



OUR COMPETENCIES IN HYDROGEN TECHNOLOGIES

1. What is the situation?

The key challenges facing the energy industry

Decarbonization

CO2 emissions from energy usage are major contributors to global warming and account for nearly 75% of all man-made greenhouse gas emissions in the EU.

Energy efficiency

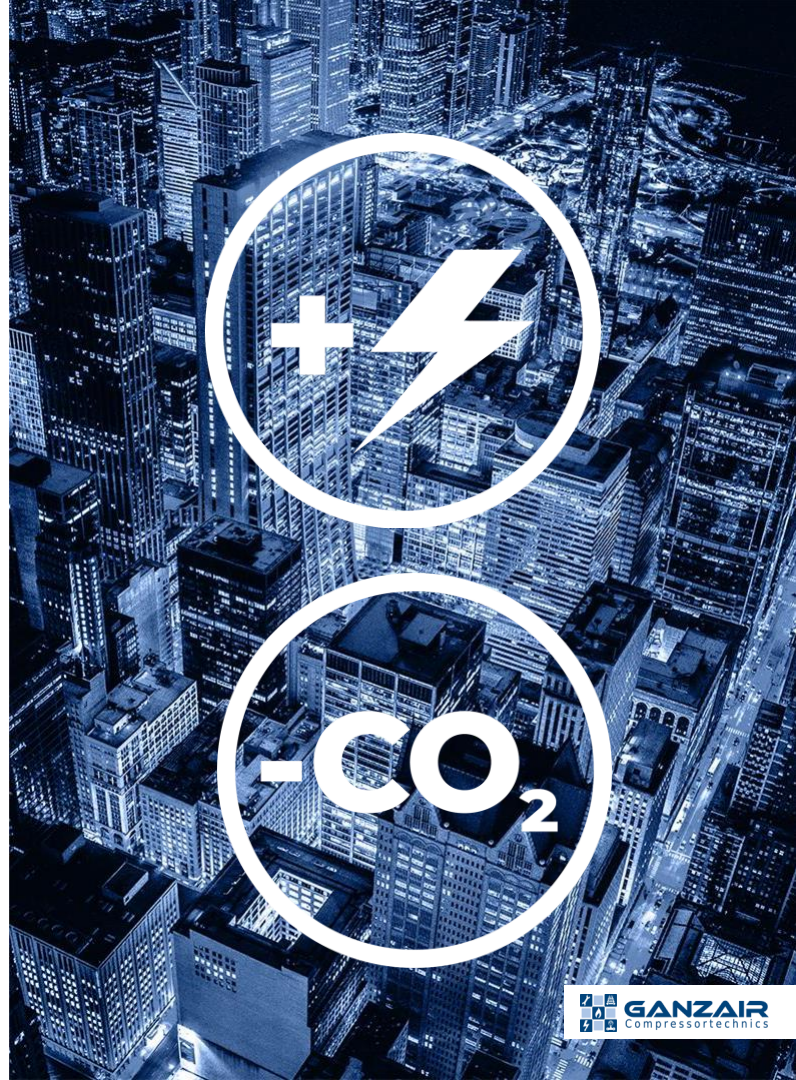
The cleanest, cheapest energy is what we do not produce, transport or use. (resource saving)

Growing energy demand

With the improving standards of living, it is estimated that by 2040, electricity generation will increase by 49%.

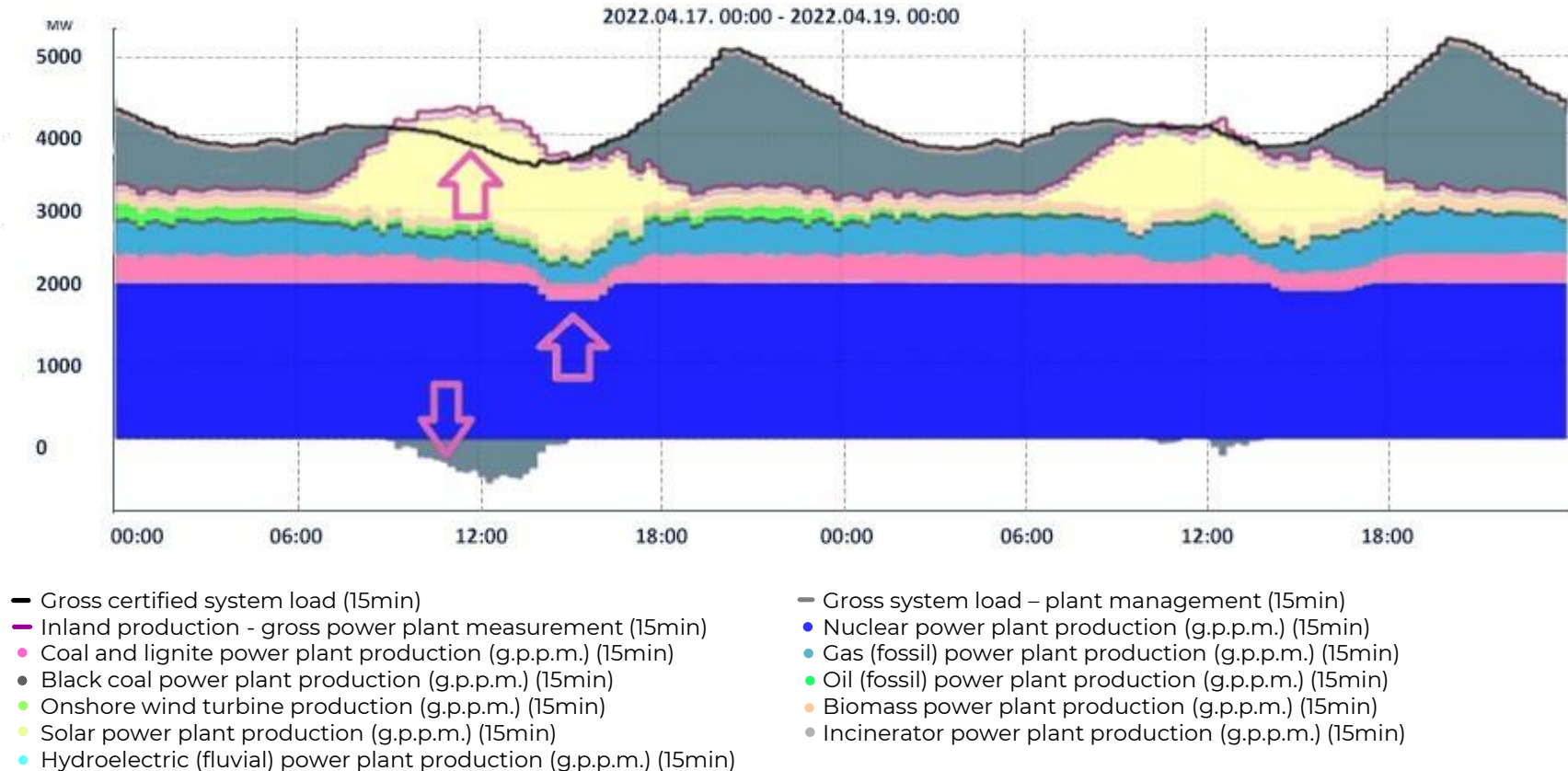
SOLUTION?

VRE – variable renewable energy is among the most important drivers of power system transformation, **BUT...**



Grid stability & control problems

Green hydrogen production with electrolyzers, storage and its shifted use as energy source can contribute to cope with this challenge in a carbon free way.



Possibilities of hydrogen utilization in Hungary

Currently:

- Energy storage, grid balancing
- Filling in cylinders for industrial use
- Hydrogen blending to natural gas

Potentially:

- Energy storage, grid balancing
- Gas engine and gas turbine operation (with hydrogen blended natural gas or pure hydrogen)
- Inhouse or public filling stations for fuel cell vehicle (bus, car, truck, forklift)
- Fuel cell backup power (datacenters, SSC)

GAS COMPRESSOR APPLICATION

Functionality

Booster Compressor



Evacuation Compressor Units



Wellhead Compressor



Well Starter Compressor



Flare Gas Compressor

Types of Gas Compressor Construction



Trailer mounted version



Stationary unit - on skid version



Containerised version

NATURAL GAS COMPRESSORS *SINCE 2005* ALMOST *100 UNITS* IN *11 COUNTRIES*



AUSTRIA



CROATIA



CZECH REPUBLIC



HUNGARY



KUWAIT



LITUANIA



ROMANIA



RUSSIA



SERBIA



SLOVAKIA



SLOVENIA



• MOL



• HUNGARIAN GAS
STORAGE



• NET4GAS



• TDE SERVICE



• NIS



• INA



• SVEGA



• EUSTREAM



• FORNOVO GAS

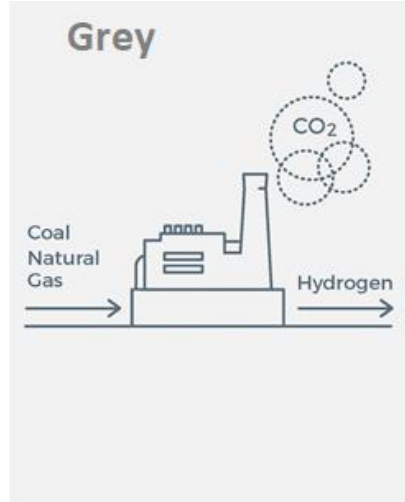


• MAGYAR HORIZONT
ENERGIA



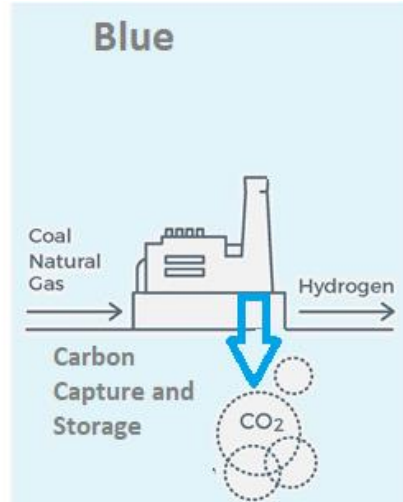
2. Where are we involved exactly?

Which Type of Hydrogen?



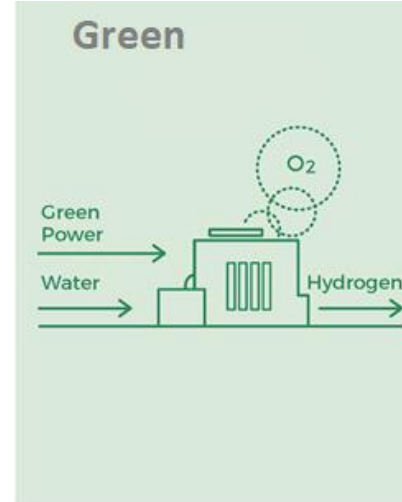
GREY hydrogen

Hydrogen
compressor



BLUE hydrogen

CO₂ compressor
system integration



GREEN hydrogen

It is the only type
produced in a climate-
neutral manner.

- ❖ Electrolyser
- ❖ Hydrogen compressor
- ❖ Storage
- ❖ System integration

H₂

Our Hydrogen Technology References

Projects in realisation phase, Ganzair as contractor

- MFGT Akvamarin 2 x 1 MW EL + compression + high pressure storage > UGS test, NG blending, engine and burner fuel
- Bükkábrány PV plant 1 MW EL + compression + high pressure storage > H2 cylinder bottling for sale for industrial use

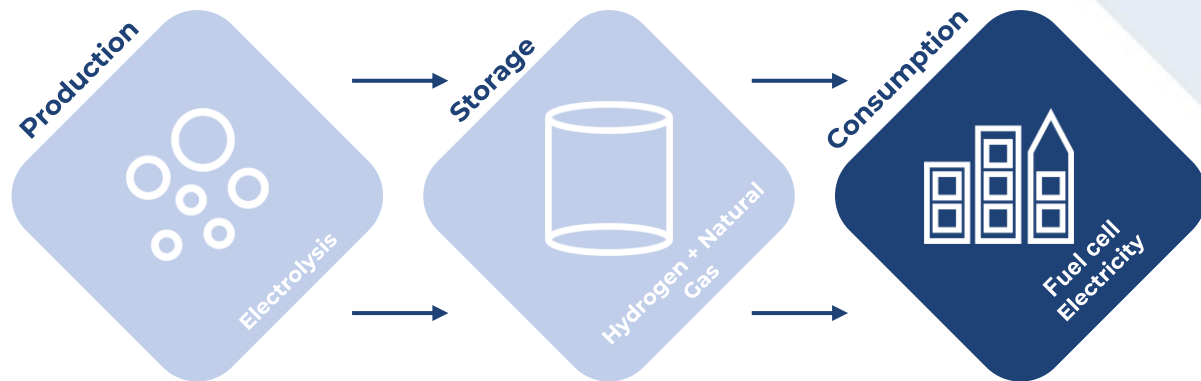
Projects in feasibility evaluation phase, Ganzair as expert support

- MVM Tisza PP 200 kW EL, storage, NG blending for engine fuel
- MVM Pécs PV plant– 500 kW EL, compression, high pressure storage > Fuel cell powered garbage truck fleet fuelling
- MVM HQ – 3 MW EL + compression + high pressure storage + 1,5 MW FC > Power grid balancing
- Recreational resort – 200 kW EL, storage, 200 kW FC > microgrid for autarchical power system
- OGD Oil and Gas Development LLC 3 MW test, then 50 MW EL + compression + high pressure storage — Oil associated gas utilisation and natural gas blending

'Akvamarin' Project of the Hungarian Gas Storage Ltd.

Case Study

The Hungarian Gas Storage Ltd—member of the MVM Group—will utilize its Kardoskút-based underground gas storage facility in the research and development project. As part of the ongoing project, an **electrolyser and compressor system will be built**, moreover, a hydrogen mixing and dosing technology system will also be developed with a total nominal electrolyser capacity of 2.5 MW. The **produced hydrogen will be mixed into natural gas** and utilized in the Hungarian Gas Storage Ltd's own gas engines and furnaces, reducing the CO₂ emissions of the technology. On the other hand, in addition to the direct energy use, as well as the capacity testing of the transmission line and distribution systems, the aim is to conduct an industrial-scale experiment **for the long-term storage of hydrogen in underground gas storage** at pressures above 100 bar. In parallel, universities and research institutes will be studying how high-pressure hydrogen impacts the surface technology equipment, the local gas network, and the geological structure of the underground gas storage facility.



The first Hungarian industrial-scale green hydrogen project is entering the implementation phase, for which **the hydrogen production unit will be supplied by GanzAir Compressortechnics LLC.**



GANZAIR
Compressortechnics

P2G-H₂ Project— Case Study

The R+D project run by **Photovoltaic Power Station Project Ltd and the University of Szeged** utilizes solar power **to produce hydrogen** by **PEM electrolysis system**. Hydrogen, produced by green energy, is planned to **be sold in industrial gas cylinder bundles**, and later there is an option to install a fuel cell unit for power generation. The electrolysis system, a hydrogen compressor, 2 pcs high pressure containerised gas storage banks and the high-pressure cylinder bundle filling system will be integrated into one of the largest 20 MW solar power plant in Hungary.

US-based Plug Power—Giner ELX will supply the electrolysis system for 1 MW input power, this will produce 200 normal cubicmeter per hours of hydrogen at 40 barg pressure. To boost the gas pressure from 40 to 350 barg to the composite MEGC storage which contains appr. 10 000 Nm³ gas at that pressure, Ganzair will build a Burckhardt Compression diaphragm compressor into the system. From the high pressure storage, a filling system will be installed as well, to fill 200 barg pressure industrial gas cylinder bundles.

Weather conditions affect the accessibility of renewable energy, thus, it is essential to store energy for periods when green energy is not available. Hydrogen has an inevitable role in the medium-long term storage of energy, therefore, it can provide a solution to balance weather-dependent renewable-energies.



The second Hungarian industrial-scale green hydrogen project is entering the implementation phase, in which **the hydrogen production unit and storage will be supplied by GanzAir Compressortechnics LLC.**



3. Systems integrator & Manufacturer

What we do...



CONSULTANCY: We contribute to the creation of Hydrogen economy, carbon-free energy industry regionally.



ENGINEERING-PROCUREMENT-CONSTRUCTION: We take part in Hungarian industrial-scale green hydrogen pilot projects as system integrator.



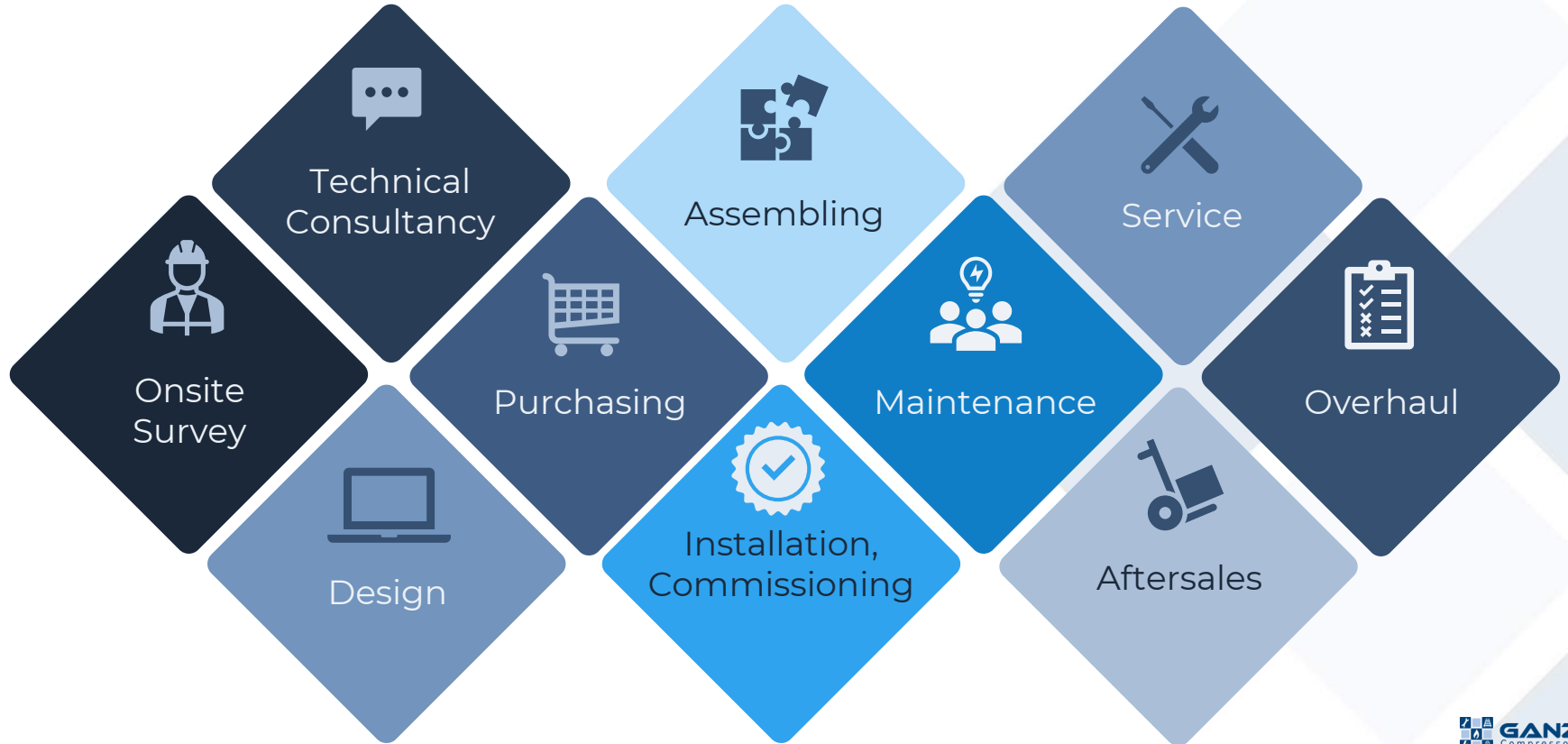
NETWORK: We connect Hungarian and international suppliers of main components and spare parts.

- 30+ years presence
- >5000 m2 production plant in Kiskunhalas
- 100+ employees, 20+ engineers
- 5000+ installed compressors
- Among our customers: Hungarian Gas Storage, MOL, MMBF, OMV, NIS-Gazprom, Eustream, Net4Gas, PGNiG
- 30+ years experience in the sector of energy, energy efficiency and industrial gas
- Collaboration with Hungarian R&D Centres
- 100+ suppliers in our network



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Compressortechnics

WE PROVIDE



From production to utilization

Production

PEM H₂
Electrolysis
(40 barg)

Compression

Piston,
Diaphragm
up to 900 barg

Storage

Steel, composite,
Stationary,
portable cylinders,
bundles, MECC
containers up to
500 barg

Utilization

Fuel cell power
generation

Produced
Hydrogen is
mixed into natural
gas
Hydrogen for
mobility



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Compressortechnics

Our production competency and supplier chain

- Decades of system integration experience in oil and gas, power generation, general manufacturing industry
- Highly trained design and project engineers, workshop staff, instrumentation & IT engineers, welders, field technicians
- Experience with high pressure and explosive gases, electric power systems
- Supplier value chain local and international



Compressor packages
Welded structures, Piping, Pressure vessels
Cabinets and containers, Heat exchangers
Cabling and wiring, PLC system and programming
Involving local subcontractors



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Suppliers (main unit)

International

Compressor blocks and packages:  **Burckhardt Compression**  **Haskel** An Ingersoll Rand Business  **Sauer Compressors**  **COOPER**

PEM electrolyser stacks and fuel cells:  **plug** AEM electrolyser modules:  **Enapter**

Transformers, motors, VFDs, power appliances:  **SIEMENS** Ingenuity for life  **ABB**  **MITSUBISHI**

Instrumentation:  **EMERSON** **YOKOGAWA**  **Endress+Hauser**  **LESER**  **WIKAI**

High pressure cylinders and MEGC:  **LUXI**  **VITKOVICE**



Local

Technology:  **AIRVENT** smart air solutions  **Eurofoam**  **Güntner**  **MAGNET** tartálygyártó kft.  **GANZAIR** Compressortechnics

NATURAL GAS COMPRESSOR APPLICATION REFERENCES

Engineered by Ganzair



NATURAL GAS COMPRESSOR



HUNGARY 2021 ONGOING

TECHNICAL DATA:

Gas:	Natural gas
Gas flow:	40 000 m ³ /day
Suction/discharge pressure:	0,5 – 1 to 4 – 11 bar
Compressor:	FornovoGas 2DA500-2 reciprocating compressor
Shaft power:	160 kW
Prime mover:	Electric motor

HUNGARY 2019 REOPENED PROJECT

TECHNICAL DATA:

Gas:	Natural gas
Gas flow:	240 000 m ³ /day
Suction/discharge pressure:	10 to 45 bar
Compressor:	Burckhardt 2HS-C14 reciprocating compressor
Shaft power:	630 kW
Prime mover:	Electric motor

4. What is our scope?

Compressor 30 → 500 bar

Suction buffer

Coolers

Cylinder filling
station

Electrolyser
Fuel cell

Trailer filling
station

Switchgears

Controllers

High pressure
buffer

200 – 500 bar

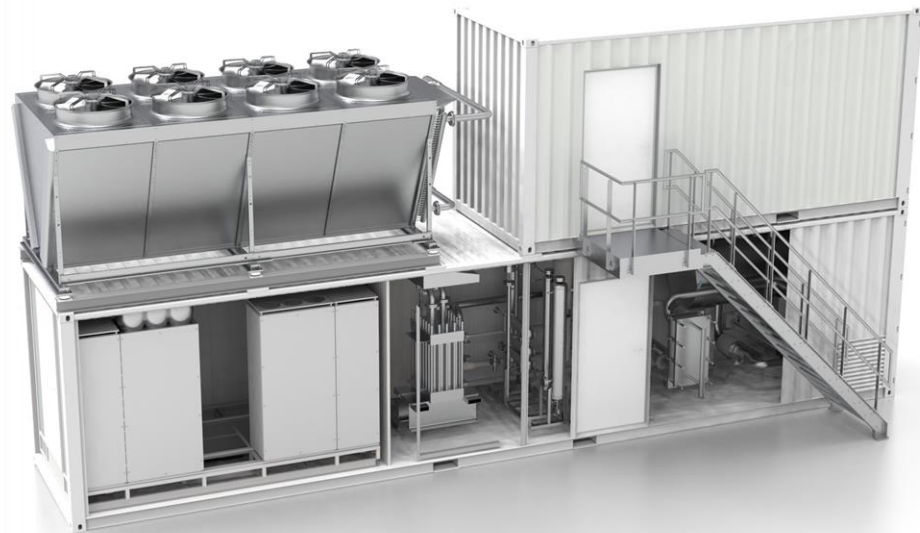
Transformer
20/0,4 kV



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Plug Power

Plug Power offers electrolyzers built in containers for industrial usage. They can provide three (1, 5 and 10 MW) different versions of electrolyser, with different maximum energy consumption.

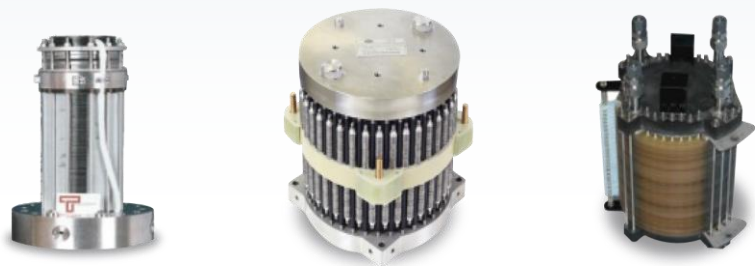


Advancements in Electrolysers by PlugPower

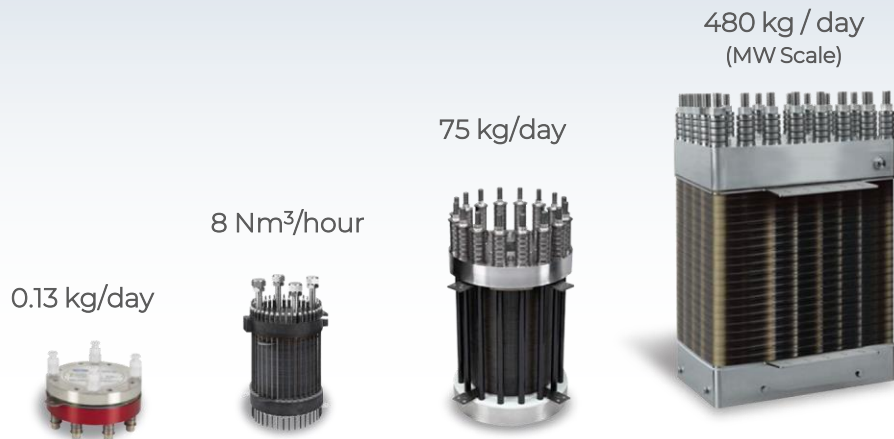
Technology comes from PEM development for advanced applications.

Navy
DARPA
NASA
Energy

Aerospace / Military Applications



Commercial / Industrial Applications



Enapter

For smaller demand Enapter's 2,5 kW electrolyser AEM module can be racked, scalable freely up to 100+ kW cluster system.



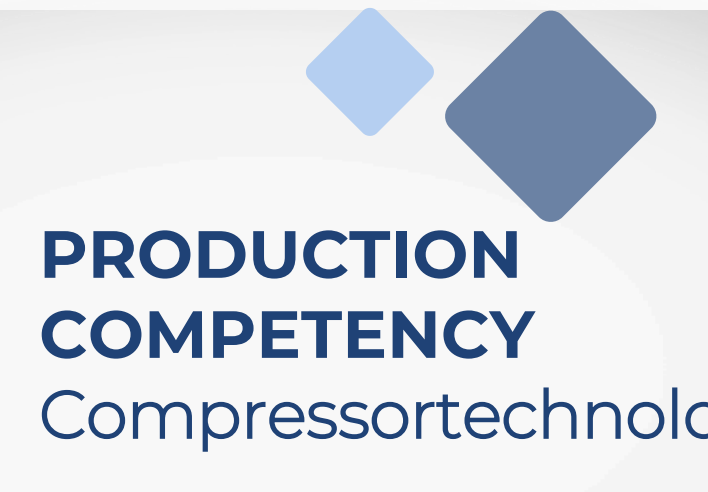
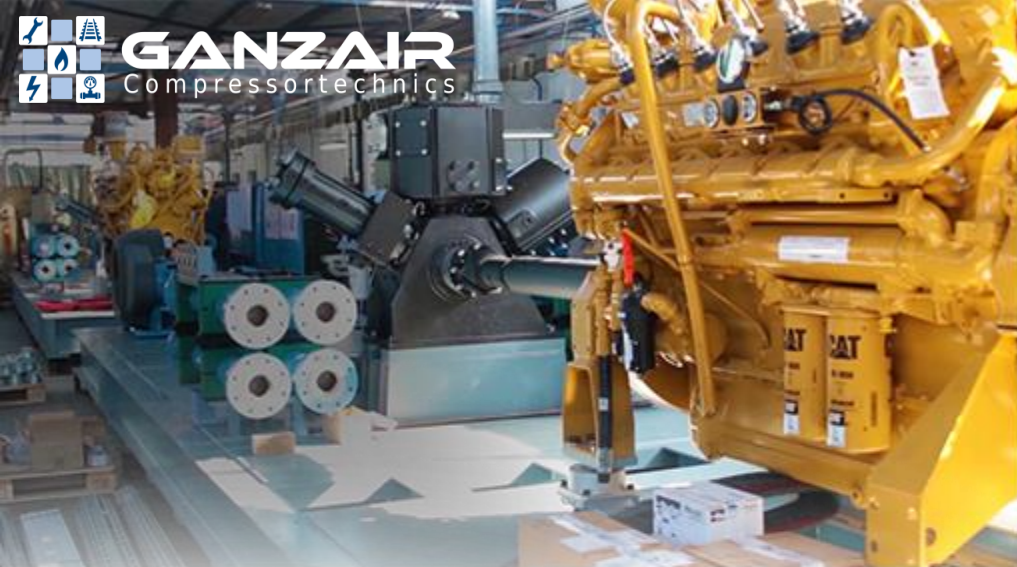
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Compressortechnics

Pressure Vessels Steel & Fibre Glass

Purpose-designed compressors and steel or composite storages to meet industry standards and customer requirements.

System integration and commissioning, onsite interconnecting, piping, cabling and wiring, IT integration with PMS, support authority approvals.





PRODUCTION COMPETENCY

Compressortechnology





PRODUCTION COMPETENCY

Compressortechnology



Our vision

OVER TIME, OUR GOAL IS TO SUPPORT THE
DEVELOPMENT OF THE DOMESTIC AND REGIONAL
HYDROGEN INDUSTRIES WITH A PRODUCTION BASE.



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... To make the vision a reality



**gaining product
experience**



**capital requirements
and market size
challenges**



**state support and
involvement**



**R & D engineers
and projects in
synergy**



**collaboration and
an integrated
approach**



**marketing/
communication and PR**



GANZAIR
Compressortechnics



THANK YOU FOR YOUR ATTENTION!

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LET'S CONTINUE THE
CONVERSATION



/ganzairkompresszortechnika



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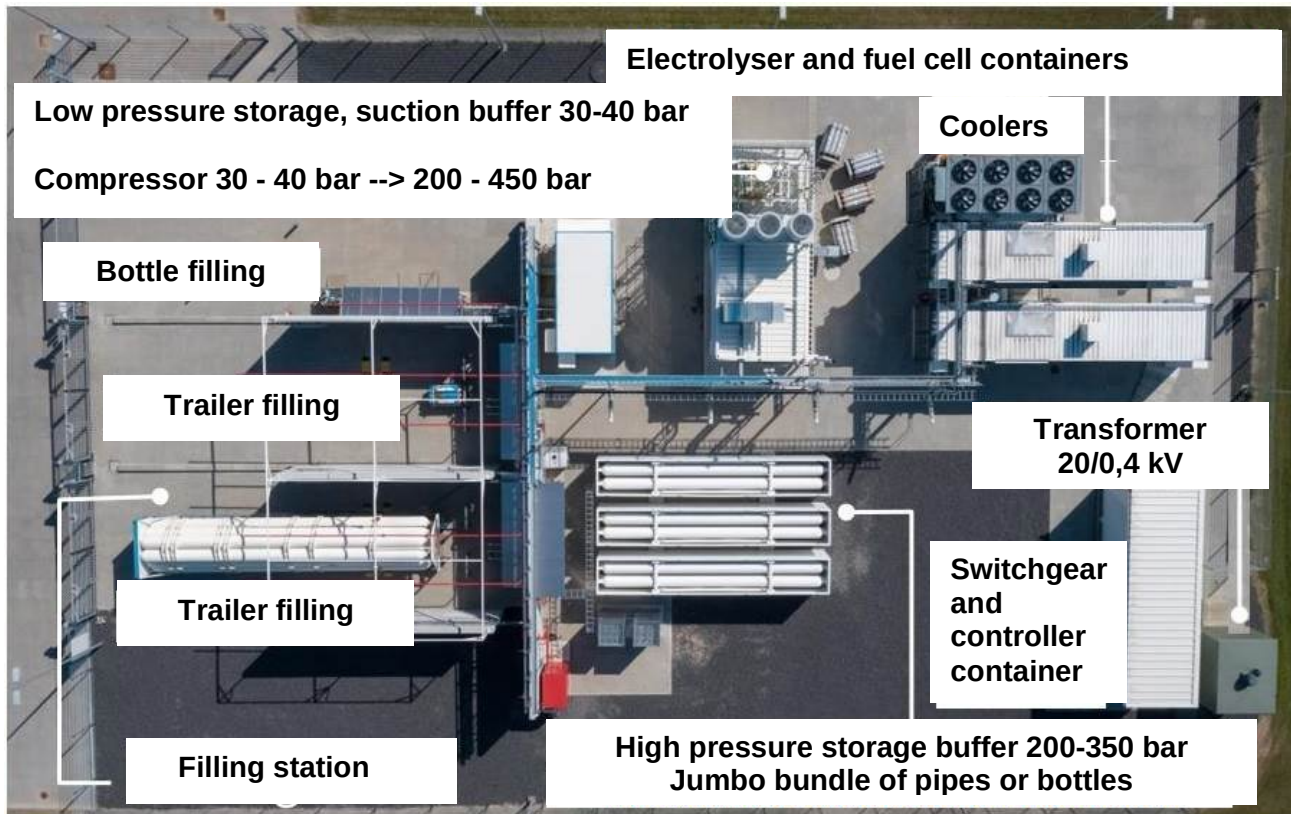
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HIGH PERFORMANCE HYDROGEN PRODUCTION, STORAGE, UTILIZATION SYSTEMS



*The picture represents a typical hydrogen system without a vehicle fuelling station
The offered system could be different in detail.*

9					
8					
7					
6					
5					
4					
3	2023/03/20	Update	T.T.	R.P.	L.I.
2	2022/04/20	Update and addition	T.T.	R.P.	L.I.
1	2021/12/29	Update and addition	T.T.	R.P.	L.I.
0	2021/02/17	Offer for information	T.T.	R.P.	L.I.
Rev.	Date	Title	Made	Checked	Approved

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Project name:	HIGH PERFORMANCE HYDROGEN PRODUCER AND UTILISATION SYSTEMS			Rev.: 3
Date :	2023-03-27			 GANZAIR Gázkompreszorok

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1 INTRODUCTION

The equipment offered by us, individually or built in a complete system and connected to the electricity system provides:

- producing, filtrating, and drying hydrogen,
- compressing regarding the technology's demand,
- storage of the produced hydrogen,
- transferring the produced hydrogen to bottles, bundles of bottles, and trailers
- forklift, personal transfer, truck, bus fuelling station
- Electricity production from hydrogen by fuel cells

Systems below 5 MW can be built modular from 1 MW container electrolyser units, in case of higher power requirements; it is possible to build from 5 and 10 MW modules or to combine all these. On request, it is uniquely sized and arranged, e.g. can be placed in buildings; however, the modular construction of the compact base units provides flexible scalability depending on the available feed energy, storage capacity, and hydrogen consumption in a cost-effective manner due to serial production. In addition, during maintenance periods and in the event of a module failure the system can continue to operate at partial capacity. Modularity also facilitates installation logistics in terms of space requirements, road transportability, relocation, ease of foundation, craning, etc. The 1 MW electrolysis modules include a 40-foot standard container floor area, a complete unit main transformer, a conditioning rectifier, water treatment, single-column water splitting stack, gas treatment, process cooling, a purge, and an inerting system with its own PLC controller. Likewise, the fuel cell blocks are built into a container and can be combined from modules of different capacities.



Layout of a 1 MW electrolyser unit

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Layout of a typical 5 MW electrolyser unit



Layout of a typical 10 MW electrolyser unit

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The medium-low power supply transformer, which is fitted to the electrolyser rectifier unit to power the electrolysis columns, is included in the unit. The auxiliary transformer must be selected on a project-by-project basis to power the auxiliary process equipment - gas dryer, coolers, pumps, fans - taking into account the hydrogen booster compressor and other smaller consumers e.g. instrument air compressor, nitrogen generator, etc. power requirements if required for the project.

The capacity of the compressors and the volume of the tanks can be selected virtually stepless according to the gas production of one or more electrolysis modules and the amount of gas to be stored. Optional compressor unit with capacity per module or multi-module can be used. Standard units for 200 or 400 Nm³ / h hydrogen compressors for electrolyzing gas production and high-pressure storage can be selected with their own PLC control unit. For larger capacities, a custom compressor solution is available.

The storage facilities are in containers to be transportable. Smaller-capacity storage facilities are the so-called standard industrial gas cylinders, which are common in gas industry practice. Larger containers have a traditional containerized steel bottle or so-called Jumbo pipes; it can be made of steel pipe or composite material. Hydrogen storage is typically at a nominal pressure of 200, 300, or 350, in special cases 450 bar. If a smaller amount of hydrogen storing is required, a tank with a pressure rating of 40 bar at the outlet of the electrolyser will suffice.

Bottle and trailer filling systems can be selected with a manual, semi-automatic or automatic solution.

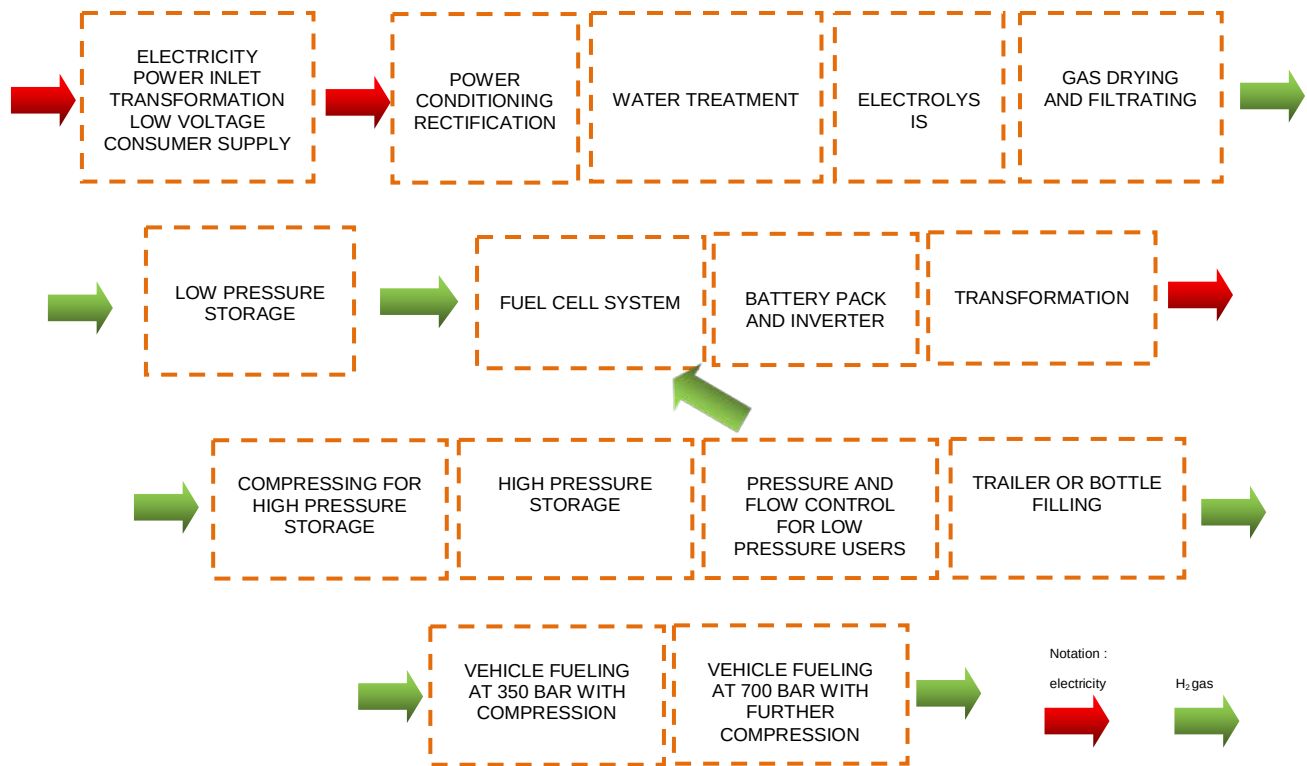
The size and pressure rating of the hydrogen refuelling stations can be selected for the type and number of forklifts, light or heavy vehicles to be refuelled per day; with backup storage units of various sizes, local electrolyser or refill hydrogen supply. The design depends to a large extent on the number of vehicles to be loaded simultaneously and each after each (back-to-back), the size and pressure of the hydrogen tank, the distribution within the day, the filling time required, etc. Fuelling stations can be selected in 350 or 700 bar or a combination of these; they can also have their own compressor unit and storage capacity.

For the auxiliary plant, we can also supply the auxiliary plant container containing the electrical supply and switching system serving as well as the control technical elements, and, if necessary, the instrument air and nitrogen production units required for the operation.

CE certification of the entire system units according to the relevant directives and legislation. Main directives and regulations used: Pressure systems PED 2014/68 / EU, Equipment used in potentially explosive atmospheres ATEX 2014/34 / EU, Safety of machines MDR2006 / 42 / EC, Low voltage equipment LV 2014/35 / EU.

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2 THE MAIN PARTS OF THE OFFERED SYSTEM



- Power supply system, transformation for rectification, low-voltage AC auxiliary system consumers and compressors, fuelling station
- Electricity condensation and rectification for electrolysis
- Water treatment system
- Cells for electrolysis
- Hydrogen and oxygen treating, water separator, hydrogen dryer and filtrate, gas cooler, bleed valve, inerting system
- Storage at small pressure
- Fuel cell, battery pack, inverter, and power outlet system
- Hydrogen compressors
- Storage at high pressure
- Pressure and flow control for small pressure users, optionally bypassing the high-pressure part system depending on pressure conditions
- Trailer, Bottle, a bundle of bottles filling optionally by pouring from the high-pressure tank depending on the pressure conditions
- Fuelling at 350 bar (bus, truck) optionally by pouring from the trailer, bundle of bottles, or direct from the producing tank
- Fuelling at 700 bar personal vehicles and trucks optionally by pouring from the trailer, bundle of bottles, or direct from the producing tank
- Control technology for the electricity, electrolyser cells, fuel cells, auxiliary systems and for the compressors and storages, filling systems, interface to the top-level supervisory management system

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3 TECHNICAL DESCRIPTION

3.1 ELECTRICITY POWER SUPPLY, TRANSFORMATION, LOW VOLTAGE CONSUMER SUPPLY

Transformers depending on local conditions:

Auxiliary container for power supply of low voltage consumers, controls, compressors, lighting, ventilation, heating, air conditioning, instrumentation, pumps, other e.g. instrument air, and nitrogen auxiliary plants, uninterruptible power supply, etc. according to configuration.

3.2 ELECTROLYSER SYSTEM

The properties of the 1 MW unit are given, and the characteristic of the 5 and 10 MW are the multiple of this system.

Main technical details

Nominal size MW	1
Capacity H2 Nm3/h	200
Environmental temperature	-20 °C..+40 °C
Controllability	10..100 %
Produced pressure	1 - 40 barg
Quality of produced hydrogen with dryer*	99,999 % H2
Design energy consumption under reference conditions	5,2 kWh/Nm3
Cold start / Warm start time	max 5 min / 10 sec - max 60 sec

* without dryer 99,9 - 99,95%

The 99.97% requirement in International SAE J2719-1 and ISO 14687: 2019 for fuel cells corresponds to a maximum pollutant content of 300 ppm.

3.2.1 ELECTRICITY CONDITIONING, RECTIFICATION

To produce hydrogen, electricity is supplied to the cells running on the Proton Exchange Membrane (PEM) technology by transformation from the incoming voltage. The rectifier and conditioning unit provides the controllable DC voltage required to operate the cells from the supply.

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3.2.2 WATER TREATMENT

To produce the high-purity water needed to produce hydrogen, the system includes an automatic water treatment system that produces deionised water for electrolysis, from the drinking water, and possibly from other water sources by filtering and ion exchanging. The contaminants filtered out of the feed water leave together with the rinsing water, which can be discharged into the sewer.

Water flows per unit with indicative value depending on the quality of the incoming water as follows:

Nominal size	MW	1
Amount of feed water,	kg/h	250-500 depending on the inlet quality
Pressure	barg	2-4
Rinsing water contaminants	-	identical to its feedwater, enriched in proportion to mass flows

3.2.3 ELECTROLYSIS WITH ELECTROLYSERS



The electrolyser can produce hydrogen at 40 barg instead of the typical 30 bar, and because of this a higher suction pressure can be applied, decreasing with this the size of the compressor and its energy consumption.

The low pressure (max 40 bar) hydrogen is produced by the electrolysis of treated water in Proton Exchange Membrane (PEM) cells, which are assembled in a stack. In the 5 MW system, there are 5 stacks and in the 10 MW system, there are 10 stacks.

One stack, according to the hydrogen demand, uses more cells, its nominal data can be found below in the table. During the project, because of the technical development, the data might be changed, but these changes do not affect the total system's performance in a negative direction.

Technical design data of the 1 MW stack

Hydrogen production nominal	Nm ³ /h	200
Oxygen production	Nm ³ /h	100
Operating pressure	barg	40
Voltage	VDC	310
Nominal energy demand	kW	1000

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Stack size	mm W-L-H	813-1066-1736
Efficiency	%	max. 88,4
Expected lifetime	hour	80 000

3.2.4 HYDROGEN AND OXYGEN TREATING SYSTEM

The hydrogen produced in the cells is treated in a water separation, filtration, and drying system to produce a gas with a purity of 99.999%, which exceeds the 99.97% requirement of SAE J2719-1 and ISO 14687: 2019 for fuel cells, which is 300 ppm corresponds to a maximum contaminant content. It also meets the purity requirements for high-purity industrial gas, which is class 4.5 in the US and 5.0 in Europe, meaning gas purity of 99.995 and 99.999%, respectively. A closed-circuit water cooler and water/gas heat exchangers are installed to cool the produced gas.

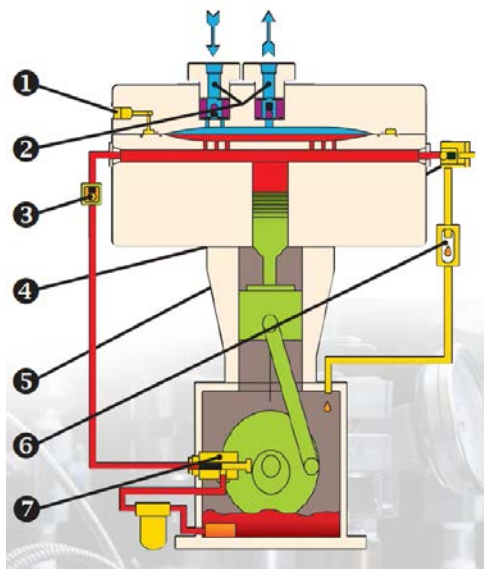
Oxygen and water vapour are produced as by-products. The by-product is provided with oxygen and a vent connection for the removal of hydrogen, hydrogen-contaminated inert gas during shutdown.

3.3 COMPRESSOR

Depending on the amount of gas and the need for controllability, the high-purity hydrogen produced in the low-pressure 40 bar hydrogen system is usually boosted in a 2-stage hydraulically operated diaphragm or piston compressor booster unit.

3.3.1 DIAPHRAGM COMPRESSOR UNITS

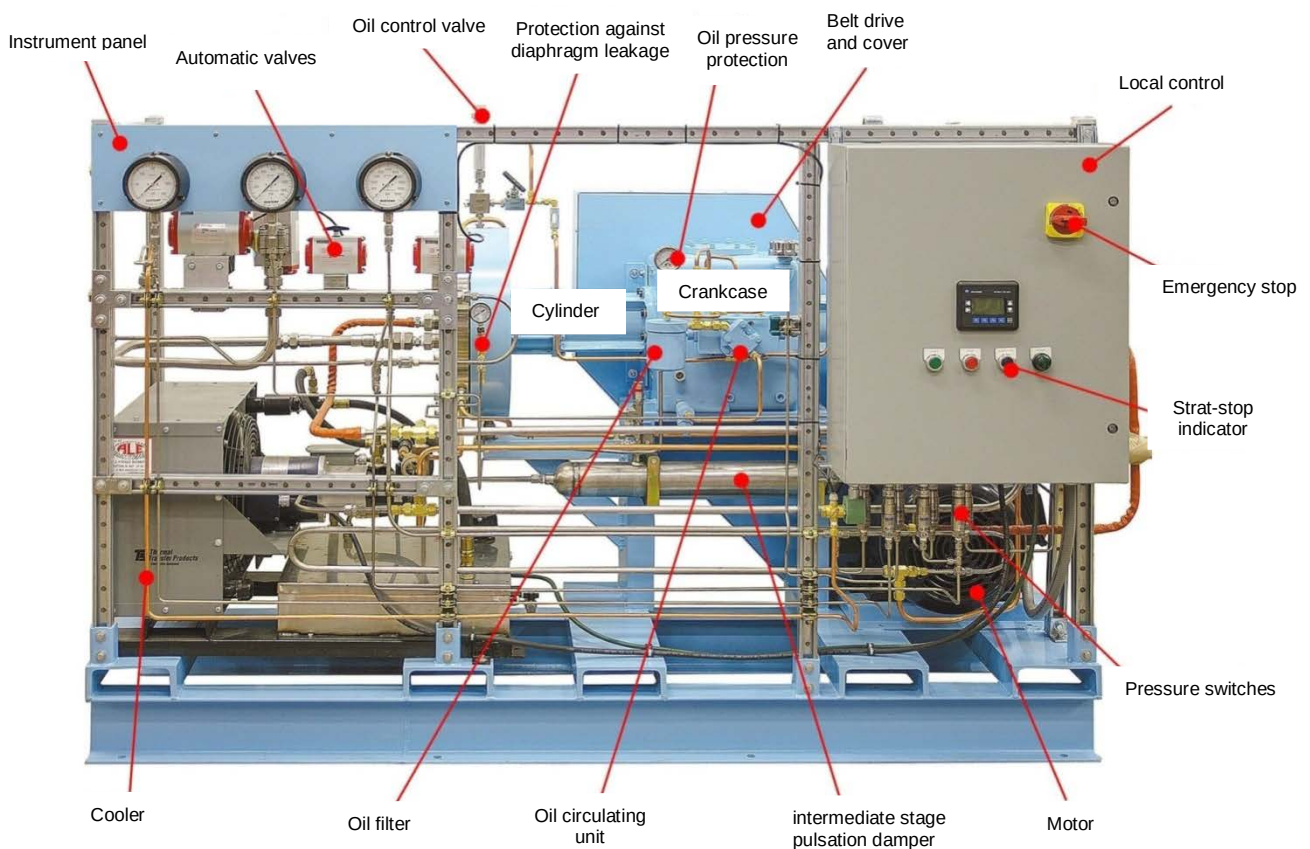
Diaphragm compressors compress the gas with an alternating-motion steel membrane. The diaphragm is driven by a crank-actuated, cross-headed oil pump at a suction and compression rate.



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The main technical data of the diaphragm compressor.

Design suction pressure	barg	30
Suction pressure range	barg	20-40
Design discharge pressure	barg	200 – 400 (700)
Flowrate	Nm ³ /h	200 - 400
Suction temperature	°C	40
Number of stages	#	2
Performance of the motor	kW	55 - 110
Compressor RPM	1/min	497
Axle performance	kW	30 - 75
ATEX Zone		Zone 2



The compressor unit is built into a frame, with complete piping, instrumentation, and control cabling. The unit is shipped after a factory function test. The autonomous operation of the compressor is ensured by the suction and discharge pressure switches.

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It is advisable to place the compressor in the open air because this means that explosion protection solutions are more economical due to the natural ventilation. The unit can be tempered with oil heating for winter operation.

The main parts of the diaphragm compressor system:

Mechanical / Main process:

- Compressor (crankcase and cylinders)
- Main flywheel and bearings
- Hydraulic system:
 - o Deaerator and oil injector pump
 - o Oil pressure control valve
 - o Pressure switches and manometer
 - o Oil cooler
- Intermediate stage pulsation damper
- Incoming filter before each stage and pressure transmitter to check for plugging
- Insulation in case of high-temperature pipe (if necessary)
- Automatic relief system (reduces pressure on diaphragms at idle to 4-5 bar before filling with oxygen)

Contaminant free operation - diaphragm leak monitoring system (per cylinder)

- Pressure switch
- Closing and non-returning valves

Drive

- Closed, self-cooling electric motor
- Antistatic, oil-resistant V-belt system
- Non-sparking protective cover on the V-belt drive

Motor starters, frequency converter installed in a safe place (MCC)

Performance: scaled to the required torque requirement

Manufacturer: Siemens, or technically similar

Controls

- Automatic operation monitoring system (suction and discharge pressure monitoring)
- Automatic emergency system: pressure, temperature, and flow switches
- The PLC has to be placed outside the zone (safe area)
- Status display on PLC: Under electric voltage, Stop, Running Signal, Standby, Warning, etc.
- Buttons: Start, Stop, Unload, Emergency Stop

Built-in cooling system

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- Piping
- Intermediate and aftercooler
- Flow switch and gauge
- Pressure relief valves
- Cooling system shut-off assembly

Instrumentation / Safety features

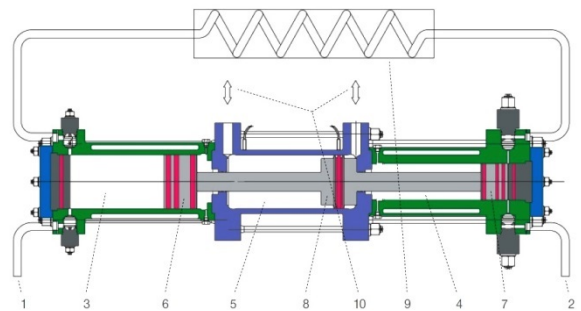
- Pressure gauges (suction, discharge, intermediate)
- Suction pressure transmitter
- Safety discharge pressure transmitter (For start and stop pressure values (P_d-L , P_d-H))
- Discharge pressure switch (P_d-HH)
- Pressure transmitter for all inlet filters (for plugging indication)
- Bleed valves (suction, discharge, intermediate)

Surface temperature monitoring

- RTD on crankcase
- RTD on pressure side after aftercooler
- RTD on the suction and discharge side (before the cooler) on each cylinder where the temperature can reach 160 °C

3.3.2 HYDRAULIC COMPRESSOR UNITS

Hydraulically driven reciprocating compressors compress gas with double-acting gas compressor cylinders driven by a hydraulic cylinder driven by a hydraulic power supply.



The hydraulic compressor unit's main technical data.

Design suction pressure	barg	30			
Suction/discharge pressure	barg	3,45 – 350 / max 1000			
Design discharge pressure	barg	200	350	200	350
Flowrate	Nm ³ /h	200		400	

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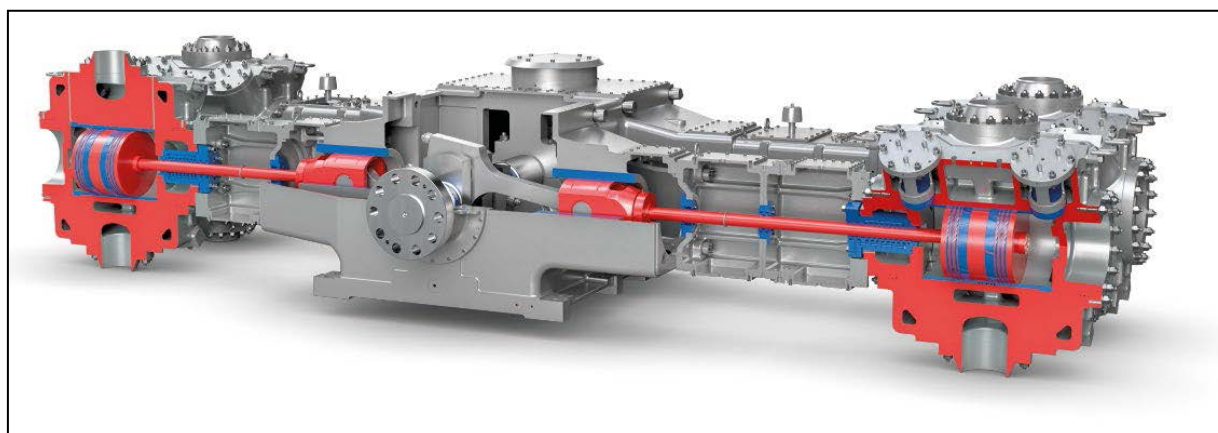
Suction pressure	C°	40			
Number of hydraulic/gas cylinders	#	2/4		4/8	
Number of stages	#	2			
Engine size for hydraulics	kW	74	90	120	180
Compressor cycle number	1/min	16		16	
Shaft power peak / operating	kW	56/38	78/54	110/78	155/110

The main components of a hydraulic compressor system:

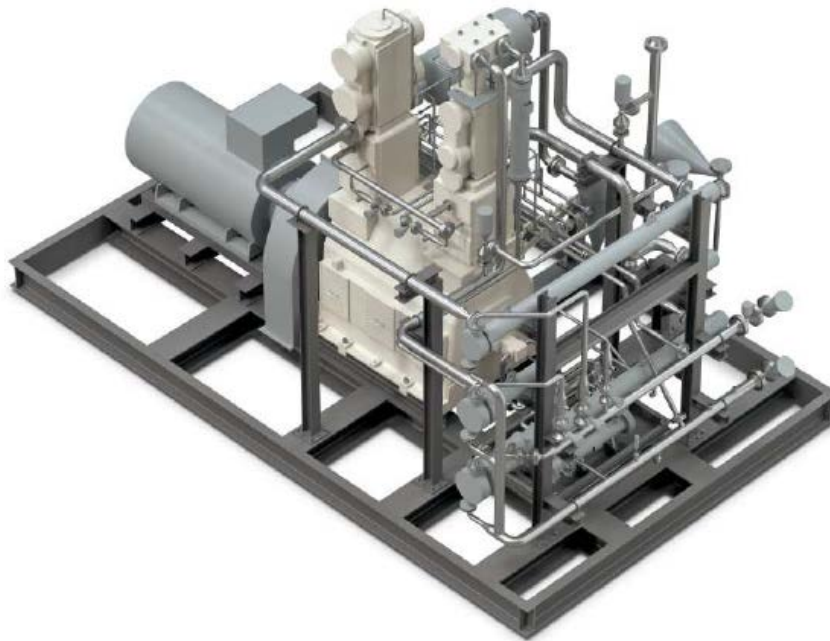
- Gas side connections
- Inlet and outlet gas filters
- Automatic inlet and outlet gas valve, non-return valve bleed valve, safety valves
- Inlet and outlet pressure measurement, temperature measurement, and transmitters
- Gas, water, and oil coolers
- Complete gas and hydraulic piping
- Hydraulic power supply
- PLC, automatic operation monitoring system (suction and discharge pressure monitoring)
- Automatic emergency system: pressure, temperature, and flow switches
- Status display on PLC: Under electrical voltage, Stop, Run, Standby, Warning, etc.
- Buttons: Start, Stop, Unload, Emergency Stop

3.3.3 CROSS HEAD PISTON COMPRESSOR UNITS

For larger gas flowrates above 800-1000 Nm³ / h, a cross-piston machine may be preferable to diaphragm and hydraulic compressors due to their size limitation, no technical data is given because it requires individual sizing.



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4 SUCTION BUFFER BEFORE COMPRESSOR AFTER ELECTROLYSER

The primary purpose of the vessel is to make the coordination of the electrolyser, the compressor gas supply, and the consumption more flexible and easier to control, thus increasing the service life and safety. Respectively, low-pressure hydrogen consumers, e.g. a fuel cell can also be fed directly from this buffer. The volume of the vessel is recommended to be 2-5 m³ per MW, and the design pressure is 40 barg, which has a buffer capacity of 80-200 Nm³ at 40 bar. Optionally expandable, which increases flexibility. In the case without compression, this low-pressure tank can be sufficient to store the hydrogen, and the volume can be increased in one vessel of e.g. 250 m³ and can be multiplied as desired.

5 DISCHARGE SIDE HIGH PRESSURE BUFFER SYSTEM

The buffer system ensures the operation of the electrolyser even in the absence of hydrogen consumption, thus increasing the utilisation of the hydrogen production system.

The buffer system can be made of standard steel bottle bundles, bundles in any number or so-called Jumbo steel tube tanks, composite bottles, or tube tanks. The cost of the composite solution is higher than the steel bottle system, but the self-weight / storable hydrogen ratio is significantly better, which is especially important for mobile versions but also affects the design of the foundation. Some container-sized constructions can be stacked with limited available space.

The pressure level can be from 200 barg to 350 (450) barg normally, less often 500 barg. 200 barg steel bottle systems are the most common and cheapest. Their disadvantage is that a compressor may be required for decomposition or a compressor connected to a hydrogen generator may be used for decomposition, which complicates the operation of the system. In the case of the 250-450 bar system, the decomposition can be solved by free flow into the more conventional 200 bar bottles and trailers on the principle of differential pressure.

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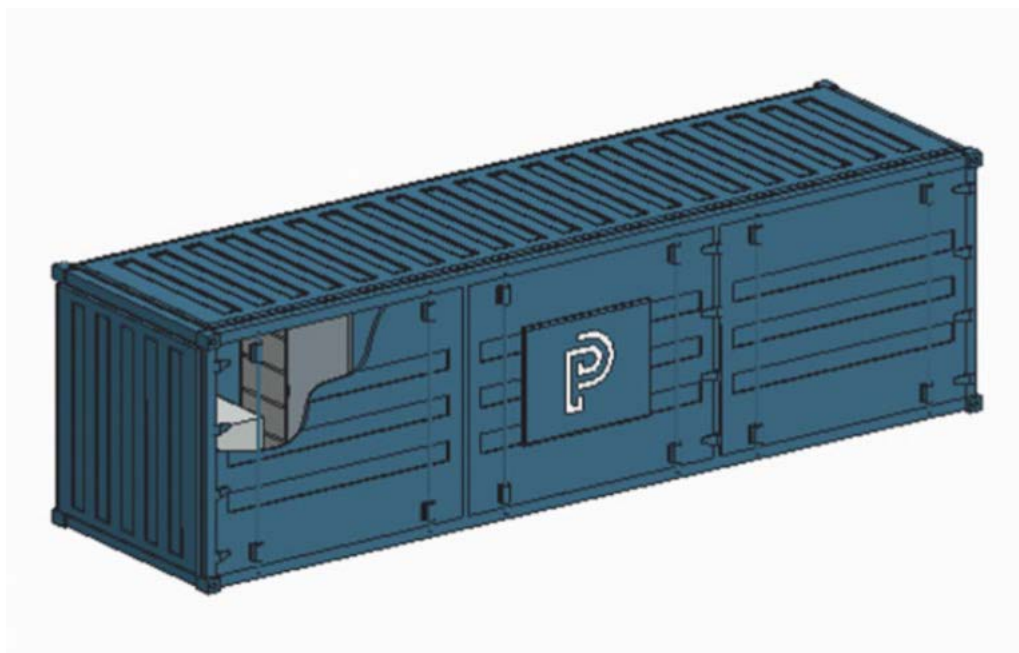
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6 FUEL CELL UNITS

The units, like the electrolyzers, are built into a container ready for quick connection to the hydrogen and electrical system. The container is equipped with a cooling system, lighting, ventilation, etc. Larger units require custom design. Modularity and scalability can be used to adapt to load characteristics over time.

Main technical properties of the fuel cell units

Size kW	250	500	1000
Reaction time variants	10 sec, 60 sec		
Efficiency	>45%		
Load performance factor	up to 0.95 capacitive, up to 0.8 inductive		
Output voltage (VAC)	400 VAC 3 phase, 50Hz		
Voltage maintenance	At even load: +/- 0.25%		
Frequency (Hz)	50 Hz +/- 0.2 Hz		
At THD nominal voltage	<2% 100% under linear load		
Overload capacity at 25 ° C	110% 1 min		
Sizes	20' ISO container	30' ISO container	40' ISO container
Location	outside		
Environmental temperature	-30°C ÷ 50°C – equipped with a cooler		
Humidity	0 ÷ 95% non-condensing		
Noise level	<65 dBA @ 15 m		
Other	Interior lighting, sockets		
Communication: Modbus, TCP over Ethernet & CAN, dry contact alarms			



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7 GAS DISTRIBUTION SYSTEMS

The distribution can be manual, fully human-assisted, semi-automatic or automatic, palletized, or individual bottle. Custom design required. Trailer, container filling systems are available, too.



8 FUELLING STATIONS

The design of fuelling stations depends to a large extent on the type of vehicles served, the expected number and distribution of daily charges, the need for parallel refuelling, local hydrogen production or gas supply, local storage capacity, and refuelling billing, etc. Consideration of the nature of production/gas supply and consumption is required to select the optimal, cost-effective solution. The following is an example of typical station data. The picture is just indicative.



Typical 700 bar system for light duty vehicles	L100	L200	L400
Capacity kg/day	100 kg	200 kg	400 kg
Loading capacity/day maximum	20	40	75
Loading head number	1	1	2
Loading without waiting	0	1	1
The number of vehicles that can be served is	100	400	800

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350 bar for heavy duty vehicles

Geno B1200

Capacity kg/day	1,200 kg
Maximum hourly capacity	200 Kg
Charging capacity of a vehicle	24 kg
Loading head number	2
Loading without waiting, 24 kg/vehicle	2

9 CONTROL TECHNOLOGY

The active components of the system, such as the electrolyser, the fuel cell, and the compressor, have independent control, regulation, and protection as standard, and can operate safely based on their own input, internal, and output parameters. It is expedient and feasible to build an over-control, monitoring DCS system, which combines these, communicates with the electrolyser and the compressor's own controller, monitors and collects the technical parameters of the entire system by remote sensing, the systems can be intervened, started and stopped from a central location.

10 TYPICAL DOCUMENTATION

- Mechanical, electrical, instrumental D-design documentation
- Operating and maintenance manuals
- CE, PED, ATEX documentation of used devices

11 NOT INCLUDED IN THE SCOPE OF DELIVERY

Contract dependent but typically:

- Official approval
- Architectural plans and works, foundation, underlayment
- Piping, cabling, hoses, cable trays, brackets, and wiring outside the units, except between units if contracted
- Grounding system, lightning protection, lightings
- Ladders, platforms, railings, etc. according to individual needs

12 INDICATIVE COSTS

Unit	Target prices without installation	Note
Electrolyser system 1 MW	1 400 -1 900 eEUR	It depends mainly on the magnitude of gas purification and installation conditions
Electrolyser system 5 MW	4 600 – 6 400 eEUR	For larger systems 900 - 1000 eEUR / MW
Diaphragm compressor 200-400 m3/h	500 – 800 eEUR	Depends on control mode, automation, instrumentation, and ATEX protection mode
Hydraulic compressor 200 -400 m3/h	450 – 700 eEUR	Depends on gas delivery, i.e.

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		number of cylinders, control mode, automation, instrumentation, ATEX protection mode
Crank cross head compressor > 600 m3/h	800 – 2 000 eEUR	It requires individual sizing and design
Low pressure storage	kb 20-25 eEUR/m3 volume	Larger volumes are specifically cheaper. Due to custom manufacturing, it is more expensive than the bottle solution.
High-pressure steel bottle storage, in 20 feet ISO container 200 – 300 - 350 barg	6 - 8 eEUR/m3	Cheapest due to mass production but highest self-weight useful volume ratio, Stackable
High-pressure storage from composite bottle or tube container bundle in 20 or 40 feet container, 200 – 350 – 450 barg	10 -18 eEUR/m3	Larger volumes are specifically cheaper. Best self-weight useful volume ratio. Stackable. Can be transported by road.
High-pressure Jumbo storage. in 40 feet ISO container. Max 200 barg.	6-10 eEUR/m3	Depending on the manufacturer's source and size, China, India, Dubai, and Italy. The 40 feet total bundle has a self-weight of 40 tons, so it can only be transported on the road by a special vehicle.
Fuel cell with inverter	1 400 – 2 100 eEUR/MW	Series with 100 kWh / MW battery capacity.
Gas producer system	individual 20 – 200 eEUR	From individual bottle manual filling to automatic batch filling.
Fuelling stations 20- 100 – 200 – 400 -1200 kg/day	400 - 1 400 -1 700 – 2 600 – 8 000 eEUR	It depends to a large extent on the design, such as a small vehicle or heavy vehicle, local storage size, number of filling heads, billing method, etc.
Control technology	50 – 100 eEUR-	Planning is required

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