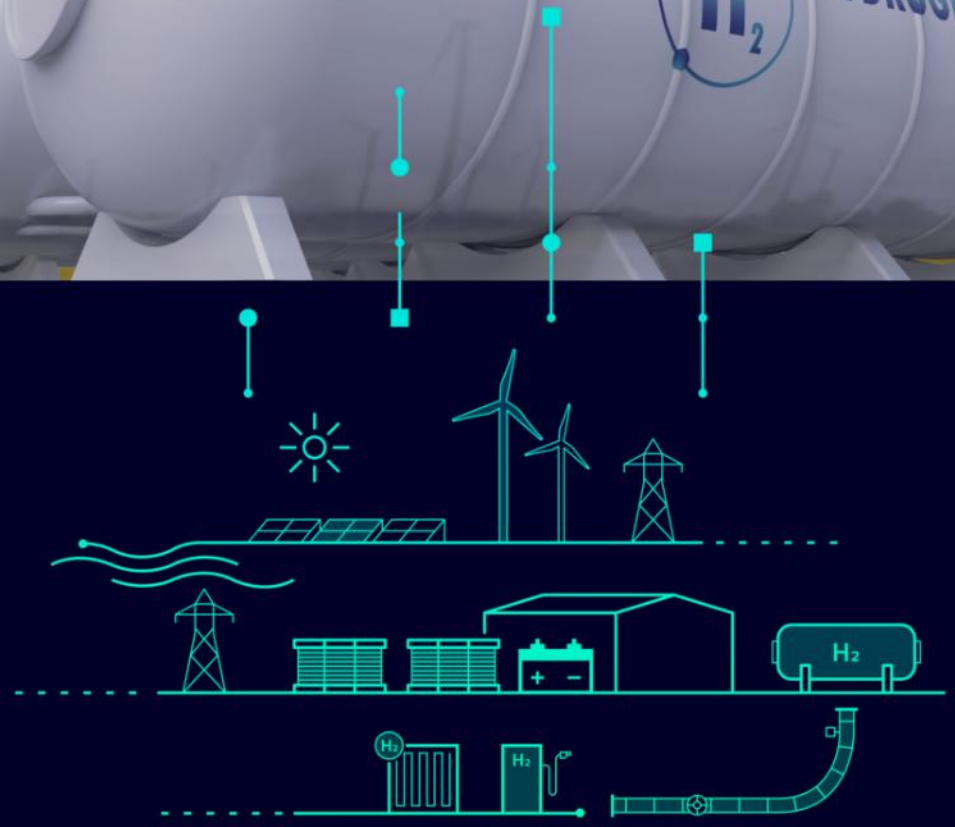
Unlocking Green Hydrogen Potential

Industry Insights

From market reality check to H2 ecosystem stakeholders' challenges



The session aims to address practical execution challenges to ensure success in green hydrogen projects

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What green Hydrogen (Molecule) is mean for
Decarbonizing what electrons can't

Direct electrification handles ~70% of the energy transition. Hydrogen exists for the remaining ~30% Places where electrons can't go:

- high-temperature heat,
- dense molecules for ships and planes,
- chemical reduction,
- long-duration storage.

It's not a competitor to renewables BUT it's their downstream conversion product.

WHERE IT GENUINELY BELONGS

Industrial Application

Refining, ammonia, methanol — green simply substitutes for grey.

High-temp / reduction

Steel via H_2-DRI, cement kilns, glass furnaces.

Heavy & long-haul

Shipping fuels (NH_3, methanol), aviation eSAF, long-haul trucking

Energy storage & Green Power

Seasonal energy storage; converts surplus renewables to a transportable molecule.

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What green Hydrogen (Molecule) is mean for
Target Market

In 2021, hydrogen was the answer to almost every decarbonization question. In 2026, the answer is more selective. Direct electrification has won several battles. Hydrogen is consolidating around use cases where it has no real alternative.

WORKING — KEEP BUILDING

Refining & chemicals

H_2 is already a feedstock; green simply substitutes grey. 80% of FID-committed investment is here.

Ammonia / fertiliser

RFNBO certification, Indian green H_2 mission, and Asian export demand provide bankable offtake.

Shipping, maritime fuels, eSAF (e-aviation fuel)

FuelEU Maritime + emerging IMO net-zero framework give regulated, near-term obligations. EU SAF mandate; small but growing premium market. Slow but real.v

Hydrogen Power Unit

Fuelcell based power unit for temporary power unit or un-electrified remote areas

STRUGGLING or DELAYED — MONITOR IT

Steel via H2-DRI

Cost premium too large vs. EAF + scrap but limited and geographically uneven. Companies are investing but still facing some H2 cost issues. Long-term solution.

Heavy road transport

Battery-electric is winning the truck wars but FCEV truck is much better option for long-haul distances.

Light-duty vehicles

BEVs already won. ~40k FCEVs globally vs >50m BEVs. Refueling infra as well as H2 cost limit the development as for now

Residential heating

Heat pumps dominate. Most national hydrogen heating trials cancelled or scaled back. H2 could be still a solution for hard-to-electrify buildings

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Baleh project

Location? Sarawak?
Key Advantages : Hydropower !!! Competitive energy is key

Sarawak is already one of the most hydro-dependent grids in Southeast Asia
Current Hydropower Capacity : about 5,900 MW
Future Hydropower Potential : Over 10-15 GW of additional economically viable hydropower potential identified in Sarawak's river systems for expansion. Baleh Hydroelectric Project under construction will add 1.285 GW, with more projects planned for 2030–2035.

Hydro Power is low Cost with low carbon intensity and produced continuously, ideal to produce green hydrogen.

→ Developing a local hydrogen economy is a meaningful option to just exporting electrons.

Sarawak’s competitive advantage is not just hydropower—it is the ability to convert surplus baseload renewable energy into globally traded green molecules

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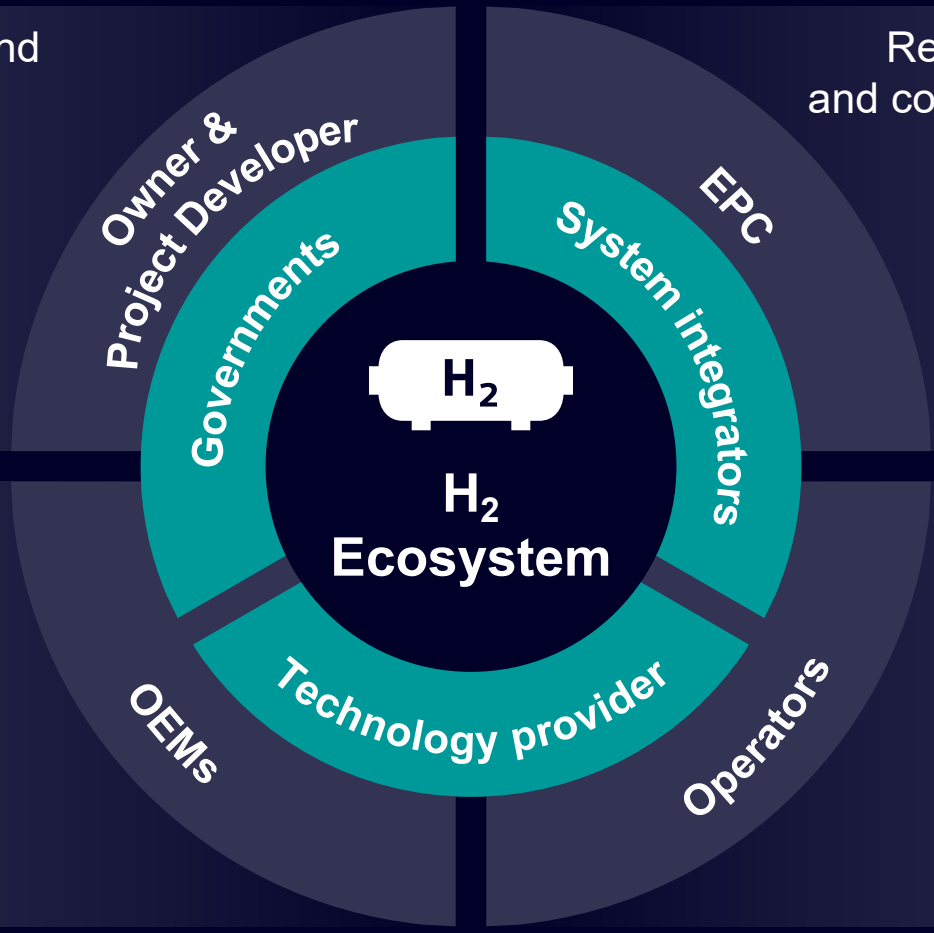
The hydrogen ecosystem included various key players from OEMs to EPC and Owner & Operators with their own sets of challenges

Secure project funding & financing and optimize concepts and project cost

Reduce risks in engineering, integration and commissioning of new plant types. Fast and cost-effective project execution

Ramp up production & scale up Factories, to ensure cost effective and high performance Solution

Safely, reliably, and efficiently operate plant throughout its lifecycle



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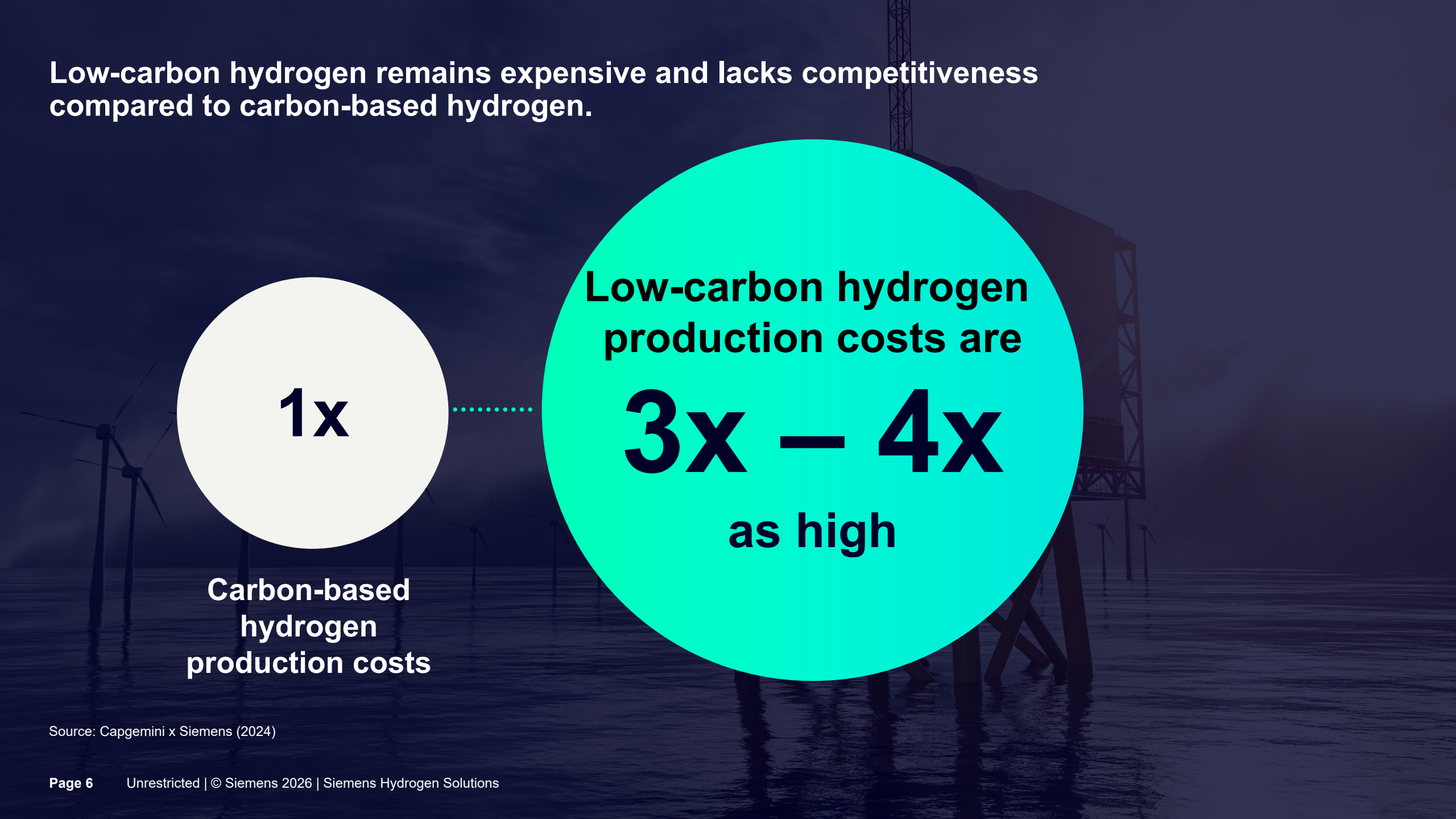
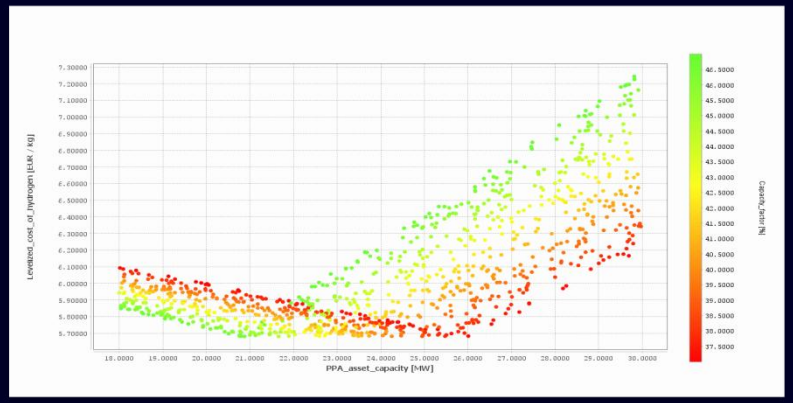
Low-carbon hydrogen remains expensive and lacks competitiveness compared to carbon-based hydrogen.



Source: Capgemini x Siemens (2024)

We identified key levers to reduce costs for every stakeholders in the hydrogen industry by quickly & efficiently bringing factories to life, products to market and plants online.

Feasibility



Confirm technical economic feasibility, technology choices Vs LCOH

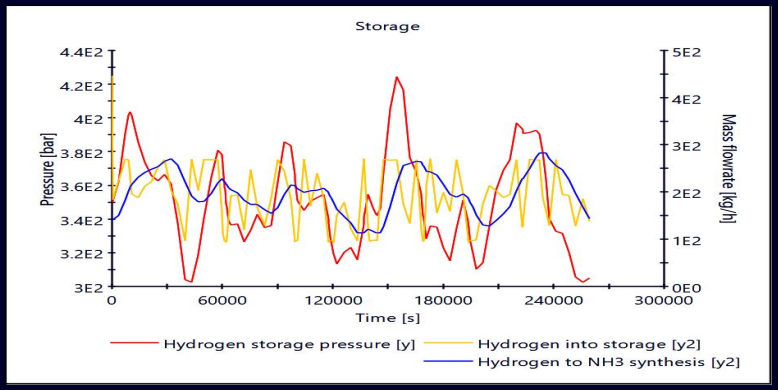
Scalability

Speed up electrolyzer production capacity ramp-up

Increase standardization

Develop blueprints for green H_2 plants to achieve scalability

Efficiency



Leverage digitalization to increase efficiency in H_2 production process

Optimize energy efficiency from electric power to production of H_2,

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Siemens Offering to Project developer

Techno-economic assessment to optimize the project planning and to ensure successful start

Benchmarking & best practices

- Analysis & benchmarking on technical & economical best practices of emerging hydrogen technology

Energy mix & sourcing

- Optimization of setup including BESS and grid connection
- Evaluation of energy sourcing options to maximize efficiency & optimize costs

Financing advisory & services

- Financial advisory & consulting services in early project phases to validate business case
- Financing solutions, incl. debt and equity in later stages

Technical design

- Design and simulations of setup and plants from electrification, including grid to process flows
- Technical advice on process design concepts and regulatory frameworks

Dimensioning

- Analysis of required input (electricity sources) and desired output (H_2/ ammonia/synfuel) volume
- Dimensioning of key plant parameters

Business model consulting

- Calculation of levelized costs of production including CapEx and OpEx relations
- Understanding of money earning options and off-take opportunities

Renewable capacity analysis

- Assessment of available renewable energy sources and seasonal fluctuations
- Comparison of capacities in different locations

Technical feasibility Economic feasibility

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Nobody designs a screw from a scratch …

… would you reinvent your Hydrogen units every time?

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Elevating hydrogen plant development through **simulation and advanced engineering**

Integrated Digital Twin

From Process design to P&ID, Automation engineering and virtual commissioning.

Standardized Engineering Templates

P&ID and Pre-tested Automation templates reduce engineering hours by over 30% for hydrogen applications.

Modular and Containerized Solutions

Factory-tested automation cabinets and E-houses pre-configured to reduce installation time and risks onsite.

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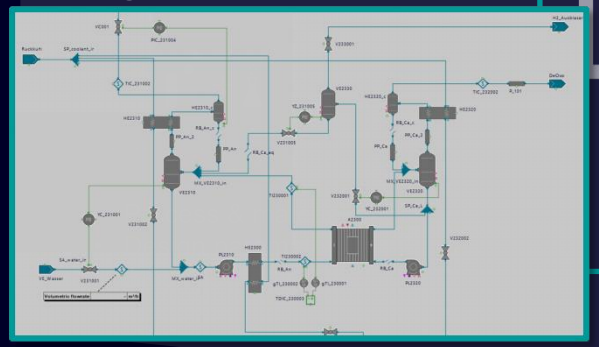
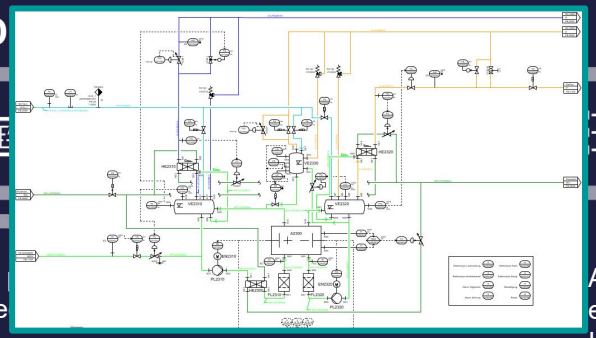
Integrated Engineering Workflow
Integration of simulation and visualization packages

Process Design (gPROMS)



Plant Engineering (COMOS)

P&ID

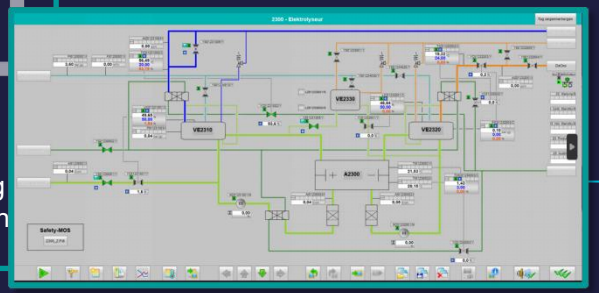


Process
& engine
P&IDs

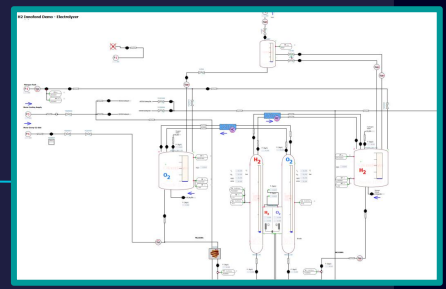
PAA

Automation
engineering
• Instantiation

Process Automation (SIMATIC PCS 7)²

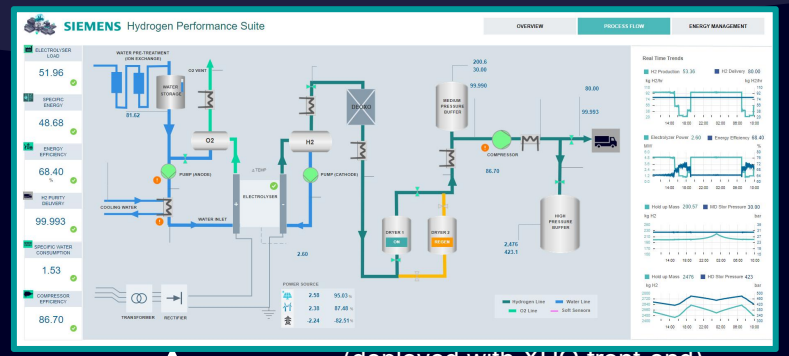


Plant Simulation (SIMIT)



- Seamless and efficient engineering workflow using digital software tools
- Pre-engineered templates

Hydrogen Performance Suite (XHQ)



(deployed with XHQ front-end)

External data

[1] import BPCM library, export automation data
[2] HPS is independent from Engineering and DCS vendor

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Siemens simplifies projects with fully equipped and pre-tested modular substations

Benefits of E-houses

Better delivery time with parallel detail design and manufacturing

Less civil works due to compact design

Reduced resource costs through one-stop contract for engineering

E-house can **reduce lead time up to** **50%**

and provides **cost saving potential up to** **20%**

in power distribution systems

Optimize the hydrogen plant operation, while meeting safety requirements and dealing with lack of skilled personal!

Remote operation
Unmanned operation and plant operation cockpit combining real data and soft sensors

Optimization & smart operation
Digital Twin and AI for process optimization and Energy management, forecasting and load management

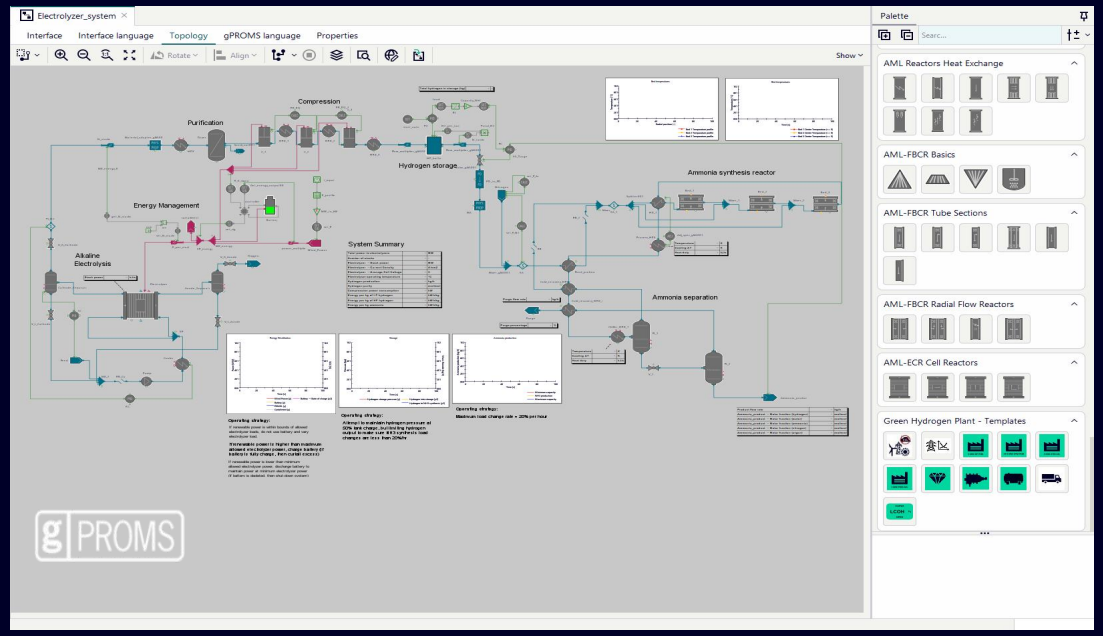
Remote & Predictive Maintenance
Smart Sensor, AI and Machine learning to predict failure on critical assets

Safety-certified products and processes, holistic **cybersecurity** concept, and transparency on **product carbon footprint**

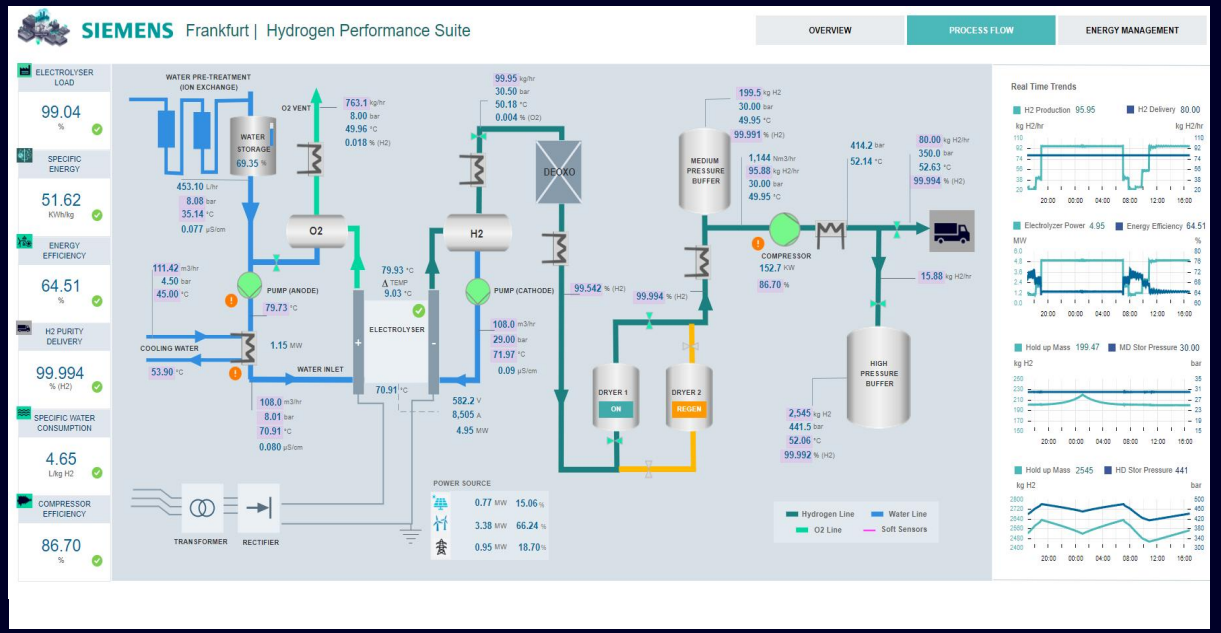
Produce high-quality hydrogen at lower cost, while meeting safety and sustainability targets

Leveraging the Process Digital Twin
A digital thread from design to operations

Offline: Building the Process Twin



Online: Deploying for Digital Operations



High-fidelity, physics-based modelling of the process

Predict performance and validate plant design

Ensure optimized asset performance

Powerful application for H_2 & Power-to-X plants

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The Hydrogen Performance Suite

An integrated process cockpit for plant management and optimization

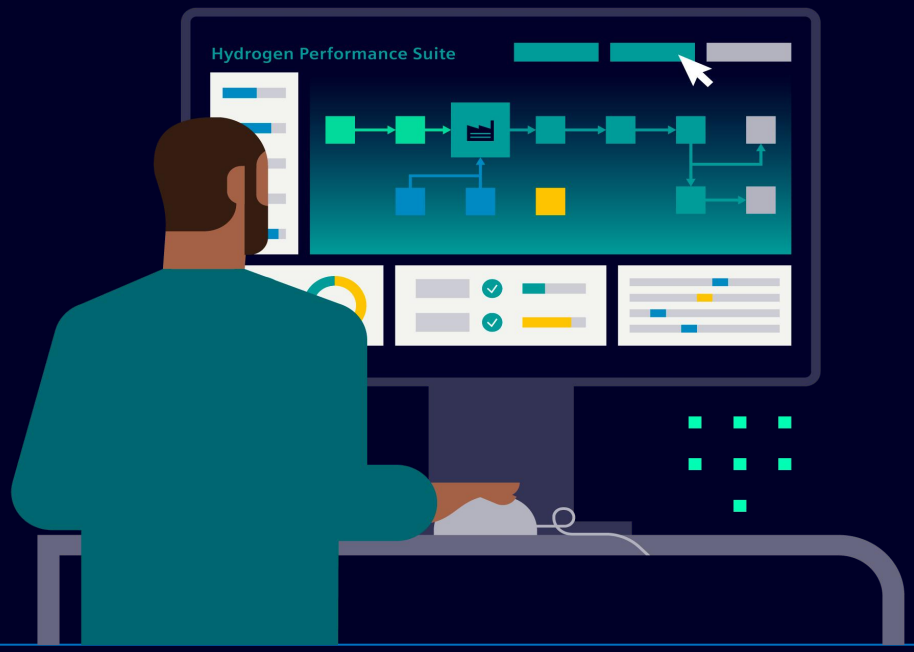
Asset Performance Monitoring

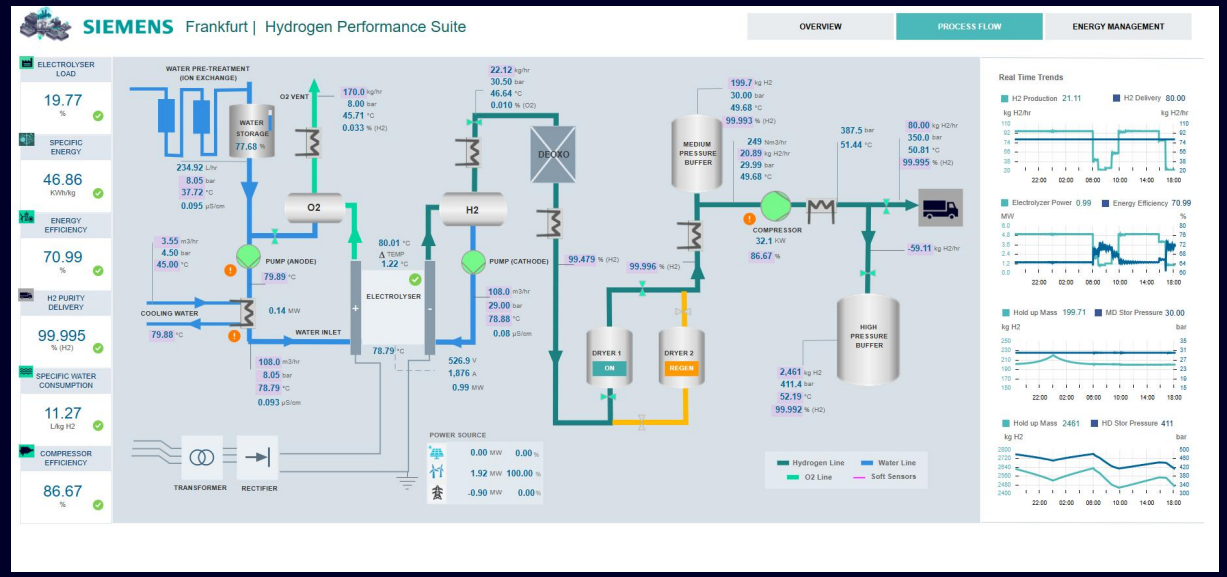
Dynamic Real-Time Optimization

Equipment Soft-Sensing

Connected to Plant Automation

Modular & Scalable Platform





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Benefits of SIEMENS solution

Energy Efficiency Improvement (5%)

- Determine optimal operating point: balancing current density against efficiency
- Dynamic load management to maintain peak efficiency across varying renewable inputs
- Preventive degradation management to prevent efficiency drift

Value = 2.3 €M/y

Improved Availability (1%)

- Detect performance deviations before failures
- Schedule maintenance during planned windows
- Reduce unplanned outages
- Monitors and forecast anomalies
- Provide 2-4 weeks advance warning of potential issues

Value = 1.3 €M/y

4.4 €M/y

Monitor, optimize and de-risk operations with *"digital native"* green H2 production

Reduce LCOH

Extended Stack Lifetime (2 – 10%)

- Monitor real-time degradation
- Operating strategies to minimise wear while maintaining production targets
- Avoiding aggressive operating conditions
- Extend stack replacement intervals

Value = … €M/y

Optimized Production Scheduling (5%)

- Increase by energy bought in the day ahead market by 5%
- Maximize benefits from agreed PPA flexibility
- Improve day-ahead grid supply by optimizing production planning

Value = 0.8 M EUR/yr

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Inefficiency Is Eating Your Margins

- **30–50% of OEM engineering hours** are spent on repetitive integration tasks.
- **Unplanned downtime** can cost up to **$260,000 per hour** in critical production lines.
- **70% of OEMs** say they lack real-time visibility across machines and systems.
- Time-to-market delays of just **2 months** can cut **profitability by 20%** in new product launches.
- Only **20% of OEMs** fully leverage digital twin or simulation in machine design.

Every day without digital integration is a day of lost margin

Source: ITIC 2020 Downtime Survey; Senseye/IIoT World; Siemens research 2024

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Siemens offering to OEM

Standardization is key as well as digitalization!

Totally integrated automation for machines & factory from design, realization to operation

Smart Factory with Full transparency over system performance & resource efficiency, data contextualization & analytics for predictive maintenance

Standardized automation specifications and support to reduce risk, save time and cost

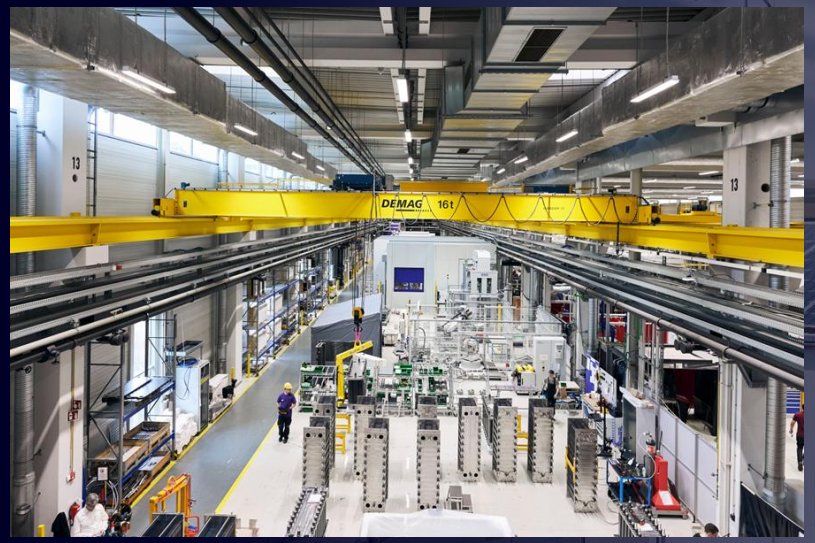
Scalable and modular hydrogen solutions from design, engineering and installation for smooth integration in every application

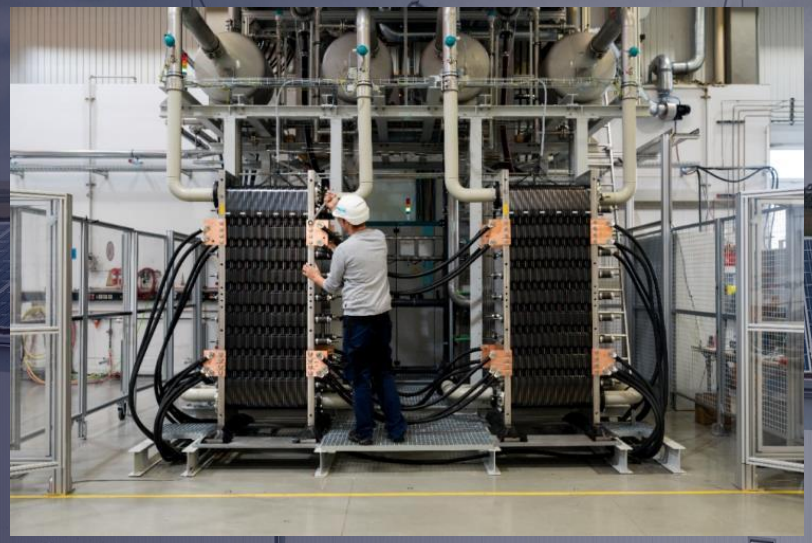
Safety-certified products and processes, holistic **cybersecurity** concept, and transparency on **product carbon footprint**

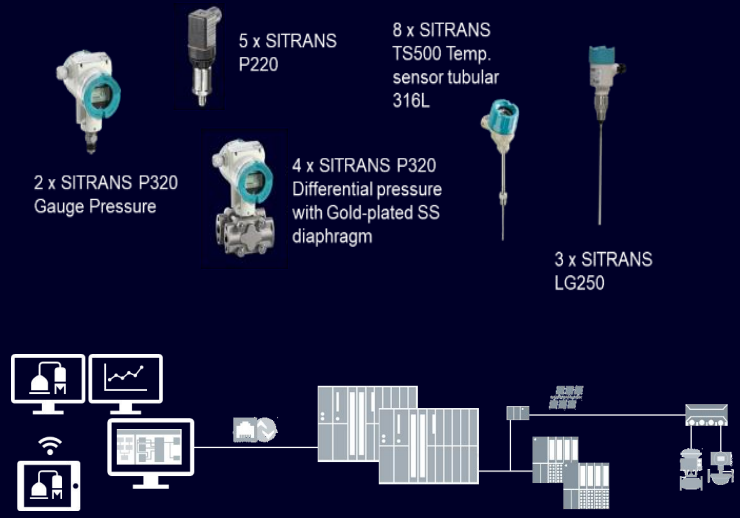
Produce high-quality hydrogen units at scale, while meeting delivery, safety, cost, and sustainability targets

Hydrogen Ecosystem

Siemens is the preferred partners of many Electrolyzer OEMs







Linde

thyssenkrupp

Air Liquide

John Cockerill 考克利尔竞立

PH2 Peric Hydrogen

LONGi

SIEMENS energy

nel

SUNGROW

sunfire

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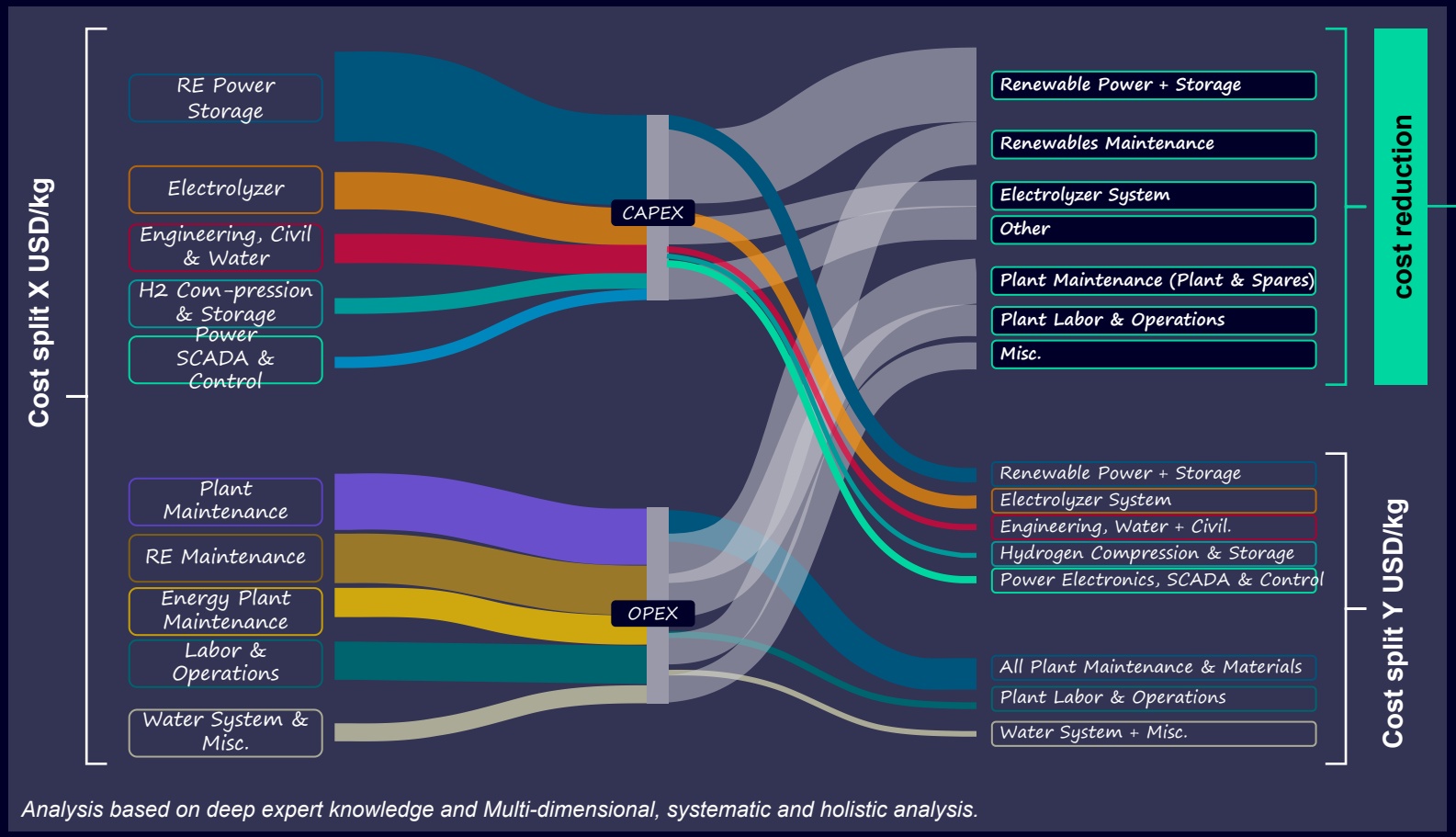
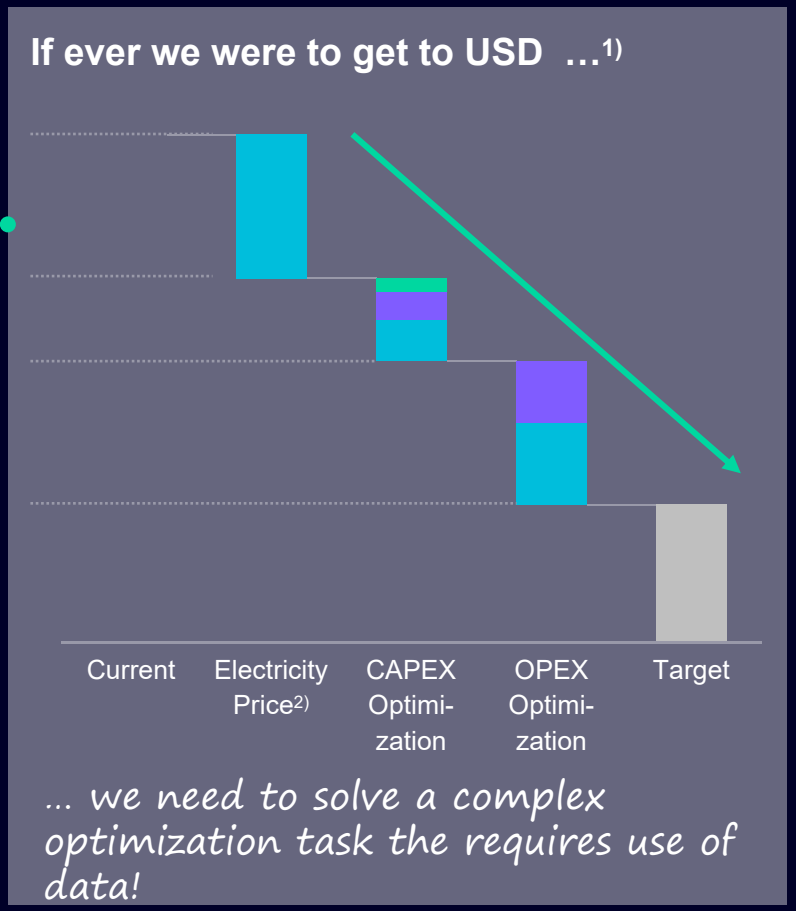
Cost savings for green hydrogen imply a complex optimization task, which requires a native Digital Plant to enable intelligent use of data in engineering and operation



Analysis based on deep expert knowledge and Multi-dimensional, systematic and holistic analysis.



Electrolyzer design hub | Electrolyzer & components plant | Green H_2 production | Power-to-X and H_2 derivatives

1) Proportions built of simulation, but are to be identified in concrete scenario
2) Some of the Electricity Price cost is included in CAPEX and OPEX optimization. Also including pumped-hydro and associated storage requirements

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Get in touch
Let’s ramp up your production and scale your business

Visit our website
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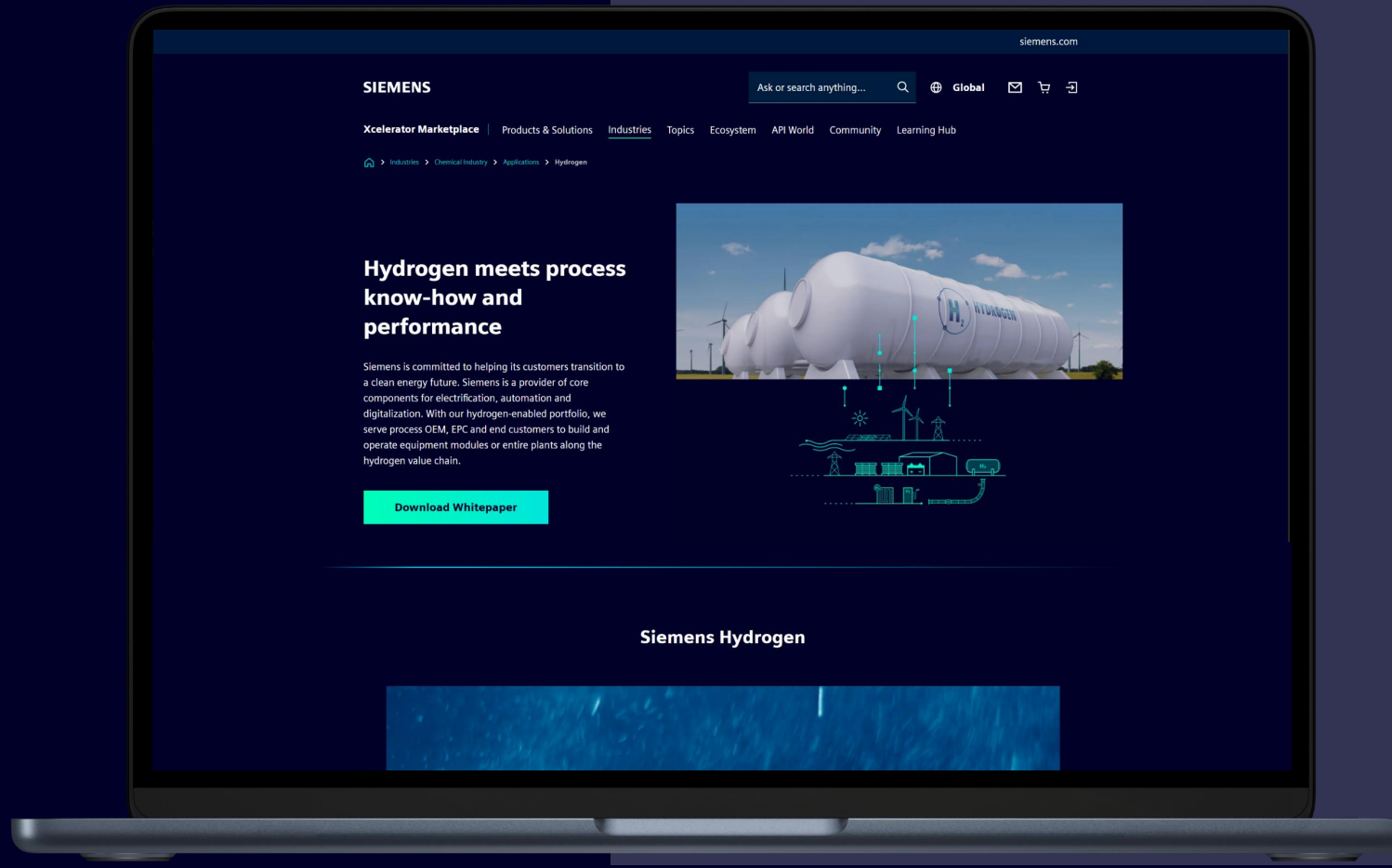

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Thank you

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