EFFICIENT ELECTROLYSERS FOR HYDROGEN PRODUCTION
NEL Hydrogen’s main business activities are focused on water electrolyser technology. We have a proud history, and have been committed to the development and continual improvement of hydrogen plants right back to our foundation in 1927. Our nearly 90 years of experience in water electrolyser technology for hydrogen production is second to none. This equips us with the experience and competence to provide a promising future for our customers who wish to produce clean hydrogen at minimum life cycle cost.

WORLD CLASS ELECTROLYSERS

The NEL A-range of electrolysers – hydrogen plants based on water electrolyser technology with atmospheric pressure – is considered world class. The NEL A-range is well recognised for its robustness, reliability and energy efficiency. With these features our technology sets a benchmark for others to follow. Add flexibility, ease-of-use, high-capacity and safety to your list of essential criteria, and you will find that we provide a solution that is second to none.

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KEY MILESTONES

1927
Norsk Hydro started its electrolyser development and installation for large scale hydrogen production at its ammonia fertilizer plant in Rjukan, Norway.

1953
Norsk Hydro started up its second large scale electrolyser plant for supply of hydrogen to ammonia production in Glimsfjord, Northern Norway. Two plants with 30,000 Nm³/hour each are now in operation.

1974
Commercial sales of electrolysers started up through the establishment of the company Norsk Hydro Electrolysers (NHEL).

2003
NHEL delivered the world’s first hydrogen fuelling station open for public use in Reykjavik, Iceland.

2006 - 2007
NHEL is renamed Hydrogen Technologies in 2006. In 2007 Statoil acquired ownership of Hydrogen Technologies as a result of the merger of Statoil and Norsk Hydro’s Oil & Energy division.

2008
Hydrogen Technologies’ 500th electrolyser sold and delivered.

2011
Hydrogen Technologies is sold by Statoil to private owners and the company is renamed NEL Hydrogen.

2014
NEL Hydrogen listed on Oslo Stock Exchange.

Today we have rationalised our range and now offer three standard electrolyser models – NEL A•150 – NEL A•300 and NEL A•485. Different production capacity ranges, but similar exceptional technology, with following key benefits:

NEL A-150 | NEL A-300 | NEL A-485

RELIABLE H₂ SUPPLY

Independence - with our on-site electrolyser plant, you are in control of your own supply of hydrogen

Reliable production - the most proven and robust electrolyser technology available

Continuous production - non-stop automatic production for years with no need for maintenance shutdown (just cell stack replacement will be required after 8-10 years)

HIGH FLEXIBILITY

H₂ on-demand - quick start-up and shut-down of the plant allows hydrogen production to match demand

Operational range - automatically controlled production between 20 and 100% of the installed capacity

Upscale of capacity - our three models are pre-designed for future expansion of capacity

COST-EFFICIENT SOLUTION

Lowest operational costs - the efficiency in energy, labour and maintenance ensure the NEL A-range has the lowest operational electrolyser cost available

Energy efficient - the most energy efficient electrolyser on the market

Labour efficient - our advanced PLC control system ensures smooth, unattended automatic running of the plant

Maintenance efficient - maximum robustness ensures minimum maintenance
The process and the hydrogen plant

Electrolysis is the process of splitting water into hydrogen and oxygen using an electrical current. The inputs to this process are simply feed water and electrical power.

The NEL A-hydrogen plants are delivered as pre-assembled modules which are easily inter-connected on-site:

**Transformer / Rectifier**
The transformer and rectifier convert the AC high voltage supply into DC current input.

**Electrolyser**
The electrolyser is of the filter press construction with bipolar electrodes separated by non-asbestos diaphragms. Hydrogen is generated at the cathode and oxygen at the anode.

**Electrolyte System**
This module consists of two gas separators and the electrolyte recirculation system. The electrolyte is recovered in the separators, then cooled and recycled into the cell block.

**Scrubber**
The scrubber has 3 main functions:
- Remove residual traces of electrolyte
- Cool down the hydrogen
- Feed water reservoir

**Gas Holder**
The gas holder is a buffer tank installed between the electrolyser and the compressor or the process at site.

**Compressor**
If required, a compressor is installed to compress the gas from atmospheric pressure in the gas holder to the pressure required for the process or the storage vessel.

**Deoxidiser**
Hydrogen generated in the electrolyser is a very pure gas. It is saturated with water, and has an oxygen content of less than 0.2%. If higher purity is required, residual oxygen can be removed by catalytic reaction in a deoxidizer.

**Dryer**
The dryer will dry the gas to the suitable dew point. It consists of twin towers filled with a desiccant to absorb the water.

**Gas Storage**
The gas storage provides a back-up solution or ensures the hydrogen make-up for batch applications with uneven gas consumption.

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- Cool down the hydrogen
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NEL A - Technical Specifications

<table>
<thead>
<tr>
<th>Capacity / Nominal Flow Rate</th>
<th>Oral</th>
<th>Oral</th>
<th>Oral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity range (Nm³ H₂/hr) per unit</td>
<td>50 - 150</td>
<td>151 - 300</td>
<td>301 - 485</td>
</tr>
<tr>
<td>Production capacity dynamic range</td>
<td>20 - 100% of nominal flow rate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Energy (electrolyser cell stack)**
Typical power consumption (kWh/Nm³ H₂) 3.8 - 4.4

**Purity (measured on dry basis)**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂ purity (%)</td>
<td>99.9 ± 0.1</td>
</tr>
<tr>
<td>O₂ purity (%)</td>
<td>99.5 ± 0.2</td>
</tr>
<tr>
<td>After purification <strong>(1)</strong></td>
<td></td>
</tr>
<tr>
<td>O₂-content</td>
<td>&lt; 2 ppm v</td>
</tr>
<tr>
<td>H₂O-content</td>
<td>&lt; 2 ppm v</td>
</tr>
</tbody>
</table>

**Pressure**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂ outlet pressure after electrolyser</td>
<td>200 - 400 mm WG</td>
</tr>
<tr>
<td>H₂ outlet pressure after compressor <strong>(2)</strong></td>
<td>Max 250 bar g</td>
</tr>
</tbody>
</table>

**Operation**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>80°C</td>
</tr>
<tr>
<td>Electrolyte</td>
<td>25% KOH aqueous solution</td>
</tr>
<tr>
<td>Feed water consumption</td>
<td>0.9 litre / Nm³ H₂</td>
</tr>
</tbody>
</table>

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**Notes:**
1. Higher purities available on demand
2. Higher pressure available on demand
Industrias de Aceite Fino S.A.

Country: Bolivia  
Application: Edible Oils & Fats
Product: NEL A•300  
Capacity: 300 Nm³/hour
Installed: 2012

Industrias de Aceite Fino, part of the Romero Group from Peru, is a manufacturer of edible oils & fats, margarine and soap. In 2012 they modernised their hydrogen production by replacing five smaller electrolysers from various manufacturers with an overhauled NEL A•100 plant from NEL Hydrogen, that originally had been in operation at another factory in Peru.

“The refurbished electrolyser plant works perfect for us. It is very easy and safe in operation compared to what we were used to. In addition we have made savings in our energy costs with this electrolyser.”

Cesar Campoverde, Production Manager

Reliance Industries Ltd.

Country: India  
Application: Petrochemicals
Product: 2 x NEL A•300  
Capacity: 2 x 280 Nm³/hour
2 x NEL A•485  
1 x 444 Nm³/hour

Reliance Industries Ltd (RIL) is the largest private sector company in India and has business in a vast number of sectors such as oil & gas, refining, petrochemicals, textiles, retail and communication. RIL have since 1996 purchased 4 electrolyser units from NEL Hydrogen. The first three are installed in Hazira, Gujarat State and the last unit in Dahod, Gujarat State. The electrolysers installed at RIL’s plants serve as a secure back-up and alternative hydrogen source for production of PTA (Purified Terephthalic Acid). PTA is a chemical used primarily in the manufacture of Polyester, for clothing and plastic bottles.

Guardian - Egyptian Glass Company

Country: Egypt  
Application: Float Glass
Product: NEL A•150  
Capacity: 120 Nm³/hour
Installed: 1998

Guardian is one of the major global float glass manufacturers with numerous factories worldwide. An reliable hydrogen supply is extremely critical for the continuous operation of these large glass factories. Many companies install full redundancy on their electrolyser plant. Egyptian Glass has, however, been relying 100% on one electrolyser only – a NEL A•150.

“Since the start-up of the plant in May 1998, we have enjoyed a stable production with high gas purity, without any problems whatsoever.”

Ihab Ishak, Utility Manager

Illovo Sugar SA (Ltd)

Country: South Africa  
Application: Refined Sugar
Product: NEL A•485  
Capacity: 360 Nm³/hour
Installed: 1983

Illovo Sugar is Africa’s largest producer of sugar and downstream products. The hydrogen is used for production of terephthalic acid. During a plant expansion in 1983 a NEL A•485 with a capacity of 360 m³/h hydrogen was purchased and commissioned.

“The original electrolyser is still in operation today and is extremely reliable. The electrolyser runs at full capacity 24 hours a day. No significant maintenance is required on the unit until the planned routine overhaul. Since sanctions were lifted in South Africa, NEL Hydrogen has been providing Illovo Sugar with spares and proficient professional expertise also through the company RTS that was appointed NEL Hydrogen representative in South Africa in 1996.”

Alastair Warman, Engineering Manager, Downstream Products

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The focus on the environment and clean production of hydrogen calls for large scale electrolyser solutions.

Industrial plants with large hydrogen consumption – chemical/petrochemical/metallurgy/polysilicon – all need to consider their environmental footprint. A change from carbon sources to electrolyser technology will give a huge saving in emission of greenhouse gases.

Balancing the energy production from renewable sources by hydrogen production through electrolyser plants – Power-to-Gas (PtG) – requires large scale solutions to make a difference.

The same goes for environmentally friendly production of synthetic liquid fuel – Power to Liquid (PtL). Large volumes of hydrogen are needed.

Large scale hydrogen production is in our genes.

We have mastered this for decades through the two largest electrolyser plants worldwide set up by Norsk Hydro. These 135 MW plants each had a production capacity of 30 000 Nm³ of hydrogen per hour, corresponding to an annual production of more than 20 million kilos.

Our proven NEL A•485 electrolyser converting up to 2.2 MW of energy at high efficiency has contributed to these two success stories and remain the ultimate solution for large scale production of hydrogen.

With these scales – sustainable energy solutions with high and beneficial impact on the environment are available today.

Today the story is about to be repeated. With more than 50 MW of plants started up since 2011, NEL Hydrogen is again the benchmark for large scale electrolyser plants.

Large scale solutions? No problem!

Whether the need is large quantities of hydrogen for industrial purposes, or utilising large amounts of renewable energy for hydrogen production – it is no problem – we have experience with both!
INDUSTRIES WE SERVE

From our inception, providing hydrogen plants for Norsk Hydro’s ammonia production, to this day more and more users have experienced the benefits of on-site hydrogen generation with electrolysers from NEL Hydrogen.

- **Edible Oils and Fats**
  Hydrogenation of oils and fats to raise the melting point. Widely used for i.e. production of margarine and shortenings for the food industry, as well as production of soap and detergents.

- **Metallurgy**
  Used in a number of high quality special steel production processes. It is commonly used in annealing furnaces (heat treatment) that require protective atmosphere to avoid oxidation.

- **Float Glass**
  Flat glass is produced by floatation on a bed of molten tin. The float glass is cooled in a controlled protective atmosphere of roughly 94-95% nitrogen and 5-6% hydrogen.

- **Electronics**
  In the production of electronic packages (semiconductor and integrated circuit) the presence of moisture and oxides can lead to reductions in yields. Nitrogen and hydrogen is used to ensure the atmosphere is free of moisture and other impurities.

- **Chemicals/Petrochemicals**
  Hydrogen is a key chemical building block in many chemical processes. Apart from ammonia and methanol; hydrogen peroxide, sorbitol, PTA, oleochemicals and many other chemical or petrochemical products use hydrogen in their process.

- **Power Plants**
  Friction in turbine generators produces large amounts of heat. Hydrogen has a small molecular size, giving it low viscosity. This, together with its superior thermal conductivity makes hydrogen ideally suited as a cooling medium for generators in power plants.

- **Power-to-Gas**
  Hydrogen is potentially the energy carrier of the future, as it provides clean and emission free fuel for transport. The introduction of fuel cell electric vehicles requires development of an infrastructure of hydrogen fuelling stations, of which many will have on-site hydrogen production through water electrolyser technology.

- **Polysilicon**
  Polysilicon is a material consisting of small silicon crystals, and is used for silicon ingots and wafer production for the solar cell industry. In the production of polysilicon via the Siemens-process, large amounts of hydrogen are used to react with tri-chlorosilane gas to produce silicon.

- **Hydrogen Fuelling Stations**
  Hydrogen is considered one of the important fuels of the future and by transforming electricity to hydrogen through water electrolysis, energy can be stored for later use. Alternatively, the hydrogen can be used to feed directly the natural gas feedstock or go through a methanisation process to produce synthetic methane.

RECOGNISED BY OUR CUSTOMERS

From Ecuador in the west to Japan in the east. From South Africa in the south to Finland in the north. The NEL A-range of electrolysers are installed in more than 50 countries across the world, recognised for their reliability amongst global, regional and national companies in a wide span of industries.
NEL Hydrogen is the worldwide leader of medium and large scale alkaline electrolyser technology for environmentally friendly hydrogen production.

Our NEL A-range of atmospheric pressure electrolyser is well recognised as the most robust, reliable and energy efficient electrolysers on the market.

We have successfully delivered electrolyser solutions since the 1920’s with a wide number of references across numerous industrial segments.