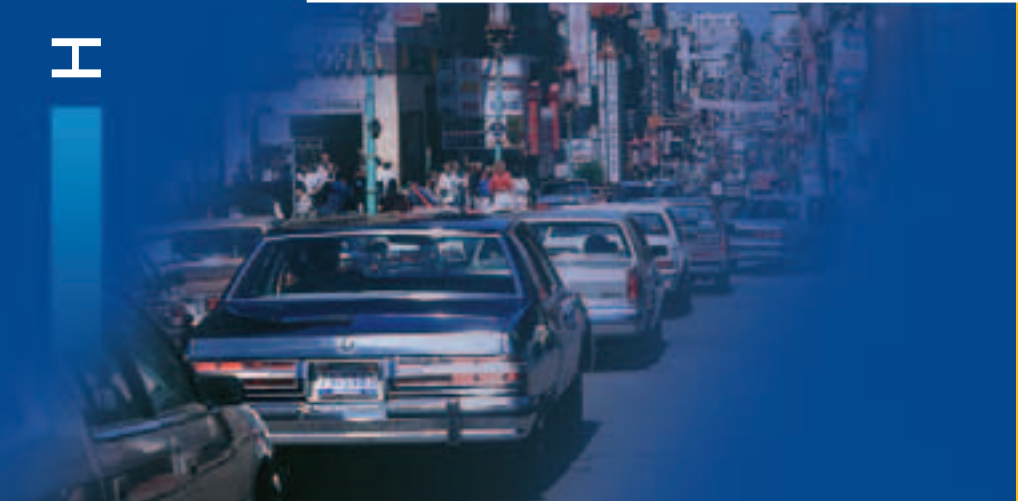




HYDRO ELECTROLYSERS



Hydrogen starts with ...



Safe, reliable and energy efficient



Through 75 years of continuous development, our electrolysers today have a simple and proven design, ensuring safe and reliable operation with a minimum of maintenance. Internal gas and lye flow ducts prevent hazardous spillage and leakage. Due to our unique catalytic cell coating, energy consumption is significantly lower than that of other commercially available electrolysers.

Safe construction

Our proven technology with its simple and unique design secures safe and reliable operation of our atmospheric electrolysers. Hazard free, optimal operation and favourable maintenance conditions are achieved, due to a number of design features of our electrolysers:

- Internal gas and lye ducts as part of an integrated cell design eliminating the need for external piping to and from each cell.
- Our specially developed asbestos-free diaphragms
- Our asbestos-free T-shaped cell gaskets.

Our electrolysers satisfy stringent environmental and safety requirements and are constructed in accordance with EN regulations, CE labeling and CE directives.

Norsk Hydro Electrolysers sets the highest standards for safety. Our design philosophy ensures a safe, controlled plant shutdown in the event of equipment malfunction or operator error. Thus, our electrolysers are approved of and are operating on nuclear installations throughout the world.

Reliable operation

Our plants are designed for automatic, unattended and continuous operation. The standard plants are supplied complete with state of the art PLC-systems (Programmable Logic Controller) and instrumentation. They are certified and approved in accordance with international standards for hazardous area installations.

Our electrolyser design implies an automatic range in gas production volumes from 20% to 100% according to demand. Labour costs are reduced to a minimum and only routine shift inspections are required. The availability of our electrolyser plant is typically better than 98%.

Due to our proven technology and long experience, the intervals between overhauls are typically seven to ten years. The Norsk Hydro electrolyser represents the ultimate design in this respect. A general cell overhaul for our largest

The term «atmospheric» means that the hydrogen and oxygen gas generation takes place in the electrolyser at a very low pressure, normally between 0,02 bar(g) and 0,05 bar(g). Illustrated: Hydrogen electrolyser unit producing 135 Nm³/h.





The atmospheric series electrolysers are competitively offered where hydrogen production volumes above 50 Nm³/h are required. Our largest single skid mounted electrolyser unit has a production capacity of 485 Nm³/h. Larger volumes are produced by simply adding more cells or additional units.

units requires only 3 to 5 days down time.

Cost efficient and economic electrolyser systems

Our bipolar, electrolyser cell design provides you with a compact, fully integrated operating unit. Even our largest units generating 485 Nm³/h hydrogen require only 4 x 13.5 meters when mounted on a skid frame, including room for service and maintenance.

The low energy consumption of 4.1 kWh/Nm³ hydrogen is achieved with our own developed catalytic coating. Consequently, the specific energy consumption is reduced by up to 20% compared to other electrolysers currently available – a significant factor considering that 80% to 90% of the

total operating expenses of large electrolysers are energy costs.

Due to the flexible design of our electrolysers, we are able to supply plants pre-designed for simple future expansion or if required, down sizing. With changing market demands our electrolysers offer a cost effective solution.

We offer a complete pre-assembled hydrogen plant with various standardized modules that all fit together. According to your specifications, we can deliver the capacity, pressure, purity and storage or distribution facilities to meet your needs. This, together with our aftersales service scheme, provides you with a cost beneficial solution.

Capacity:	50–485 Nm ³ /h
Energy consumption:	4.1 ± 0.1 kWh/Nm ³
Purity:	
	<i>Hydrogen directly from electrolyser: 99.9 ± 0.1%</i>
	<i>Oxygen directly from electrolyser: 99.8 ± 0.5%</i>
	<i>After purification: 99.9998%</i>

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Electrolysers offer an immediate solution to your hydrogen fuel demand

The necessary infrastructure for the new hydrogen driven vehicles is easily built up step by step using electrolysers from Hydro. They are compact and need only water and electricity to produce hydrogen. The fuelling of vehicles will be as convenient as with petrol and diesel.

Electrolysers paving the way for hydrogen infrastructure

New solutions for fuel supply are required for the introduction of hydrogen fuel cell vehicles. The absence of pipelines and other

infrastructure solutions from other fuels is no obstacle to using hydrogen today.

We can deliver efficient electrolyser based fuelling stations producing hydrogen locally to

supply hydrogen just as convenient as fuelling today's gasoline and diesel vehicles.

All you need is water and electricity

Compact electrolysers from Hydro need only water and electricity to produce hydrogen locally at required pressures and volumes. Our electrolysers offer a feasible solution for on-site generation.

Characteristics that make our electrolysers world leading

With Hydro's electrolysers you get a complete, reliable hydrogen facility, installed and ready to operate. With our modular design, you are assured simple and fast installation, as well as minimal and rapid main-

Making local hydrogen production possible: Our energy-efficient, reliable and compact electrolysers reflect Hydro's 75-years of experience within electrolyser technology and hydrogen use. The units can be installed quickly and satisfy stringent environmental and safety requirements.

(Photo: Mediafoto as)





Already available: Hydro can deliver complete electrolyser based hydrogen fuelling stations. Until the market for hydrogen vehicles is large enough for central hydrogen production to be profitable, local hydrogen production with electrolysers is a good infrastructure solution.

tenance. The design also makes it possible to adapt to your different needs – whether it's capacity, pressure or gas quality.

Hydro's electrolysers are:

- Space-efficient – due to a compact, bi-polar cell design.
- Energy-efficient – with an energy consumption rate from 4.1 kWh/Nm³ hydrogen.
- Asbestos-free and leak proof – satisfying high safety and environmental requirements.
- Constructed in accordance with EN regulations, CE labelling and CE directives.

What is an electrolyser?

An electrolyser is an apparatus producing hydrogen and oxygen gas by splitting water molecules. These gases are produced when an electric current flows through an electrolyte from an anode to a cathode. The electrolyte is water mixed with a substance to optimise electrical conductivity.

The produced hydrogen and oxygen gases are separated, purified, compressed and stored in gas bottle battery banks or storage vessels.

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Safe, compact and durable

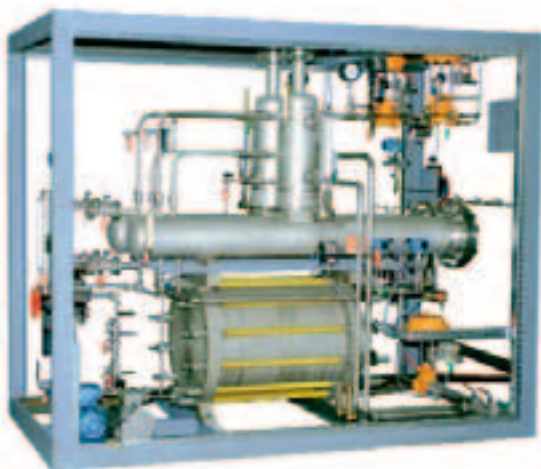
The HPE series (High Pressure Electrolysers) retain the same safe and verified technology as all our electrolysers. They are compact and are assembled on a single skid. The proven design of our electrolysers' internal gas and lye flow ducts prevents hazardous spillage and leakage. The electrolysers are full load tested at our works before shipment. The robust design and choice of material provide a long-life, durable system.

Safe construction

The High Pressure Electrolyser retains the proven technology and simple design that ensures safe and reliable operation – common to all our electrolysers. The gas and lye ducts are formed internally as part of the integrated bipolar cell design

and provide hazard-free, optimal operation and favourable maintenance conditions. Our electrolysers satisfy stringent environmental and safety requirements and are constructed in accordance with EN regulations, CE labelling and CE directives.

Norsk Hydro Electrolysers set the highest standards for safety. Our design philosophy ensures a safe and controlled plant shutdown in the event of operator error or equipment malfunction. Thus, our electrolysers are approved for and operate in nuclear installations throughout the world.



*The term «pressurized» means that the hydrogen (and oxygen) gas generated by the electrolyser is at pressure, normally 15 bar(g).
Illustrated: 10 Nm³/h HPE unit.*

Compact assembly

The electrolyser plant, complete with automatic control, power supply and where required, gas purification equipment, is mounted and fully assembled on a single skid. Even the largest unit (65 Nm³/h hydrogen) can be installed on a skid with a footprint size similar to a standard 20 feet container. You need only utility supply, such as water, power and nitrogen gas, to start-up the electrolyser. Due to the easy hook-up and the compact design, the HPE electrolyser can easily be moved to another location.



The High Pressure Electrolyser (HPE) series electrolyzers are compact, durable and the best choice where volumes of hydrogen generation in ranges from 10 Nm³/h to 65 Nm³/h are required. Illustrated: 60 Nm³/h HPE unit.

The supply of complete systems usually enables us to conduct full functional tests of the equipment at maximum load before delivery. This pre-testing, together with optional container housing reduces on-site installation and start-up costs to a minimum.

Durable and long-life materials

Our choice of materials and surface treatment provides a durable and long-life cell package. We have specially developed asbestos-free diaphragms and gaskets. We use nickel electrodes and nickel plated cell frames and all the auxiliary equipment and piping material is stainless steel. Therefore, cell maintenance and lifetime costs are kept to a minimum.

Our plants are designed for automatic, unattended and continuous

operation. A remote control system is also an available option. The standard plants are supplied complete with state of the art programmable logic control (PLC) systems and instrumentation. They are certified and approved in accordance with international standards for hazardous area installations.

Our electrolyser design implies an automatic range in gas production volumes from 50% to 100% according to demand. Labour costs are reduced to a minimum and only routine shift inspections are required. The availability of our electrolyser plant is typically better than 98%.

Cost efficient and economic electrolyser systems

Our HPE series can be part of a complete and integrated hydrogen

production and gas handling system. In many cases a compressor is not required due to gas production at 15 bar (g) pressure. Due to the high inlet pressure, you can save on compressor purchase, when higher pressures are required. The HPE series with its compact design allows cost savings both in gas compression, gas storage and gas handling.

Capacity:	10-65 Nm ³ /h
Energy consumption:	4.8 ± 0.1 kWh/Nm ³
Purity:	
Hydrogen directly from electrolyser:	99.9 ± 0.1%
Oxygen directly from electrolyser:	99.8 ± 0.5%
After purification:	99.9998%

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NORSK HYDRO ELECTROLYSERS — A COMPANY IN HYDRO

Norsk Hydro Electrolysers — world leader in water electrolysis

Norsk Hydro Electrolysers AS (NHEL) is a world-leading supplier of water electrolysis equipment and complete hydrogen generation units for industrial applications, hydrogen fuelling stations and distributed energy systems. In addition to more than 300 units for internal Hydro applications, NHEL has supplied more than 170 hydrogen generation units throughout the world.

Norsk Hydro Electrolysers has been chosen by ABB as the most suitable company to offer the Oerlikon/BBC customers after sales and service support. We offer complete after sales support and modernisation consultation, to update these plants in accordance with today's technology.

NHEL is an independent limited company, fully owned by Norsk Hydro ASA. Norsk Hydro ASA [NYSE: NHY] established 1905 is a leading supplier of oil and energy, light metals and plant nutrition. Based in Norway the company is operating in more than 70 countries worldwide. More than 50,000 employees are exploring and producing energy, marketing energy or processing energy to light metals and plant nutrition.

NHEL is integrated into the Hydrogen Unit in the Energy sector of Norsk Hydro Oil and Energy. Hydro Energy is responsible for Hydro's commercial operations relating to Hydro's electricity, crude oil, gas and NGL



products. Hydro Energy is also responsible for Hydro's power production and refinery operations, in addition to the transport of oil and gas. With the hydrogen unit and Norsk Hydro Electrolysers a part of Hydro Energy, all commercial energy activities are gathered.

Sustainable conduct – responsibilities and areas of concentration

In our activities we are committed to making a contribution to sustainable conduct, and this includes running our operations within the limits of what nature can tolerate. Our concentration on the development and utilization of hydrogen as the energy carrier of the future is part of this conduct. We can see a huge potential in this area – in both environmental, societal and economic terms.

Hydrogen from water and electricity used in fuel cells offers a zero emission alternative when electricity is generated from renewable sources.

**The future belongs to those
who create real values**



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