

HORIBA



Energy Innovation with **HORIBA**

Introduction of HORIBA's Initiatives towards
a Hydrogen Society and Carbon Neutrality
2023 - 2024

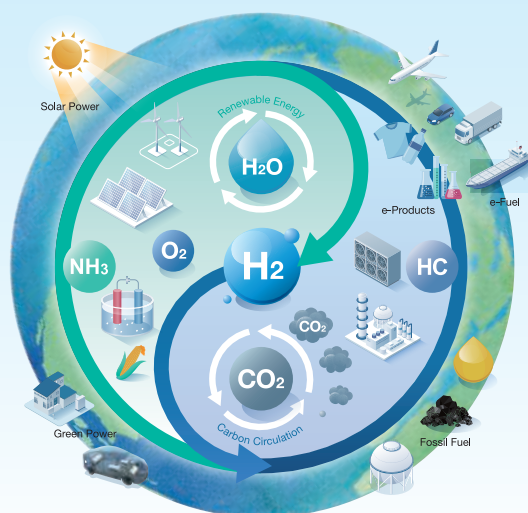
Energy Innovation with HORIBA

HORIBA is committed to the realization of a carbon-neutral society and the adoption of new energies, such as hydrogen, to enhance energy efficiency worldwide. However, the practical implementation faces challenges, including reducing manufacturing costs. While technology development for CO₂ capture and reuse progresses, there are still hurdles to overcome.

Since our founding, we have been dedicated to developing and implementing advanced analytical and measurement technologies to protect the Earth and human health. In the field of hydrogen and energy, we offer flexible solutions ranging from gas measurement for hydrogen and CO₂, material analysis, plant monitoring, to the evaluation of

secondary batteries, fuel cells, and electrolysis. Additionally, we provide comprehensive services, including engineering, consulting, contract analysis, and testing and evaluation expertise to meet your diverse needs.

With our global products and solutions, we contribute to achieving a carbon-neutral society and accelerating the scale-up of the hydrogen and energy industry. As your true partner, we address the evolving measurement needs of the new era by harnessing our knowledge and technology.



HORIBA WILL CONTRIBUTE TO REALIZE THE CARBON NEUTRALITY THROUGH OUR MEASUREMENT TECHNOLOGIES TOWARD 2050.

Maximize Total Energy Efficiency

To realize the optimization of energy society as a whole by improving energy efficiency, implementing energy-saving measures, and leveraging digital and IT technologies.

Utilize Sustainable Green Energy

By generating electricity and heat energy from renewable energy sources and using that energy to convert water into hydrogen, it can be efficiently utilized as an energy source for daily life, transportation, and industry.

Realize Carbon Capture & Circulation

To effectively capture and recycle carbon dioxide (CO₂) to use it as a valuable resource for chemicals and synthetic fuels. Hydrogen also plays a key role in this process.

HORIBA is the World's Partner in Sustainable Society

HORIBA, chosen by the world for the implementation of hydrogen society.

USA



HIMaC²
(HORIBA Institute for Mobility and Connectivity²)

- A Joint Initiative with University California Irvine (UCI)




Official Website Facility Tour Video

Projects with World's Leading European Companies

U.K.

- Ceres (Fuel Cell)
- OCTOPUS (H₂ On-site Production & Distribution)

France

- Genvia (Electrolysis)
- CRMT (H₂ Engine/FCV)
- SYMBIO (Fuel Cell)
- HORIBA France H₂ Laboratory Venissieux



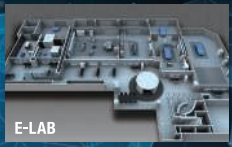
Germany

Our Global Center of Excellence for Fuel Cells, Batteries and Electrolyzers

HORIBA eHUB



Japan



E-LAB

Our Flagship Factory with Complete Test Cell for xEV

HORIBA BIWAKO E-HARBOR

Projects with Fraunhofer Institutes

- IKTS (SO Electrolysis)
- ISE (PEM Fuel Cell & Battery)
- IWES (Electrolysis)
- and others



China

Our Largest Base for R&D, Engineering and Mass-production

HORIBA C-CUBE



Netherlands

Partnering with European Space Agency (ESA)

- PEM Fuel Cell Evaluation



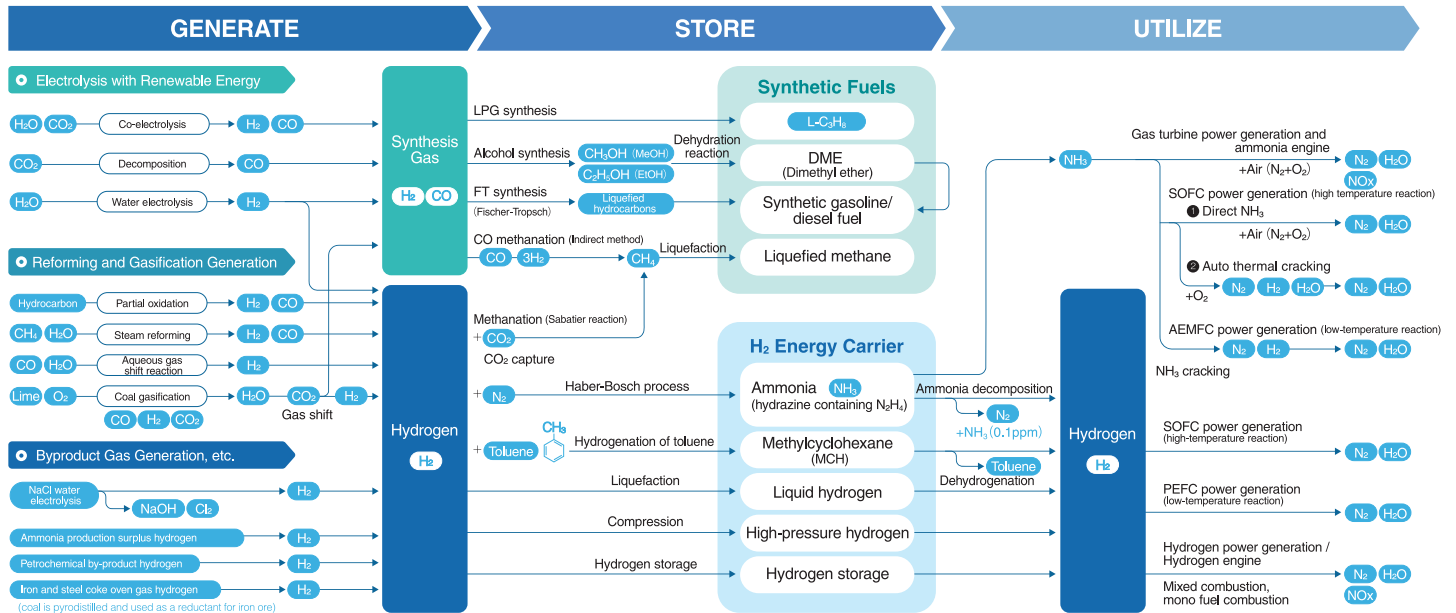
R&D Project for Mass Produce Electrolysis H₂Giga

- In Cooperation with Sunfire for HTEL-Stacks Project



Why Hydrogen?

Hydrogen is a common medium for generating, storing and utilizing energy, and can be converted into the wide variety of hydrocarbon fuels and bulk materials.



Our Measurement and Testing Solutions for Decarbonation Technologies



Fuel Cell



Fuel Cell Vehicle



Stationary Fuel Cell



Engine & Combustion



Hydrogen Station



Water Electrolysis



Hydrogen Production



Battery and Its Recycling



Reduction of CO₂ Emission



Direct Carbon Capture



Carbon Recycling



Life Cycle Assessment (GHG protocol)

Materials and Physical Properties

- Structural analysis
- Elemental analysis / quantitative elemental analysis
- Particle characterization and particle size analysis
- Thin film characterization
- Optical property characterization
- Hydrogen embrittlement evaluation
- In-line and on-line analysis

Monitoring of Industrial Process

- Real-time gas monitoring
- Air quality (CO₂) monitoring
- Process monitoring for thermal power generation
- Synthesis process monitoring
- Temperature monitoring
- Semiconductor manufacturing process monitoring
- Water quality analysis
- Water, sewage and wastewater monitoring

Evaluation of Performance

- Fuel cell and water electrolysis performance evaluation
- Hydrogen and ammonia combustion evaluation
- Battery charge/discharge characteristics evaluation
- Initial shipping performance inspection (Fuel cells, water electrolysis, batteries)
- Catalyst performance evaluation
- Battery material degradation analysis

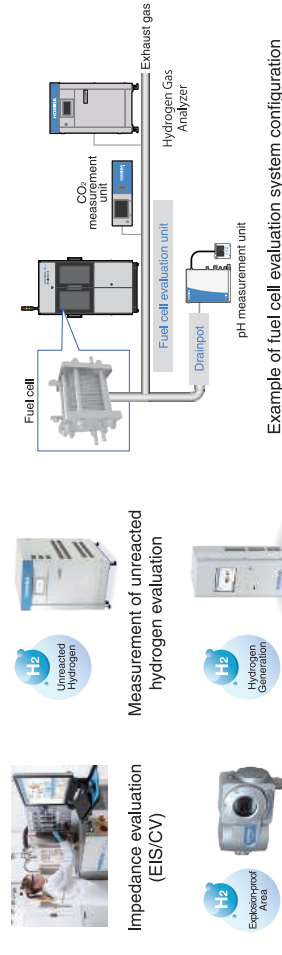
Evaluation of System

- Powertrain evaluation
- Conformity and certification testing
- Vehicle evaluation and testing
- On-road real driving evaluation
- Factory energy management system
- Thermal management
- Safe operation of labs

Analysis of FC / EC Materials

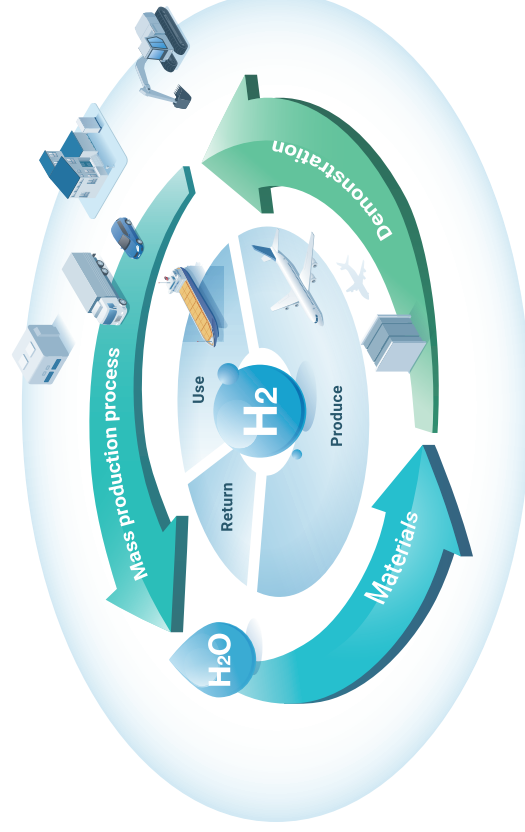
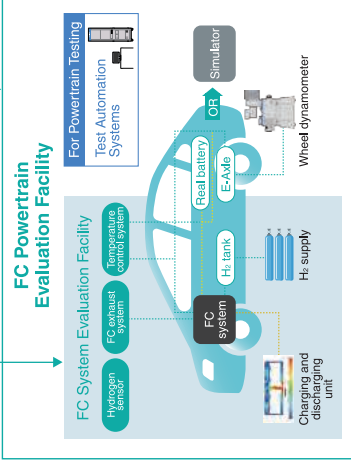
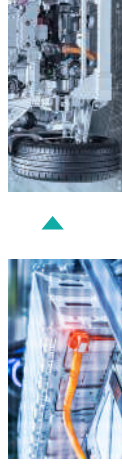


Performance Evaluation of FC / EC



Evaluation of FC System

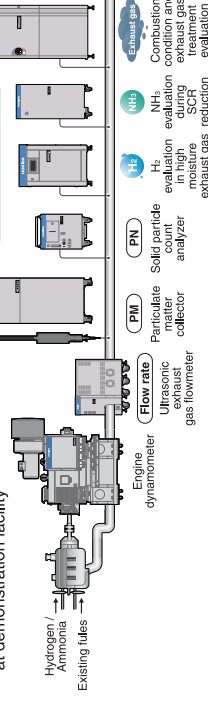
- ① FC system**
Development and adaptation of systems combining FC with auxiliary equipment such as air compressors, converters, and pumps.
- ② FC powertrain**
Development and adaptation of powertrains combining FC systems and E-Axle batteries.



EIS: Electrochemical Impedance Spectroscopy
CV: Cyclic Voltammetry

Hydrogen and Ammonia Combustion

- Combustion evaluation at engine test lab
 - Hydrogen / ammonia evaluation
 - Combustion condition / exhaust gas evaluation
- Various exhaust gas measurements at demonstration facility



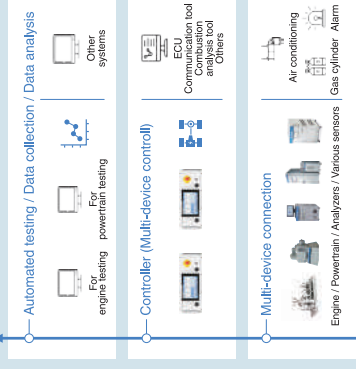
Example of hydrogen / ammonia evaluation system configuration

HORIBA proposes an upgrade to the FC system leveraging existing test-bench assets. Furthermore, HORIBA will enable real-time connectivity with the powertrain bench in the future.



Test Automation System

Improved development efficiency by integrating and automating the measurement and control required for testing



Characterization of Catalyst Materials



Evaluation of nanoparticle size of metal complexes for artificial photosynthesis



Particle size evaluation in catalyst ink



Adhesion evaluation of precious metal catalyst

Characterization of Surface Reaction



Evaluation of crystallinity of catalyst and adsorption / desorption materials



Evaluation of photocatalyst luminescence characteristics

Measurement of Performance and Generation



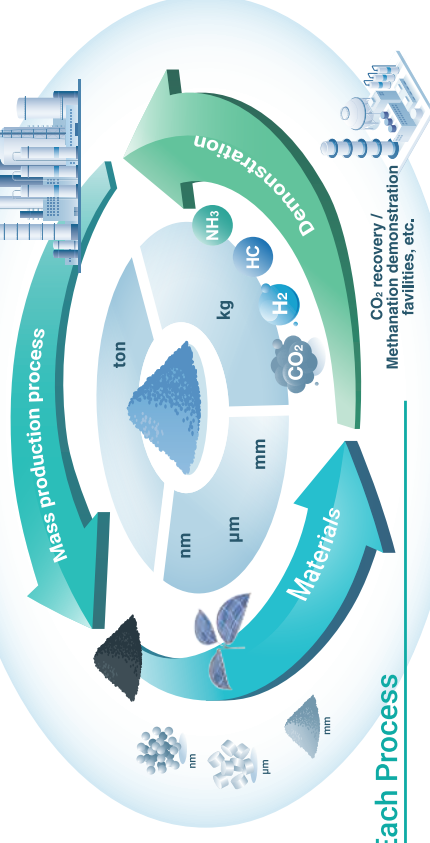
Evaluation of photocatalytic conversion efficiency



Performance evaluation of ammonia synthesis catalyst (NH₃ measurement)



Efficiency evaluation of hydrogen generation (H₂ measurement)



Operation of Each Process



Desulfurization, denitrification, exhaust gas monitoring



Solution and drainage monitoring



Capacity Assessment of the Entire Facility



Desulfurization and denitrification (SO₂, NH₃, NOx measurement)



Hydrogen generation and purification (H₂ and impurity gas measurement)



CO₂ capture (CO₂ and impurity gas measurement)

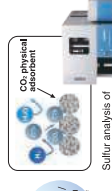
Evaluation of CO₂ Adsorbent / Desorbent



- Evaluation of CO₂ adsorption activity point of zeolite and amine
- Evaluation of CO₂ adsorption of concrete



Structural analysis of material solutions

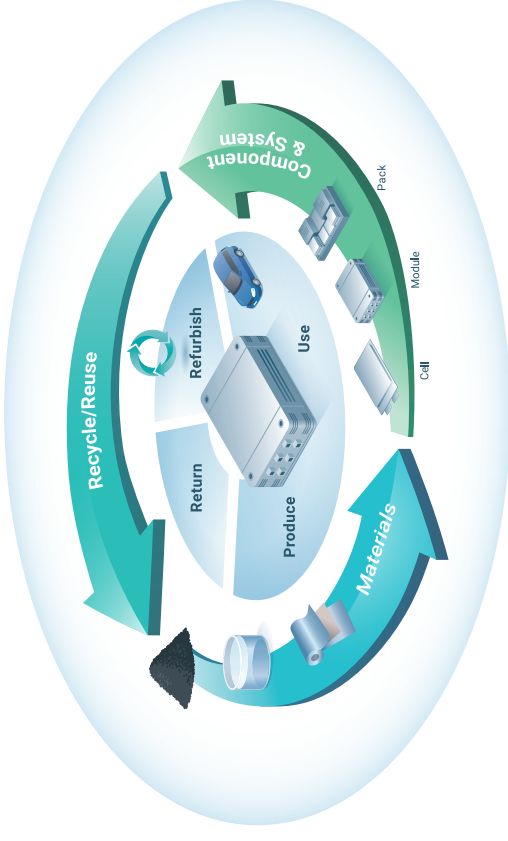


Sulfur analysis of CO₂ separation membrane



Material analysis (sampling)

Measurement of gases generated in each reaction process



Recycle and Reuse of Batteries



Contract analysis;
subscription and
remote support for analysis



Diagnosis of deterioration
(SoH: State of Health)
of used batteries



Quantitative analysis of
impurity elements in
recycled materials



GHG (Green House Gas) and
emission gas measurement of
recycling furnaces



Component & System Testing Solutions



All
Solid-state
Battery



Battery performance evaluator



Thermostatic chamber with shaker

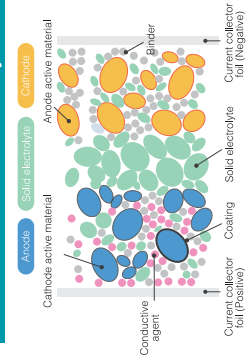


Charge / discharge characteristic evaluation of batteries

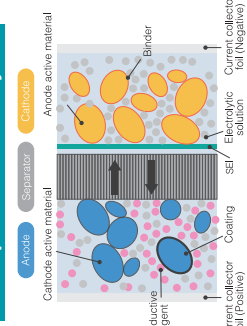


Thermal model

All Solid-state Battery



Liquid Li-ion Battery



Material Analysis of All-Solid State Battery



Solid
Electrolyte

Crystal structure evaluation of
solid electrolytes



Solid
Electrolyte

Measurement of oxygen concentration in
solid electrolytes



Solid
Electrolyte

Depth profiling of
solid electrolytes

Material Analysis of Lithium-ion Battery



Electrode
Material

Particle dispersion evaluation of
electrode material



Electrode
Material

Evaluation of crystallinity of
carbon for anode and cathode
material, and dispersion state
of electrode material



Electrode
Slurry

Analysis of mixing condition of
electrode slurry

Quality Assurance of Batteries



All
Solid-state
Battery

Gas concentration measurement
during material production
(H₂S measurement)



Anode

Evaluation of anode degradation
due to cathode leaching
(Depth profiling / surface analysis)



Anode/
Cathode

In-line foreign material analysis
in electrodes



Anode/
Cathode

Safety evaluation in nail
penetration tests of battery pack



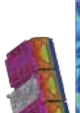
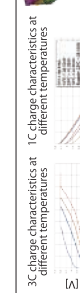
Battery
Cell



Battery
Cell



BMS development according to
application

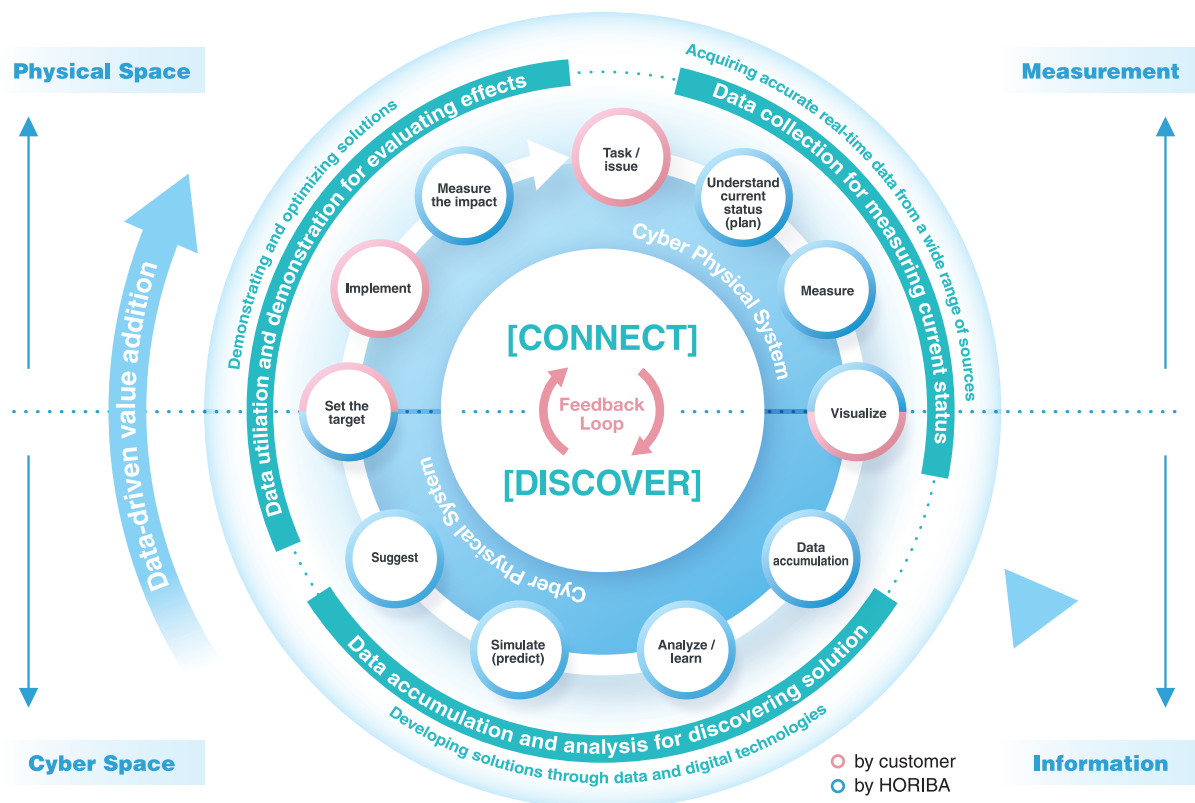


Thermal model

Consulting - development, design, and prototyping of
BMS (Battery Management System) and thermal management

HORIBA's Contribution to the Future of Measurement Technology

We will advance the evolution of our measuring, connecting and discovering technologies and build a Cyber-Physical System (CPS).

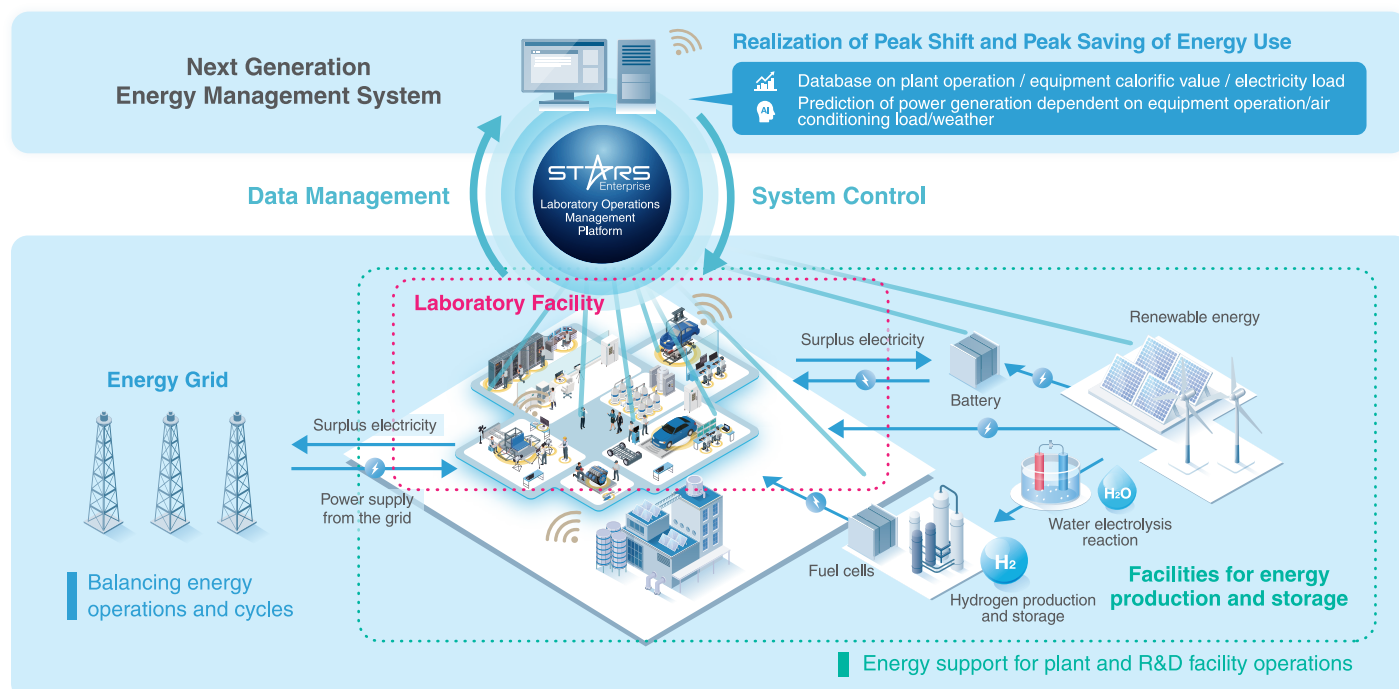


HORIBA's Vision for CPS Implementation

HORIBA Energy Management System Concept for Lab

HORIBA is addressing the challenges of fluctuating energy demand and the promotion of energy efficiency and renewable energy utilization in research and development facilities, where it is difficult to standardize the business processes for a wide range of experimentation and evaluation tasks.

We are working on establishing an "Energy Management System" that visualizes energy consumption in research and development sites and connects it to optimal utilization. Furthermore, we aim to develop a system that conducts software-based energy utilization simulations in virtual spaces, enabling us to propose optimal facility designs from the early stages of construction in research and development facilities.



HORIBA Global Initiatives for Carbon Neutrality & Hydrogen Society

As a global company, HORIBA has 50 offices and centers of activity around the world, as well as technology development and business centers in key business areas, which can be regarded as the "headquarters" of HORIBA's business operations.

In the field of energy, we have development and production sites in main areas such as Japan, Europe, the U.S., and China, where we can find clues to global trends, and our excellent engineers continue to work on new technological development rooted in the needs of each region.



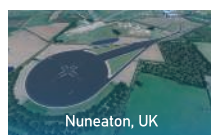
Magdeburg, Germany



Oberursel, Darmstadt,
Leichlingen, Germany



Paris Saclay, France



Nuneaton, UK



Northampton, UK



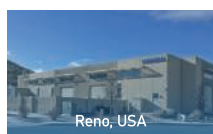
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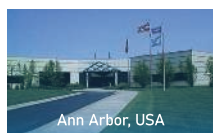
Irvine CA, USA



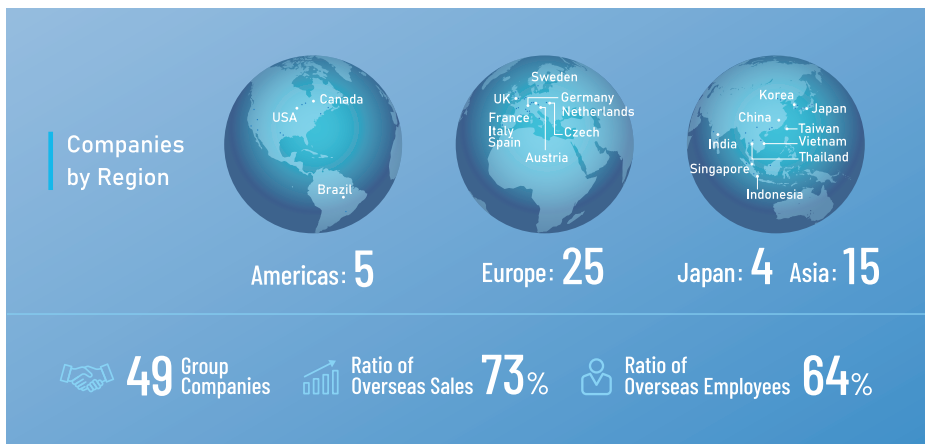
Houston, USA



Reno, USA



Ann Arbor, USA



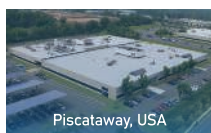
Analytical Solution Plaza
Kyoto



Otsu, Japan



BIWAKO E-HARBOR/
E-LAB in Otsu



Piscataway, USA



Sao Paulo, Brazil



Pune, India



Shanghai, China



Aso, Japan

As of December, 2022

Special Website for the Energy Field

Please visit our website for the latest energy trends and a wide range of analysis and measurement solutions related to hydrogen energy, CO₂ circulation, and energy management systems.

HORIBA contributes to the new era of smart energy production, storage and utilization.



Please access from the link:

<https://horiba.link/energy>

HORIBA
Energy-related
industry associations
membership
(as of 2023)

Japan

- FC-Cubic Technology Research Association
- Hydrogen Value Chain Promotion Council
- Technical Research Association Lithium Ion Battery Materials Evaluation Research Center

Germany

- Hydrogen Europe

HORIBA, Ltd.



Bulletin: HRE-0078B