HYDROGEN: THE NEXT GENERATION
DISCOVER CUMMINS ELECTROLYZER TECHNOLOGIES

FOR A WORLD THAT’S ALWAYS ON™

#GENERATIONH
Cummins has a 100-year history rooted in innovation. We transformed diesel into an everyday power source. Today, we’re a technology business with diverse power solutions for every need, with 10,000 of the world’s brightest engineering minds focused on the future. Hydrogen has a major role in clean power, industry, and mobility, as we look to the next 100 years.

**OUR RESEARCH AND TECHNOLOGY COMMITMENT**
Annual spend $1bn to advance power technologies. Integration expertise to help manufacturers define the best power source for their applications and equipment.

**INNOVATION LEADERSHIP**
Breakthrough innovations in Proton Exchange Membrane (PEM) technology. Leading the way in hydrogen generation at megawatt (MW) scale.

**BEST TOTAL COST OF OWNERSHIP**
Advanced technology with high efficiency, lower maintenance costs and fit-and-forget reliability delivers unrivalled lifetime value.

**GLOBAL REACH**
Cummins has the global resources to support your hydrogen project, no matter how big and no matter where.

**SPECIALIST HYDROGEN KNOWHOW**
More than 70 years of hydrogen leadership. Over 600 electrolyzers in 100 countries worldwide.

**IMPECCABLE SAFETY RECORD**
Zero significant safety breaches in decades of use.

**UNLIMITED PEACE OF MIND**
Cummins is your long-term partner into the hydrogen future.
Green hydrogen from water is the next generation solution, for generations to come.

As the world heads on its challenging journey towards decarbonization, the role of clean hydrogen is mission critical. Yet today, some 95% of the world’s hydrogen is still produced from fossil fuels.

Green hydrogen is the future, and Cummins is one of the few global companies with expertise across both critical technologies – clean zero-carbon hydrogen generation through both primary electrolysis technologies, and the fuel cell technology that the future of power depends on. We’re at the heart of the new hydrogen economy. However large or small your hydrogen ambitions and however hydrogen fits into your future, Cummins is ready to support you today. Welcome to GENERATION H.
TOWARDS ZERO CARBON POWER
THE GREEN HYDROGEN ECONOMY

Hydrogen produced from renewable power through advanced electrolysis technology is the key to unlocking a cleaner and more sustainable future.

RENEWABLE POWER
Electrolyzers are ideal to balance the growing share of renewable energy in power grids. They allow more renewable power to enter into the energy system for power production, injection in gas grids, industrial use, ammonia production, renewable fuels, or use in mobility, like fuel cell electric vehicles.

ENERGY STORAGE
As a gas, hydrogen can be stored and transported in existing natural grids or in dedicated hydrogen pipelines, to support the storage of renewable energy in large quantities and the decarbonization of a variety of applications.

MOBILITY
Hydrogen is at the start of its journey towards playing a pivotal role in the future of mobility worldwide. Hydrogen is produced on-site in hydrogen refueling stations to refuel light (passenger cars) and heavy-duty (trains, trucks, and buses) fuel cell electric vehicles.

INDUSTRY
Worldwide, a wide range of critical industrial processes depend on hydrogen:
- Ammonia and fertilizers
- Crude oil refining
- Electronics and semiconductors
- Hydrogenation of oil and fats
- Metal processing
- Manufacturing (for float gas)
- Power plants cooling

Plus, more industrial processes are being converted to hydrogen to reduce CO₂ emissions such as in steel making or industrial heat.
THE ESSENTIALS OF ELECTROLYSIS

At the heart of Cummins’ hydrogen generation technology is electrolysis, a highly efficient electrochemical reaction using electricity to break down water (H₂O) into its constituent elements, hydrogen (H₂) and oxygen (O₂).

The core components of an electrolyzer are cell stacks containing two electrodes through which electricity enters and exits the system, separated by a membrane across which the current passes. When electricity is applied to the system, hydrogen is formed at the cathode, oxygen at the anode. The membrane effectively keeps the gasses separate while they are harvested. Hydrogen can be captured as a gas at extremely high purities, leaving oxygen that can be used for other purposes including industrial and medical uses. The hydrogen gas can be easily stored as a compressed gas or liquid.

ELECTROLYZER EFFICIENCY

MEASUREMENT

Energy experts like to express the efficiency of electrolyzer products as one single percentage (%) value. Hydrogen experts prefer to express electrolyzer efficiency in kilowatt-hours per kilogram (kWh/kg) for two reasons. Firstly, as an electrolyzer uses energy to generate hydrogen, the efficiency can be expressed as the ratio between electrical energy input and energy output (hydrogen). Secondly, the energy content of hydrogen is 33.3 kWh per kilogram, compared to 39.4 kWh at a high heating value.

COMPARING EFFICIENCY

The power consumption of an electrolyzer depends on the exact scope of supply. To allow a fair comparison between various products, the scope of supply (cells stacks, balance-of-stack, balance-of-plant), hydrogen output pressure (in bar) and hydrogen purity (in %), need to be the same. Consumption will also vary over time – electrolyzers will consume less energy at the beginning of life (BOL) and more energy at the end of life (EOL) – and, over the operating window of the electrolyzer – electrolyzers will be more efficient at partial load (50%) than at nominal load (100%). Efficiency values for Cummins electrolyzer products are expressed at the product boundaries, at rated pressure, nameplate capacity, hydrogen purity and at the BOL. Cummins electrolyzer efficiency degrades by less than 1% per year (assuming 8,500 hours of annual operation). After 80,000 hours, stacks can be easily refurbished to as-new efficiency.
Proton Exchange Membrane (PEM) is the most robust and efficient technology for pure hydrogen generation at scale. Cummins is the industry benchmark for safe, widely proven PEM systems, delivering productivity and return on investment (ROI) beyond our competitors. Our ‘plug-and-play’ systems arrive onsite ready to safely and reliably produce very high purity hydrogen, continuously or flexibly, indoors, or out.

High efficiency aligns with low maintenance needs, delivering low capital and operational expense, with modularity that allows for simple scaling. Cummins systems connect to standard power and water connections and come equipped with standard water purification, power conditioning, hydrogen purification and remote servicing.

**CUMMINS HyLYZER®**

Cummins HyLYZER® Proton Exchange Membrane (PEM) technology is state-of-the-art. With the most efficient and compact solution on the market, HyLYZER® delivers on market leading operational expense and low levelized cost of hydrogen. Exceptionally compact systems deliver hydrogen at 30 bar without compression at extremely high purities. Operating flexibly at higher current densities, HyLYZER® is perfectly suited to projects where dynamic operation is valuable, such as in combination with renewables. And where megawatt scale matters, HyLYZER® scales up to meet the highest output needs.

**MEGAWATT SCALE STACKS**

Industry-leading 2.5 MW stacks, highly scalable for larger demands.

**EXCEPTIONALLY COMPACT**

Industry-leading design – lower land, site preparation and building costs and shorter installation time.

**RESPONSIVE**

Ultrafast responses to changes in hydrogen demand or power input.

**30 BAR PRESSURIZED STACKS**

High output pressure without compressors.

### PEM Electrolyzers | HyLYZER® Series

<table>
<thead>
<tr>
<th>Product</th>
<th>Max Flow Rate (Nm³/h)</th>
<th>System efficiency (kWh/kg)</th>
<th>Equivalent power rating (MW)*</th>
<th>Output pressure (bar)</th>
<th>Outdoor/Indoor</th>
<th>Size</th>
<th>Power module</th>
</tr>
</thead>
<tbody>
<tr>
<td>HyLYZER® 200-30</td>
<td>200</td>
<td>≤ 55</td>
<td>1</td>
<td>30</td>
<td>Outdoor</td>
<td>40ft container</td>
<td>20ft container</td>
</tr>
<tr>
<td>HyLYZER® 250-30</td>
<td>250</td>
<td>≤ 55</td>
<td>1.25</td>
<td>30</td>
<td>Outdoor</td>
<td>40ft container</td>
<td>20ft container</td>
</tr>
<tr>
<td>HyLYZER® 400-30</td>
<td>400</td>
<td>≤ 54</td>
<td>2</td>
<td>30</td>
<td>Outdoor</td>
<td>40ft container</td>
<td>40ft container</td>
</tr>
<tr>
<td>HyLYZER® 500-30</td>
<td>500</td>
<td>≤ 54</td>
<td>2.5</td>
<td>30</td>
<td>Outdoor</td>
<td>40ft container</td>
<td>40ft container</td>
</tr>
<tr>
<td>HyLYZER® 1000-30</td>
<td>1000</td>
<td>≤ 51</td>
<td>5</td>
<td>30</td>
<td>Indoor</td>
<td>27.7m x 7.5m</td>
<td>50ft x 25ft</td>
</tr>
<tr>
<td>HyLYZER® 4000-30</td>
<td>4000</td>
<td>≤ 51</td>
<td>20</td>
<td>30</td>
<td>Indoor</td>
<td>50ft x 7.5m</td>
<td>23ft x 30ft</td>
</tr>
</tbody>
</table>

The standard scope of supply for our electrolyzers differs between the outdoor and indoor products.

### STACK AND BALANCE-OF-STACK (BOS)

<table>
<thead>
<tr>
<th>Outdoor</th>
<th>Indoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell stacks and Gas Generation System</td>
<td>*</td>
</tr>
<tr>
<td>Power rectifiers</td>
<td>*</td>
</tr>
<tr>
<td>Control Panel</td>
<td>*</td>
</tr>
<tr>
<td>Water quality monitoring system</td>
<td>*</td>
</tr>
<tr>
<td>Rectifier Cooling</td>
<td>*</td>
</tr>
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</table>

### BALANCE-OF-PLANT (BOP)

<table>
<thead>
<tr>
<th>Outdoor</th>
<th>Indoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Cooling with Chiller</td>
<td>*</td>
</tr>
<tr>
<td>Electrolysis Cooling with Dry Cooler</td>
<td>*</td>
</tr>
<tr>
<td>Water Purification System</td>
<td>*</td>
</tr>
<tr>
<td>Instrument Air Compressor</td>
<td>*</td>
</tr>
<tr>
<td>Hydrogen Purification System</td>
<td>*</td>
</tr>
</tbody>
</table>

**LONG, MAINTENANCE-FREE LIFECYCLE**

Limited and optimized maintenance, minimal degradation, 80,000 hours between stack membrane refurbishments; fast stack swap-out when required.

**HIGH EFFICIENCY AND ADVANCED CONTROL SYSTEMS**

Lower power usage and low annual maintenance costs, with integrated safety sensors for safe plant operations.

*For the indicative power rating, a standard efficiency value of 5 kWh/Nm³ has been used across all products to give an indication of the product power rating. Our products are designed to supply a nominal hydrogen flowrate during its expected lifetime. In practice, our electrolyzers will consume less energy at the beginning of life (BOL) and more energy at the end of life (EOL) for a specific hydrogen production.*

1 kg of hydrogen is equivalent to 11,126 Nm³ (volume of hydrogen under normalized conditions of 1 atmosphere and 0˚C).
ALKALINE TECHNOLOGY

This long-standing technology is based on Cummins proprietary IMET membrane, offering best-in-class systems with the strongest safety record and reliability in the market.

CUMMINS HySTAT®

HySTAT® is Cummins globally proven modular alkaline electrolyzer system designed for easy onsite installation inside or out, with simple interconnectivity to scale up, and an unrivalled record for reliability, low maintenance and onsite safety.

PROVEN DURABILITY

Robust technology and long lifetime with minimal maintenance.

Up to 2 cell stacks 30 Nm³/h.

Up to 4 cell stacks 70 Nm³/h.

Up to 6 cell stacks 100 Nm³/h.

ROBUST PROVEN TECHNOLOGY

Over 500 pressurized alkaline installations worldwide.

MODULAR AND FLEXIBLE

Stack configurations available in 1, 2, 4 and 6 stacks with nominal hydrogen outputs from 10 to 100 Nm³/h, easily scalable to future needs.

SAFE

Flawless safety record over decades.

Alkaline Electrolyzers | HySTAT® Series

<table>
<thead>
<tr>
<th>Product</th>
<th>H2 Flow (Nm³/h)</th>
<th>System efficiency (kWh/Nm³)</th>
<th>Indicative power rating (kW)*</th>
<th>Output pressure (bar)</th>
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<th>Size</th>
</tr>
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<tbody>
<tr>
<td>HySTAT® 10-10</td>
<td>10</td>
<td>55-60</td>
<td>50</td>
<td>10</td>
<td>Outdoor &amp; Indoor</td>
<td>20ft container</td>
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<tr>
<td>HySTAT® 15-10</td>
<td>15</td>
<td>55-60</td>
<td>75</td>
<td>10</td>
<td>Outdoor &amp; Indoor</td>
<td>20ft container</td>
</tr>
<tr>
<td>HySTAT® 30-10</td>
<td>30</td>
<td>55-60</td>
<td>150</td>
<td>10</td>
<td>Outdoor &amp; Indoor</td>
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<td>HySTAT® 60-10</td>
<td>60</td>
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<td>HySTAT® 100-10</td>
<td>100</td>
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The standard scope of supply for our electrolyzers differs between the outdoor and indoor products.

STACK AND BALANCE-OF-STACK (BOS)

- Cell stacks and Gas Generation System
- Power rectifiers
- Control Panel
- Water quality monitoring system
- Rectifier Cooling

BALANCE-OF-PLANT (BOP)

- Gas Cooling with Chiller
- Electrolysis Cooling with Dry Cooler
- Water Purification System
- Instrument Air Compressor
- Hydrogen Purification System

* = standard

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1kg of hydrogen is equivalent to 11,126 Nm³ (volume of hydrogen under normalized conditions of 1 atmosphere and 0˚C).
Taking hydrogen power generation to megawatt scales and beyond is a complex technical challenge. At Cummins, we’re proud to lead the way. We were the first to achieve MW scale, and today, we’re setting records with some of the largest plants in the world. If scale is your goal, no one understands it better.

Cummins technology powers the largest PEM electrolyzer in operation in the world.

Installed at the Air Liquide hydrogen production facility in Becancour, Quebec, the 20 MW Cummins electrolyzer system can produce over 3,000 tons of hydrogen annually using clean hydropower. The modular and scalable electrolyzer platform addresses utility-scale hydrogen production.

Central water purification system
Converts tap water into clean de-ionized water suitable for the cell stacks.

Electrical substation
Transformer and switchgear where high voltage from the grid is converted to medium voltage AC.

Rectifier and transformer
Medium voltage AC is converted into DC power for the cell stacks.

Electrolyzer system
Breaks water molecules into hydrogen gas and oxygen gas, separated from water in gas-liquid separators. Enclosed, monitored and ventilated hydrogen production means building does not need to be classified as a hazardous area. The result: 99.99% pure hydrogen produced at 30 bar.

Optional hydrogen purification system
If required, hydrogen can be further purified to fuel cell quality (99.998%).

Central cooling system
Cools water circulating through the cell stacks to optimize electrolysis efficiency.

Control room
Centralized plant logic and safety control system.
WORLD’S FIRST MEGAWATT-SCALE POWER-TO-GAS PROJECT
FALKENHAGEN, GERMANY

At the first demonstration plant for storing wind energy in the natural gas grid, around 360 Nm³/h of hydrogen is generated by six Cummins HySTAT® 60-10 electrolyzers. The hydrogen generated is fed via a pipeline into the gas grid. The energy is available to the electricity, heating, mobility, and industrial market when required, just like normal natural gas. In the first year of operation, more than 2 million kWh of hydrogen (“WindGas”) were fed into the gas grid.

HYDROGEN REFUELING
ABERDEEN, SCOTLAND

Cummins supplied the HySTAT 60® electrolyzer for the Aberdeen City Hydrogen Energy Storage (ACHES) facility. The facility offers hydrogen refueling for cars, vans, trucks and buses. The station has multiple electric recharging points and has the potential to produce 130 kg of hydrogen per day. To enable fast refueling, hydrogen is dispensed at 350 bar and 700 bar pressure.
EXPERIENCE MEETS INNOVATION

With the acquisition of Hydrogenics in 2019, Cummins became one of the world’s leaders in hydrogen generation and fuel cell development. No one else combines cutting-edge expertise in hydrogen generation with the manufacturing scale, global support network and century-long experience of the Cummins corporation. No one is better equipped to support your hydrogen ambitions.

190 countries

Pioneering the world’s largest scale PEM electrolyzer installation

$1bn annual spend to advance power technologies

70+ years of hydrogen expertise

600+ electrolyzers systems installed worldwide
ALWAYS INNOVATING FOR A WORLD THAT’S ALWAYS ON

Find out more at cummins.com/hydrogen
WE’RE READY. TODAY.