Accelerating the Hydrogen Value Chain

Virtual Media Briefing

EMERSON

Emerson Virtual Media Briefing:

Accelerating the Hydrogen Value Chain

Loic Charbonneau

Global Pursuit Director

Emerson Automation Solutions

How Policy & Sustainability Targets are Shaping the Viability of Hydrogen

Brandon Bromberek

Vice President, Measurement Solutions

Emerson Automation Solutions

How Automation Solutions Advance Developments Across the Value Chain

Logistics

RECORDING

We’re recording the session.

CHAT

Submit questions through the chat at any time.

Q&A + SURVEY

When Q&A starts, I’ll unmute you to ask your question.

We'd appreciate your feedback via the survey.

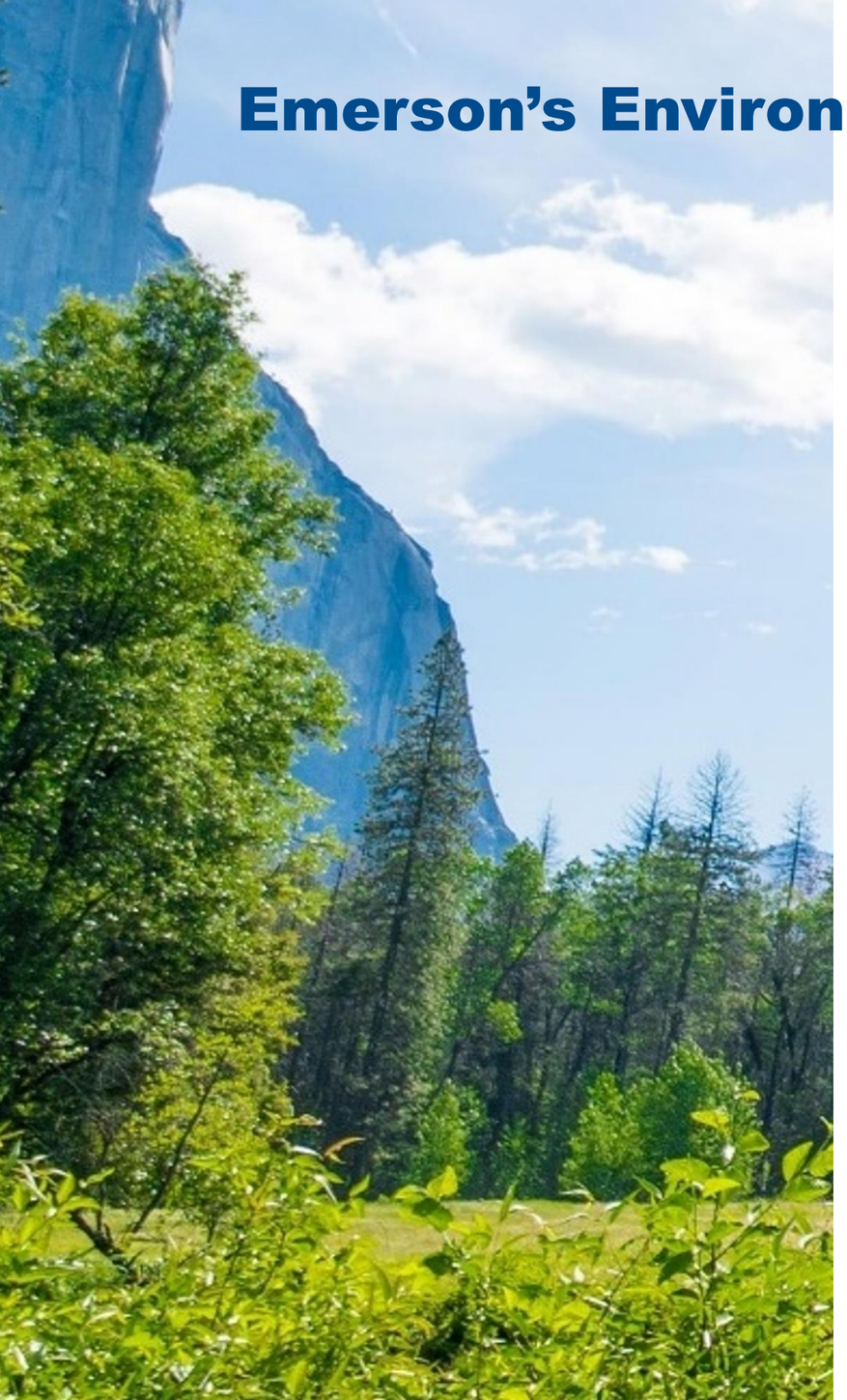
Emerson ESG Report and Net Zero Targets

Net Zero
Targets

Net zero GHG emissions
(Scopes 1, 2 and 3) by

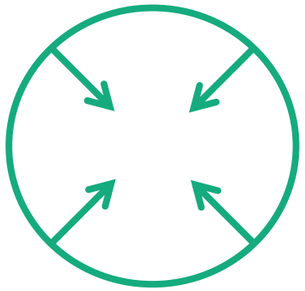
2045

with a science-based aligned approach



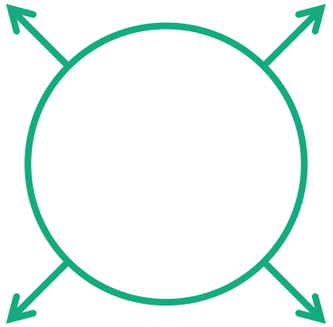
Emerson’s Environmental Sustainability Framework

Greening OF



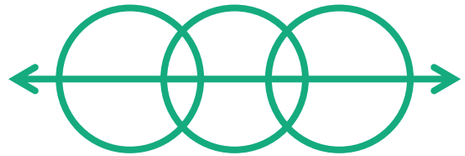
Improving Emerson’s environmental sustainability performance

Greening BY



Enabling our customers’ decarbonization and sustainability journeys

Greening WITH



Fostering collaboration among stakeholders

Four “Greening By” Strategies for Environmental Sustainability

1 ENERGY SOURCE DECARBONIZATION

- LOW-CARBON POWER (SOLAR, WIND, NUCLEAR, HYDRO)
- LOW-CARBON FUELS (BIOFUELS, LNG)
- HYDROGEN & HYDROGEN-BASED FUELS

2 EMISSIONS MANAGEMENT

- EMISSIONS MONITORING & CONTROL
- CARBON CAPTURE UTILIZATION & STORAGE
- NATURAL & LOW GHG REFRIGERANTS

3 ELECTRIFICATION & SYSTEM INTEGRATION

- END-USE ELECTRIFICATION (HEAT PUMPS)
- ENERGY SUPPLY OPTIMIZATION
- ENERGY STORAGE & GRID MANAGEMENT

4 ENERGY EFFICIENCY & OPTIMIZATION

- ADVANCED CONTROLS & ANALYTICS
- SIMULATION & REMOTE MONITORING
- WASTE MANAGEMENT

Loic Charbonneau

Global Pursuit Director

Emerson Automation Solutions

- The hydrogen economy is accelerating
- Cost will proportionately decrease as capacity increases
- Industry must evolve from small-scale to large-scale plant mentality
- Hydrogen complements renewables with flexible energy storage

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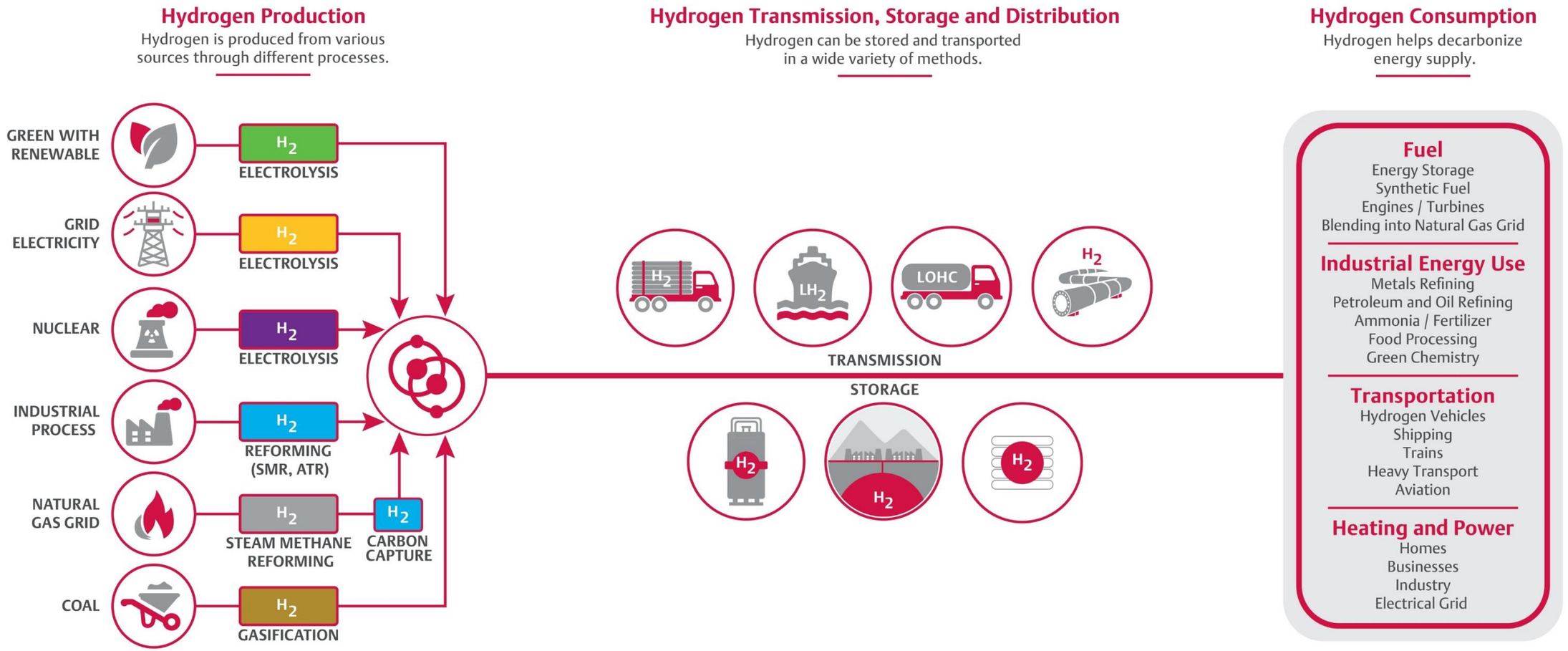
Hydrogen viability depends on success across the value chain

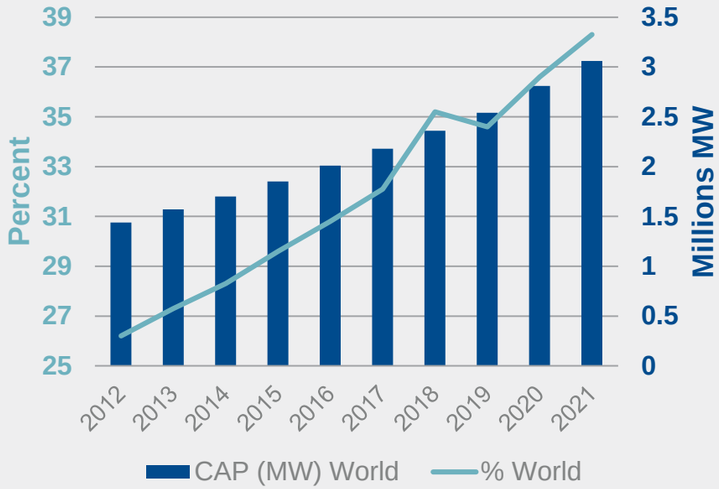


Production | Transmissions, Storage and Distribution | Consumption

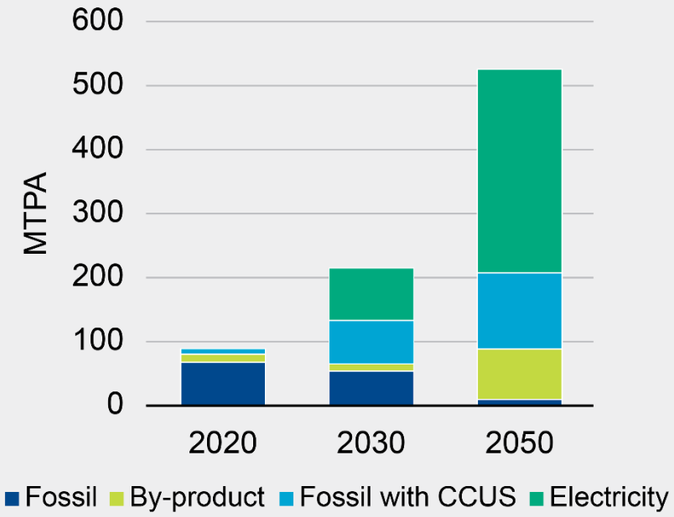
Market Update

- Global Renewables capacity has doubled in the last 8 years to 3 million MW.
- Share of hydrocarbons in primary energy streams could drop from around 85% in 2018 to as low as 20% in 2050.
- Today, less than 1% of the global Hydrogen production (circa 75M t/y) is green.
- Acceleration of the Hydrogen Value Chain at all levels.

Renewable energy share of electricity capacity



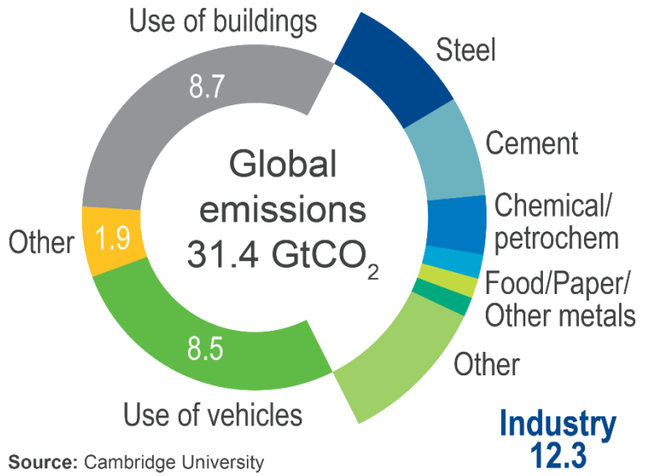
Sources of hydrogen production 2020–2050



Source: IEA (2021), Net zero by 2050

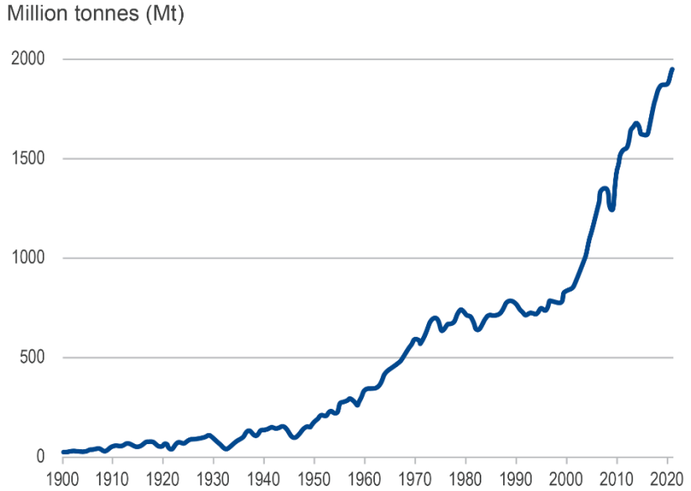
Renewable H_2 could cut global CO_2 emissions by 25% at scale

Global Emissions



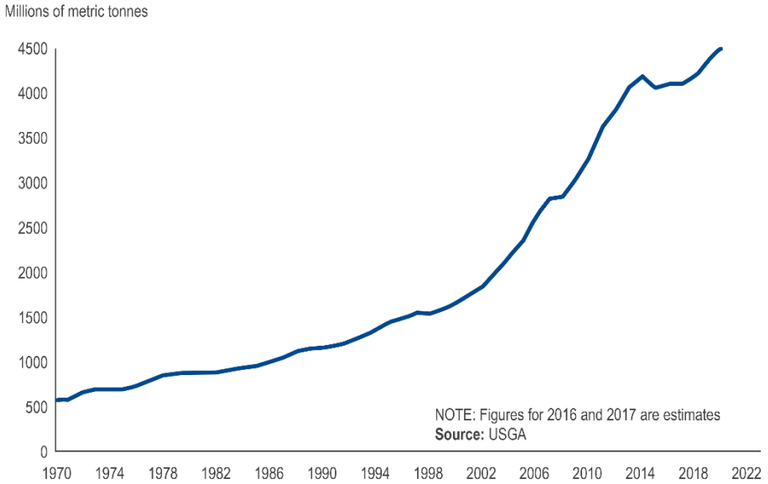
- **Global emissions**
  Deep decarbonization requires a multi-pronged strategy.
- **Industrial emissions**
  Account for almost 40% of global CO_2 emissions, once electricity emissions are allocated.

Steel Production



- **Steel emissions**
  Steel alone accounts for about 7–8% of global emissions, about half of all road transport emissions.

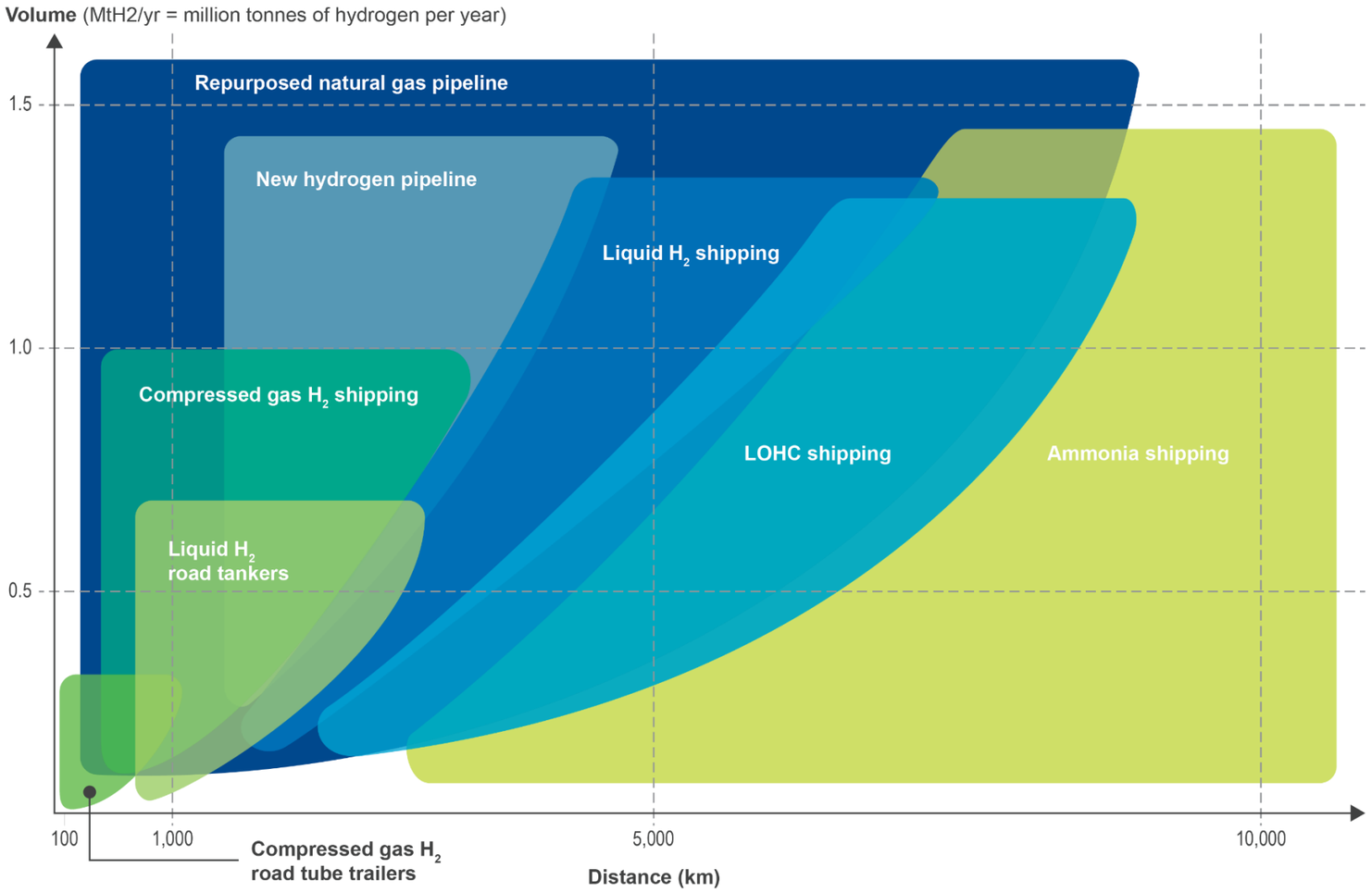
Cement Production



- **Cement emissions**
  3X growth in global cement market, since 1995.
- **CAGR of 5.1%** during the forecast period to 2029.

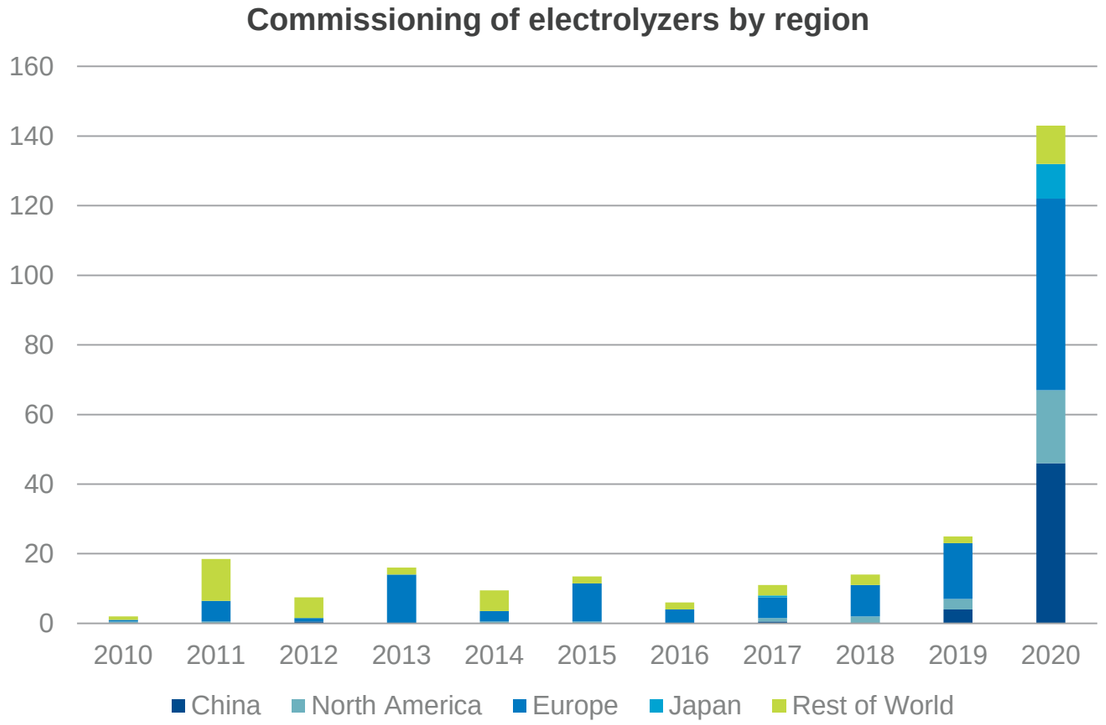
Production | **Transmissions, Storage and Distribution** | **Consumption**

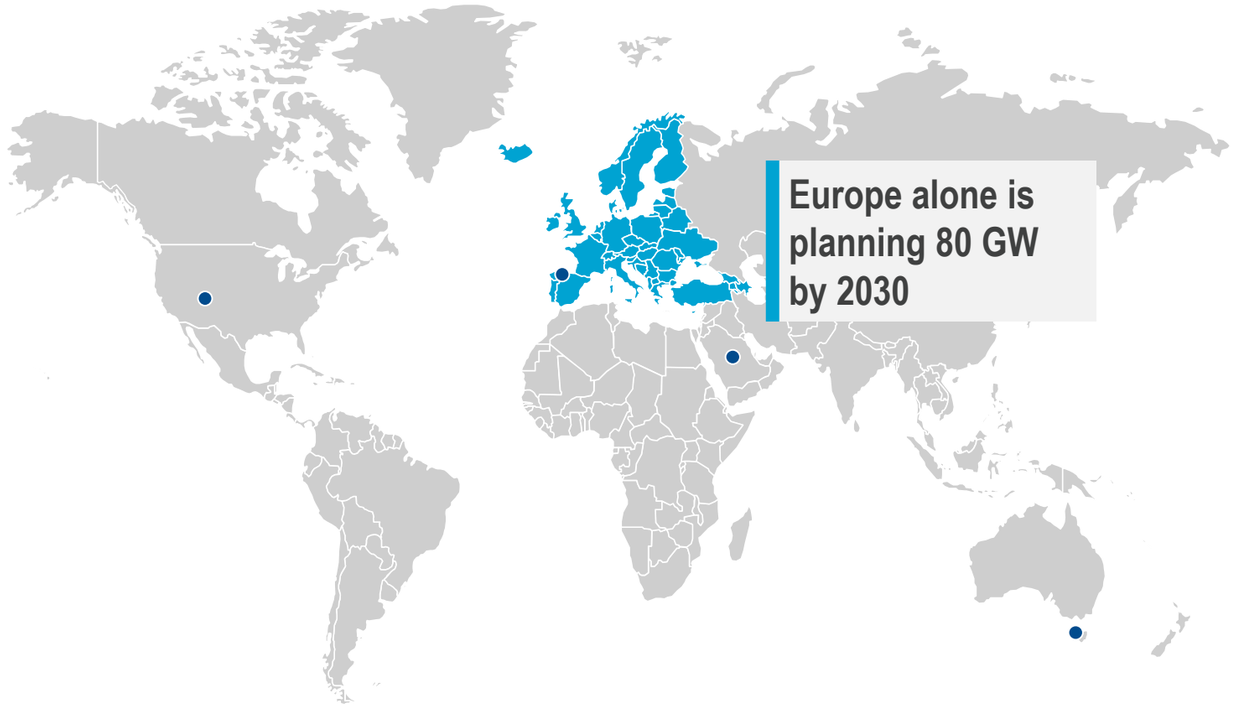
Strategic Storage & Transmission



- Flexible strategic storage and transmission of hydrogen can be done at scale to complement electrical battery storage.
- Alternative to natural gas imports ensuring greater geopolitical autonomy.
- Emerging regulation and standards for global certification such as RED II and CertifHY.
- Ports are becoming Multi-Energy Hubs.

Accelerating Hydrogen Production



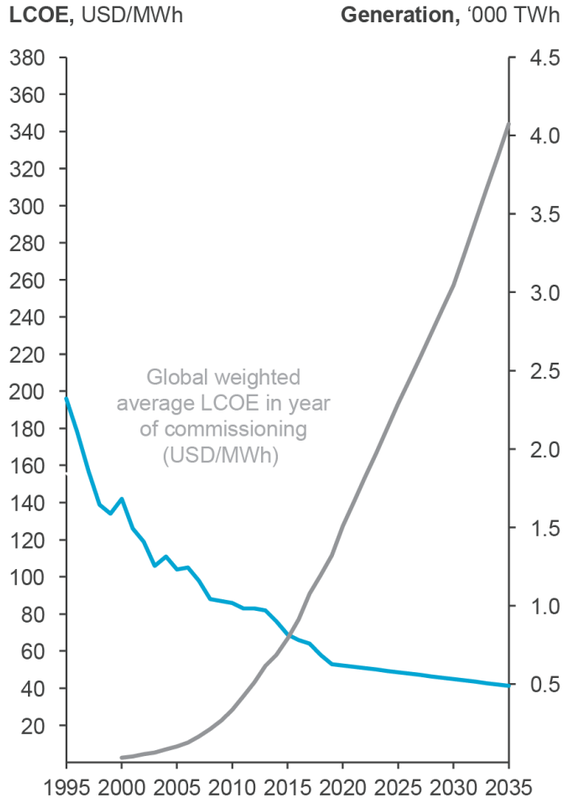


A $600B investment opportunity by 2050.

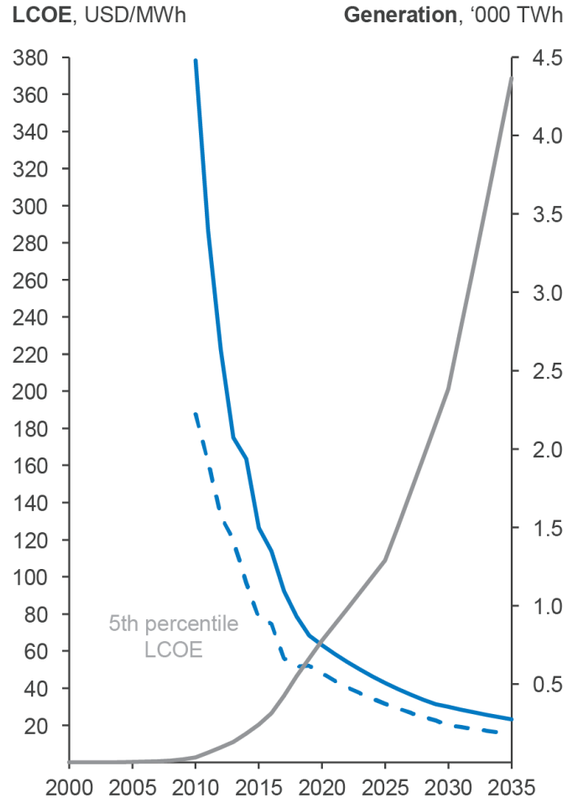
Production | **Transmissions, Storage and Distribution** | **Consumption**

Impact of Accelerating Hydrogen Production

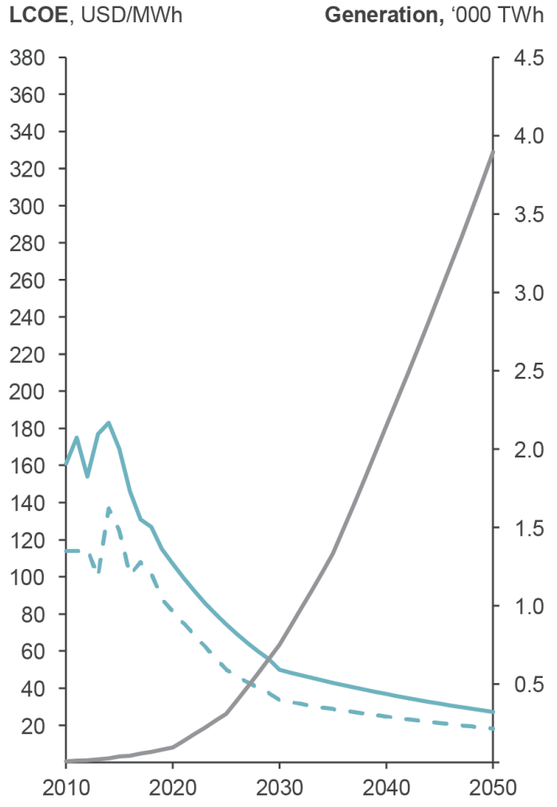
Onshore wind[1]
1990s



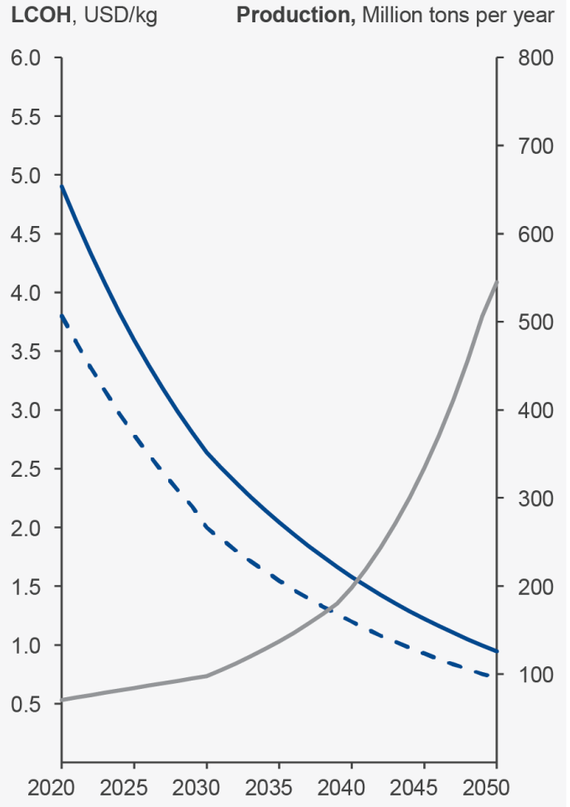
Solar PV[1]
2000s



Offshore shallow-water wind[1]
2010s



Industrial-scale hydrogen[1],[2]
2020s

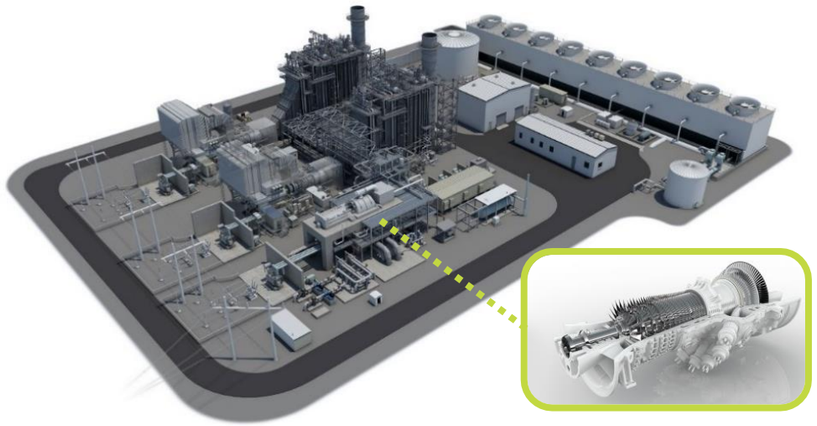


Production | **Transmissions, Storage and Distribution** | **Consumption**

How to Accelerate Optimized Hydrogen Production

Combined Cycle Plants
1980–2010

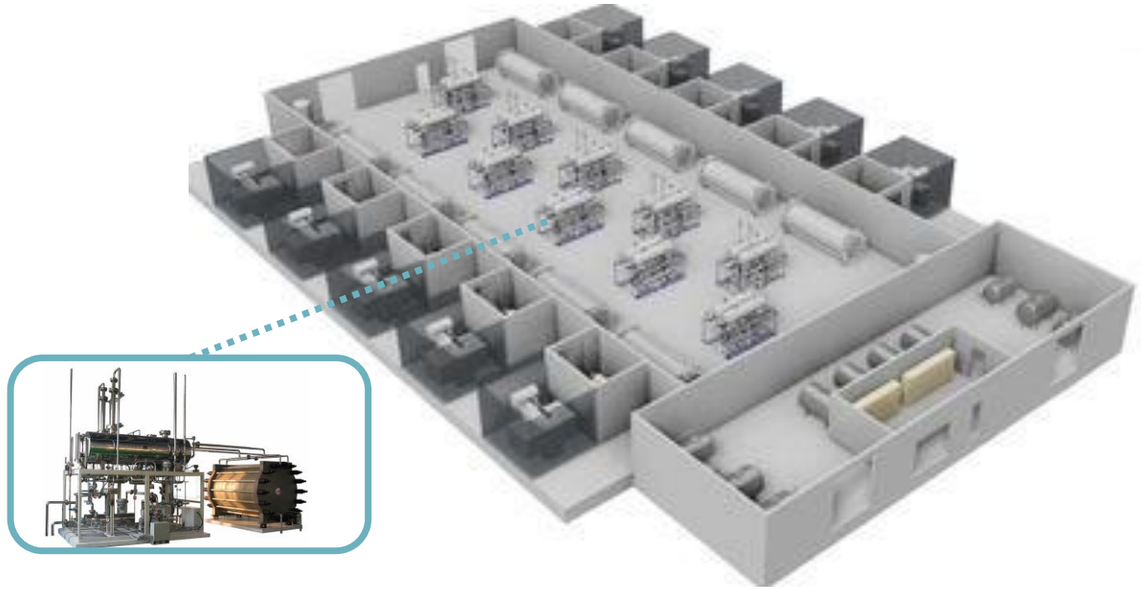
- Plant size from sub 100MW to almost 800MW
- Combined cycle efficiency from less than 40% to more than 60%
- Availability from low 80% to high 90%
- True operational flexibility now achieved
- Predictive maintenance strategies
- Enhanced process safety



Hydrogen Plants
2020–2030

- Accelerated learning rate for optimized operation
- Efficiency and availability improvements, predictive maintenance strategies
- Plant-wide enhanced process safety

Automation and simulation software will again play a key role in improving reliability, performance, safety and start-stop flexibility.



Digital Transformation

Accelerate Learning Rate Powered by Digital Twin & Data Analytics

4 MW

Unit Tuning based on
First Principles (FP)

Excel MATLAB aspentech

20 MW

Digital Twin &
Plantwide Process Safety

aspentech

100 MW

Enhanced Digital Twin with
Data analytics for patterns recognition

200 MW

Data Lake enabling
unlimited scalability

EMERSON PLANTWEB optics

Industry Maturity
& knowledge
(2030)

GW Fleet

Fleet Management +
CertifHy green origin

H_2 $/t

Core Assets Manufacturers | **Plant Builders** | **Large Scale Operators**

- The hydrogen economy is accelerating
- Cost will proportionately decrease as capacity increases
- Industry must evolve from small-scale to large-scale plant mentality
- Hydrogen complements renewables with flexible energy storage

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- There are significant opportunities across the hydrogen value chain to drive safety, efficiency, reliability and cost competitiveness
- Digital foundations and automation are strategic levers to accelerate learning and help scale the hydrogen economy
- Emerson’s technologies offer value-added solutions to overcome new challenges facing operators in the hydrogen sector

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Digital Transformation & Automation Across the H_2 Value Chain

Value Chain Area	Challenges	Key Enablers
Renewable Hydrogen Production (“Green” H_2)	• Safety & integrity • Scalability • Cost optimization	• Non-intrusive, wireless fluid property and asset monitoring • Digital design, analytics and collaboration
Decarbonized Hydrogen Production (“Blue” H_2)	• Efficiency • Process optimization	• Measurements independent of fluid properties • Intermediate stream analysis • Carbon capture integrity
Transmission, Storage and Distribution	• Reliability • Compliance	• High integrity valve and packing solutions • Compositional analysis suitable for varying H_2 blends
Consumption	• Safety • Efficiency • Accuracy	• High accuracy, high pressure, efficient dispensing solutions • Scalable H_2 flame and gas detection

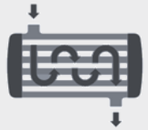
Emerson's Digital Transformation Ecosystem

MANY PLANTS

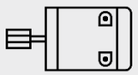
PLANT

PROCESS UNITS & COMPLEX ASSETS

ASSETS



COMPONENTS



PLANTWEB

Plantweb Optics Analytics

Operational Certainty Consulting

Data Management & Integration

Simulation & Digital Twin
Mimic, GSS software

AI & Machine Learning
Plantweb Optics Analytics

Embedded APC
DeltaV with Analytics

Plant Health & Performance
Plantweb Optics Analytics Templates

Machinery Health
PeakVue & Integrated Prediction and Protection

Equipment Health
20+ Plantweb Insight Applications

Device Diagnostics
1000s of Embedded Diagnostics

AMS: Industry Leading Asset Manager

Predictive Field Analytics
Analytics in Devices & Software

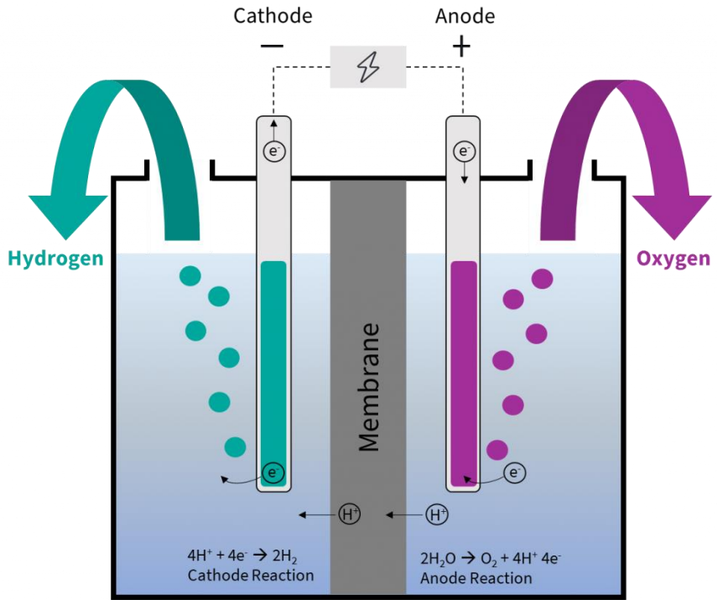
Device Health Alerts

1980

2022

Hydrogen Generation Primer

Renewable hydrogen
("green H_2")

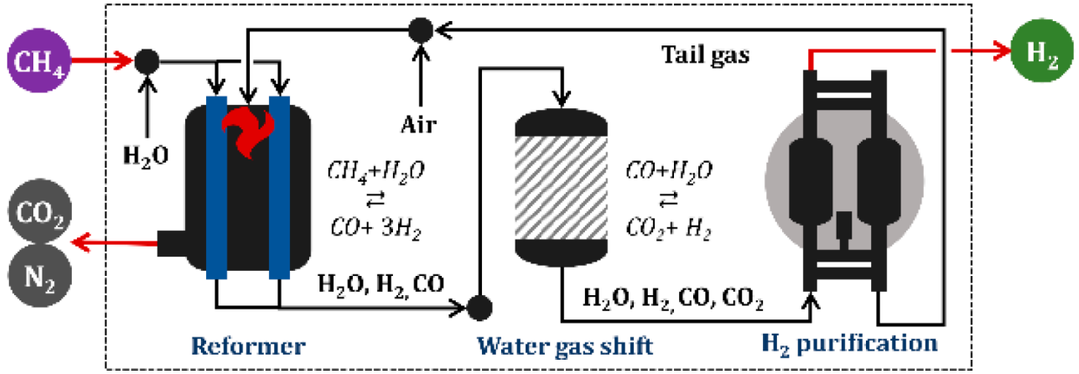


Process unit: Electrolyzer

Inputs: renewable electricity, water, catalysts, heat (optional)

Outputs: oxygen gas, hydrogen gas

Decarbonized hydrogen
("blue H_2")



Process unit: Steam methane reformer (SMR)

Inputs: methane gas, steam, heat

Outputs: hydrogen gas, carbon dioxide (captured), other impurities

Ensure Electrolyzer Safety and Integrity with Process Measurement

Operational Challenges

Premature **fouling and degradation** due to insufficient **temperature and pressure** control

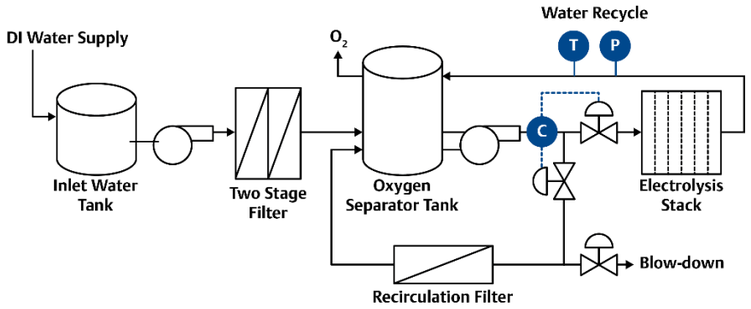
Plant **safety** concerns due to **H_2 flammability**

Water quality can **affect electrolyzer stack**

Premature equipment failure and safety/environmental concerns

Value Improvement Practice

Non-intrusive measurement, wireless installation, gas & water analysis



Implement process measurement and control before damage occurs or safety compromised

Impact on Operations

Prevent electrolyzer **damage** and **ensure operational performance**

Improve electrolyzer and overall site **safety**

Reduce installation costs and design **complexity**

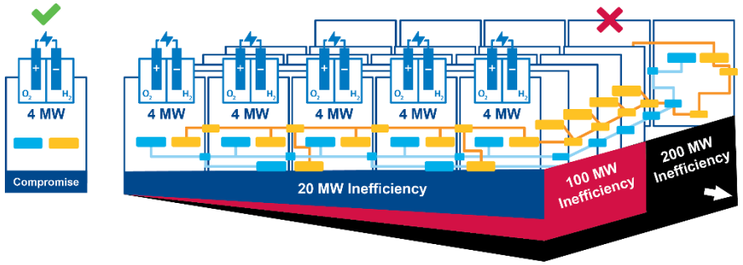
Top Quartile Performance

Automation Enables Scalability for Large Plant Production

Operational Challenges

Large scale H_2 plants designed of modular electrolyzer assemblies

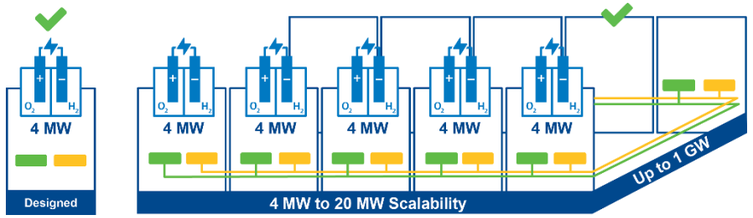
Base design compromises for one electrolyzer become plant inefficiencies



Premature equipment failure and safety/environmental concerns

Value Improvement Practice

Smart devices, data analytics, digital twins, collaborative tools



Implement digital automation technology to streamline scalability

Impact on Operations

Accelerate learning curve

Improve operational efficiency

Optimize design and **implementation**

Top Quartile Performance

Automation Integral to World's First Offshore Green Hydrogen Production Process

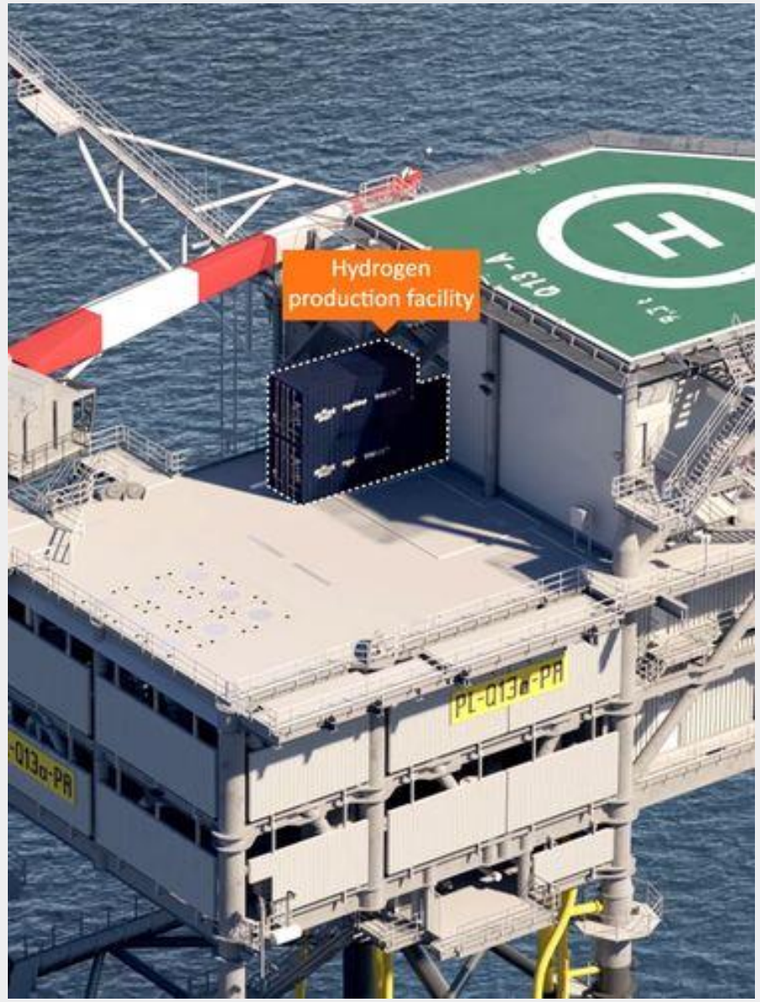
PosHYdon Project by Neptune Energy

OBJECTIVES
- Validate integration of offshore wind power and natural gas and hydrogen production at sea for large-scale renewable hydrogen production

CHALLENGES
- Operational variability of wind power supply
- Variable desalinated water feedstock and power supply

SOLUTIONS
- Ensure existing natural gas operations remain unaffected
- Ensure blended gas meets required specifications
- Enhanced safety, uptime and operational efficiency

KEY EMERSON TECHNOLOGIES
- DeltaV, flow meters, valves, regulators



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Measurement Insight to Drive Blue Hydrogen Production Efficiency

Operational Challenges

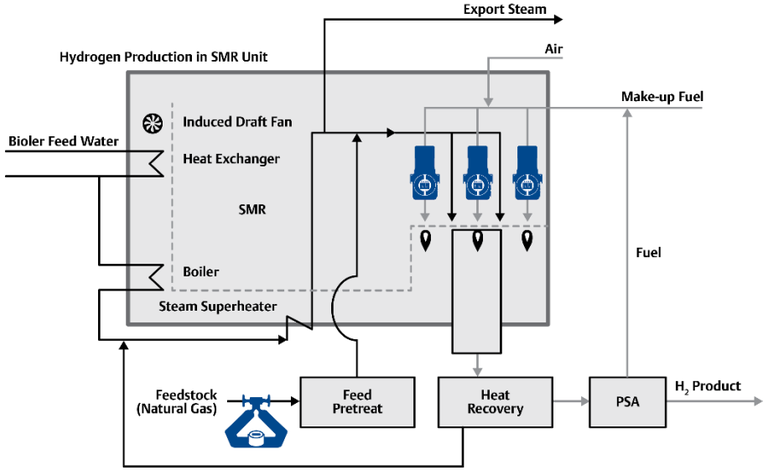
Difficulty maintaining target steam to carbon ratio

Energy and maintenance costs challenge economics

Suboptimal intermediate streams **drive inefficiency**

Value Improvement Practice

Coriolis mass-based flow metering and continuous, online compositional analysis



Impact on Operations

Minimize methane releases through efficient combustion

Lower operating costs and energy consumption

Extend catalyst life and avoid costly reformer damage

Changing feedstock quality leads to issues controlling reformer efficiency

Smart metering systems and process analysis can optimize SMR

Top Quartile Performance

Improve Carbon Capture Reliability, Throughput & Treatment Capacity

Operational Challenges

Carbonic acid attack where water vapor condenses

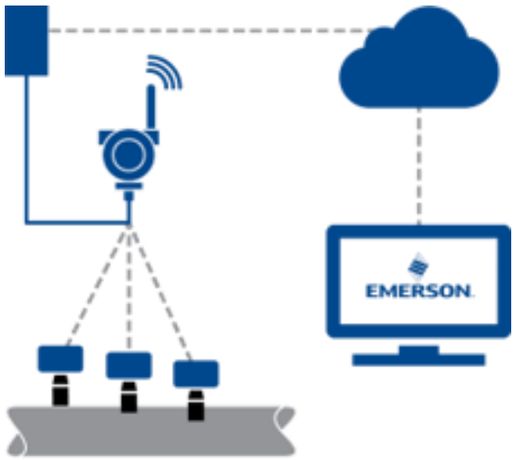
Formation of two-phase feed can result in **erosion**

Heated stable salts can cause **foaming and fouling**

Multiple process conditions can affect amine solvent reliability

Value Improvement Practice

Wireless ultrasonic sensors can measure wall pipe thickness and detect impact of corrosion to assets



Continuous monitoring of asset integrity extends equipment life and avoids costly upsets

Impact on Operations

Detect corrosion events early to **prevent loss of containment**

Reduce cost and **increase uptime** by prioritizing maintenance

Decrease installed cost with wireless capabilities

Cost-effectively ensure captured carbon stays captured

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Prevent Releases and Drive Compliance in Blended H_2 Transmission

Operational Challenges

Embrittlement and leakage concerns can impact reliability

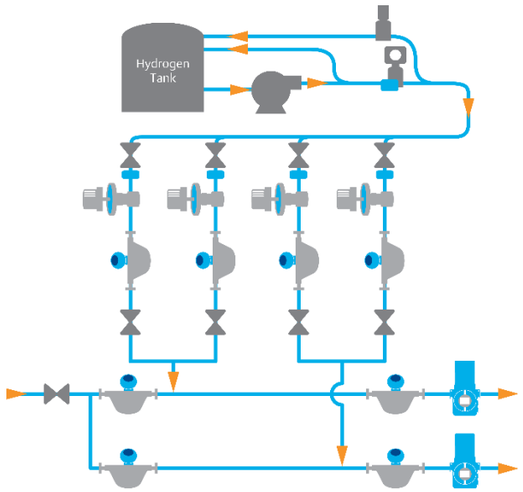
High vibration and pressure can cause **unplanned emissions**

Installed gas analysis equipment **not suitable for H_2** analysis

Hydrogen embrittlement can impact pipeline reliability

Value Improvement Practice

Smart pressure regulation, integral valve design and packing solutions, complete compositional analysis



Optimize, control and monitor blends while eliminating potential leaks

Impact on Operations

Stable pipeline pressure control

Compliance to as quality standards

Fast, accurate valve actuation and **improved diagnostics**

Increased safety, reduced emission risk, contractual compliance

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Ensure Safe, Efficient and Accurate H_2 Dispensing Applications

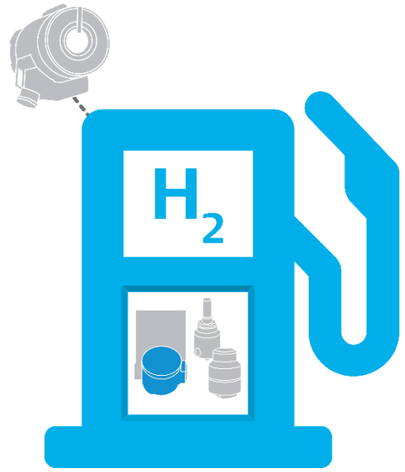
Operational Challenges

- **Precise pressure** and **flow** control at reasonable **dispensing speed**
- Financial impact to buyer/seller in case of inaccurate measurement
- Filling stations bring **hydrogen hazards to general public**

Consumer demand for safety, efficiency and accurate transactions

Value Improvement Practice

High pressure dispensing with accurate flow control; robust hydrogen flame detection



On-board diagnostics and certified designs for implementation and scalability

Impact on Operations

- **Certified metering** to meet dispensing requirements
- Industry-leading accuracy ensures **appropriate billing**
- H_2 **flame and gas detection; reliable** fuel flow starts and stops

Safe, efficient, accurate, certified dispensing solutions

Total Energies Brings Hydrogen Dispensing to the Netherlands

PinPoint Refueling Station in Arnhem, Netherlands

OBJECTIVES
- Design, build and implement dispensing stations in the Netherlands to provide fuel to hydrogen vehicles

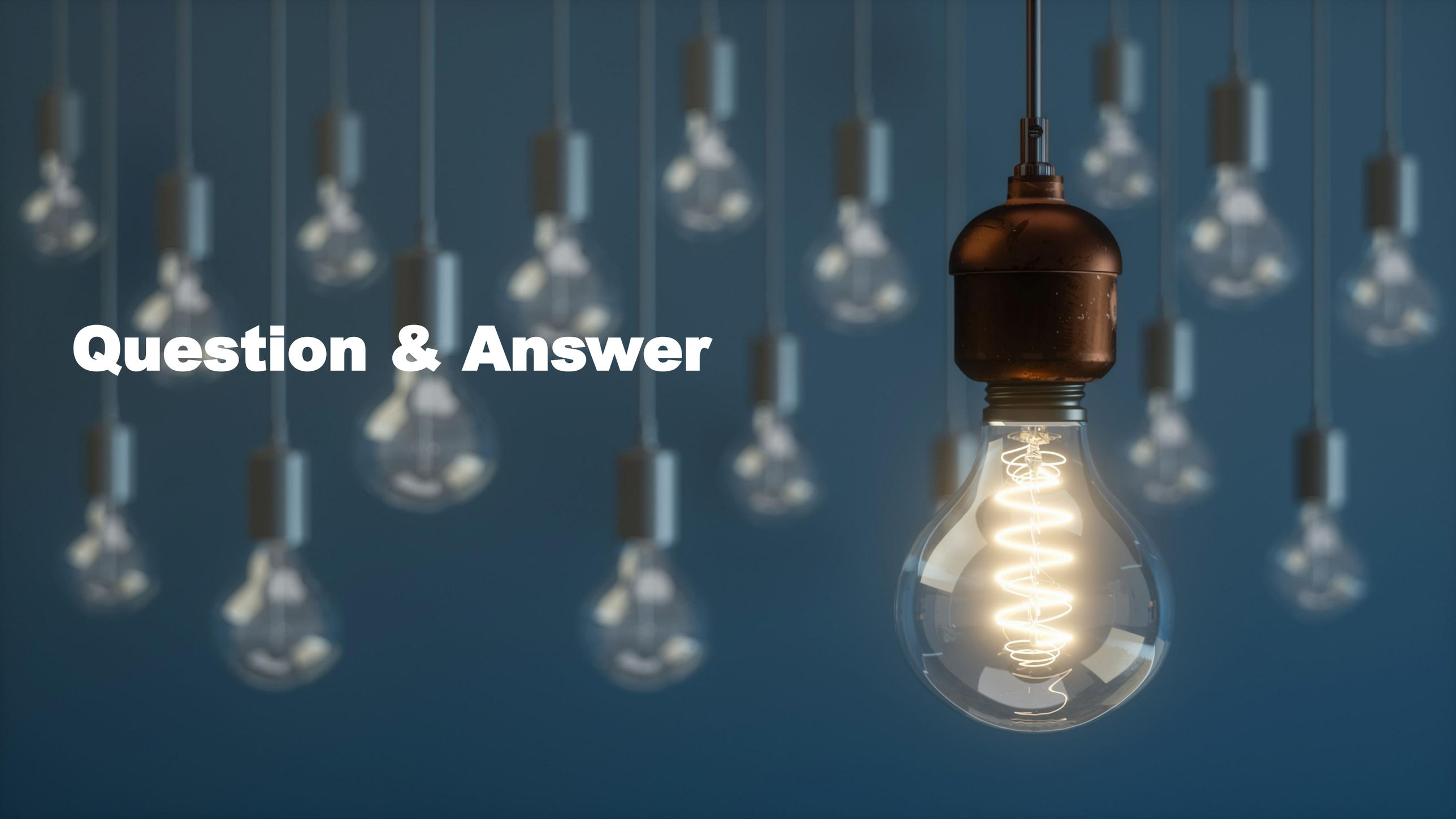
CHALLENGES
- Hydrogen fuel dispensing certification relatively new
- Limited options for high-pressure flow metering
- Lack of calibration and certification protocol

SOLUTIONS
- Confidence and transparency in H_2 dispensing applications
- Collaboration amongst independent and national metrology institutes

KEY EMERSON TECHNOLOGIES
- Micro Motion High Pressure Coriolis Flow Meter

- There are significant opportunities across the hydrogen value chain to drive safety, efficiency, reliability and cost competitiveness
- Digital foundations and automation are strategic levers to accelerate learning and help scale the hydrogen economy
- Emerson’s technologies offer value-added solutions to overcome new challenges facing operators in the hydrogen sector

Question & Answer



THANK YOU

Please share your feedback

Join at **slido.com** or follow the link in the chat.

Participant code: **#8983348**

Password: **56fqiv**

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