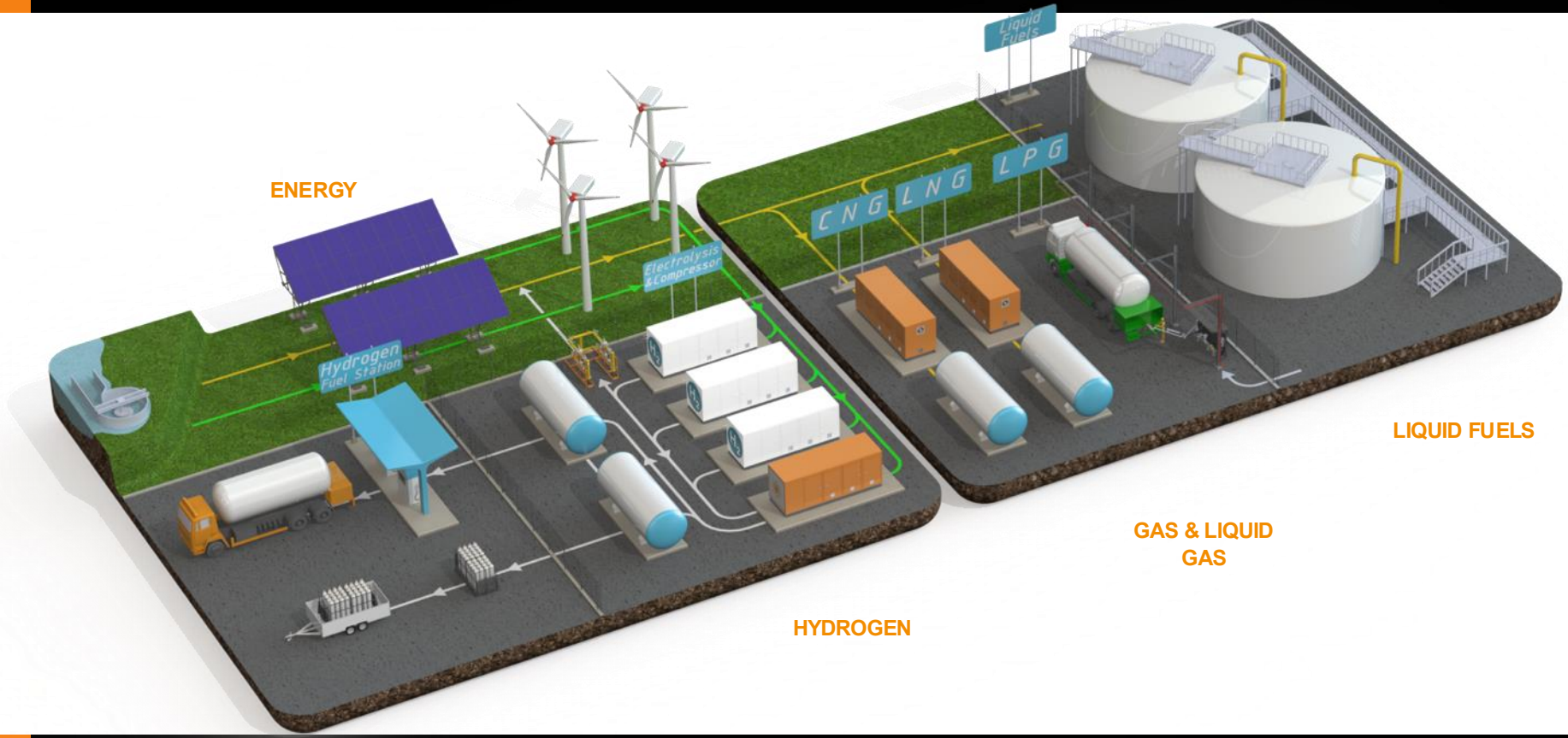
Hydrogen - Creativity



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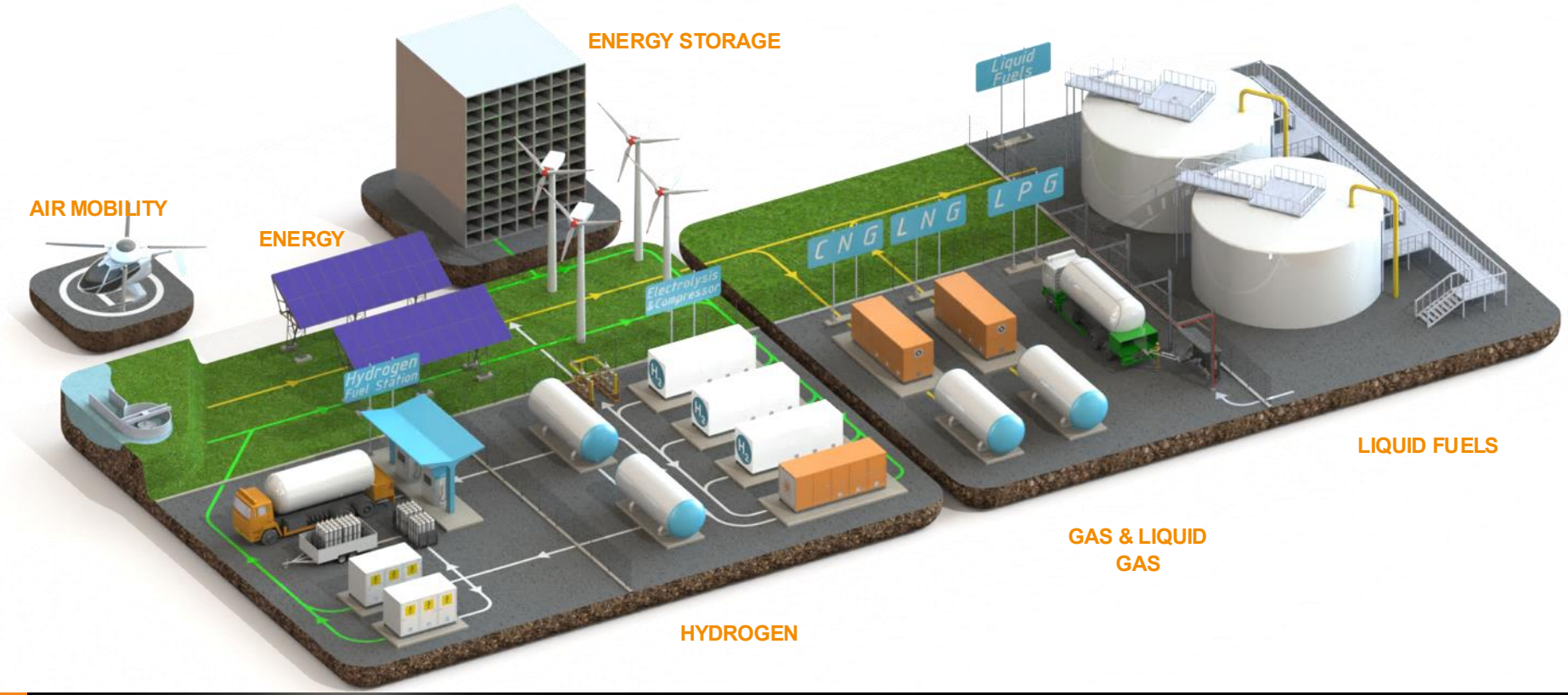

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