Hydrogen Solutions Guide

of the electrodigital industry

Edited by GIMELEC

As part of its partnership with France Hydrogène

Engagée pour la transition écologique

Automation

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Introduction

About the GIMELEC Hydrogen Commission

GIMELEC Hydrogen Commission brings together more than 50 manufacturers and solutions providers active across the entire hydrogen value chain, from production to transport, storage and use (industry, mobility, H_2-to-Power, etc.). Their solutions allow project developers to optimize the operation, safety, costs and environmental footprint of hydrogen installations.
https://gimelec.fr/hydrogene

About this guide

This publication is intended for project developers and integrators. It has been redacted by GIMELEC as part of its partnership with France Hydrogène. **The first part is a "white paper"** identifying the challenges and constraints for automation across the hydrogen value chain; the second part presents the solutions to meet them and is a directory of GIMELEC companies.
GIMELEC companies offer solutions for electrolyser power supply, automation and instrumentation. This part of the guide is dedicated to automation for the hydrogen sector. Find the two other sections at the following link.

About GIMELEC

GIMELEC brings together companies from the French electronics and digital sector. Our 210 members design, manufacture and deploy electrification, automation and digitalisation solutions for industry, buildings, mobility, energy and digital infrastructures.
https://gimelec.fr

About France Hydrogène

With 450 members, France Hydrogène brings together the players of the French hydrogen industry along the entire value chain: large industrial groups, SMEs, start-ups, laboratories and research centres, associations, competitiveness clusters and local authorities.
GIMELEC is a partner of France Hydrogène and this document follows and complements the Panorama of Hydrogen Solutions published by France Hydrogène.

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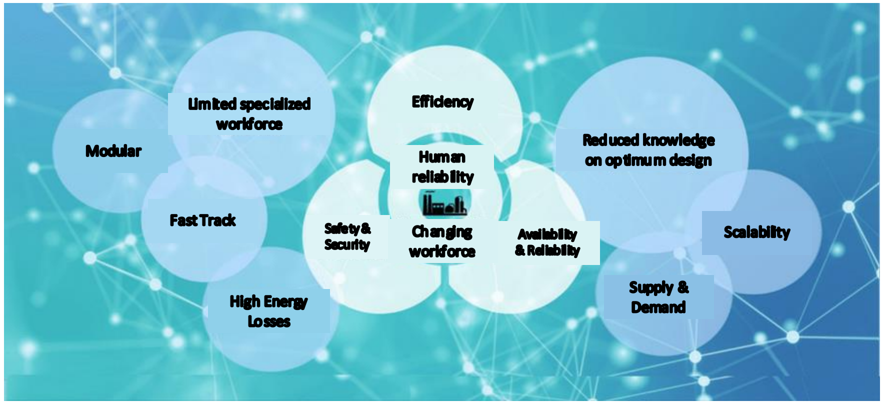
Major automation challenges in hydrogen



CAPEX / OPEX reduction

→ Optimization of renewable power supply cost
→ Greater cost synergies with oxygen and waste heat valorization
→ Plant design optimization & operational efficiency improvements
→ Remote & predictive maintenance

Carbon footprint reduction

→ Full traceability of energy consumptions and GHG emissions across the value chain

Operations & workers safety

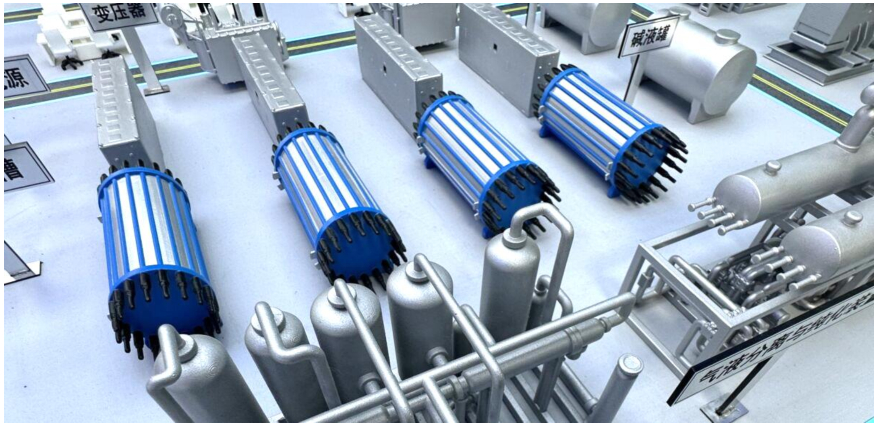
→ Process control & safety
→ Efficient maintenance
→ Cybersecurity
→ Asset surveillance

Capacity scale-up

→ Standard and modularized solutions
→ Progressive upscaling from a few MW to a few hundred MW to GW scale

Resource flexibility & control

→ Balancing power supply and production loading to optimize LCOH
→ Balancing intermittent power supply and production loading in P2X projects with subsequent continuous processes

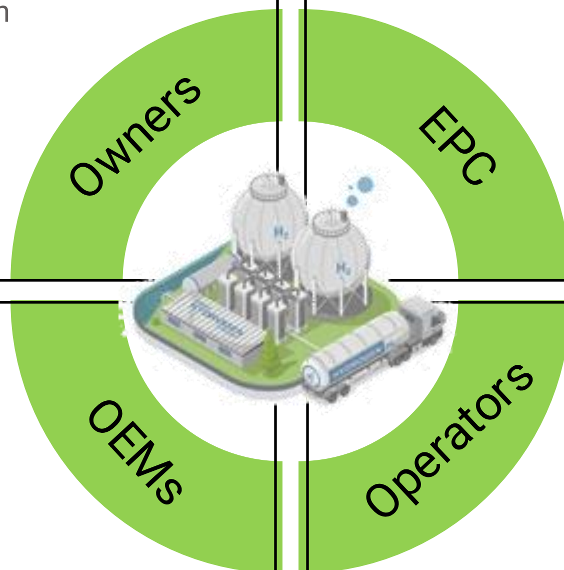


Nota : LCOH = Levelized cost of Hydrogen
Image credit : PV magazine, Yokogawa

AUTOMATION IN HYDROGEN (2/2)

Automation solutions address key stakeholders' challenges

Automation solutions help key stakeholders meet their targets across the entire project lifecycle:



Owners

- **Objectives:** Produce high-quality hydrogen at scale while achieving best returns and sustainability targets
- **Challenges:** secure project funding & financing, optimize concepts

EPC

- **Objectives:** Provide high-quality, cost-effective and on-time hydrogen projects while meeting customer and regulatory requirements
- **Challenges:** Reduce risks in engineering, integration and commissioning of new plant types

OEMs

- **Objectives:** Produce high-quality hydrogen units at scale while meeting delivery, safety, reliability, cost and sustainability targets
- **Challenges:** Ramp up production, scale-up factories

Operators

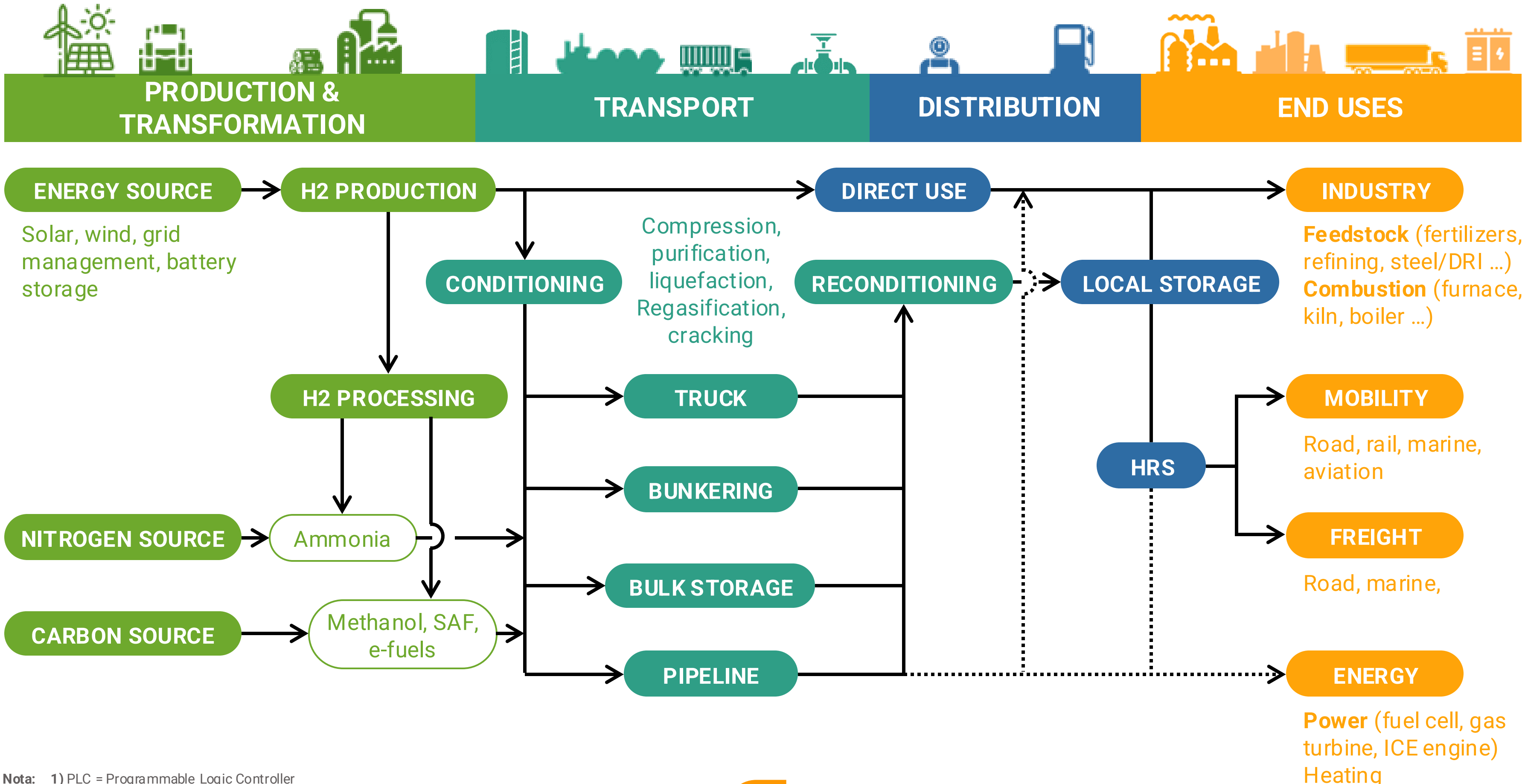
- **Objectives:** Optimize plant operations while meeting safety requirements and dealing with lack of skilled personal
- **Challenges:** safely, reliably and efficiently operate plant throughout its lifecycle

Image credit: Adaptation from Siemens

CHALLENGES IN HYDROGEN VALUE CHAIN (1/2)

Hydrogen & derivatives value chain

Automation equipment can be found all along the hydrogen & derivatives value chain. Although the functioning principle is very similar across products, the features can be very different depending on the settings (e.g. PLC[1] vs. DCS[2]).



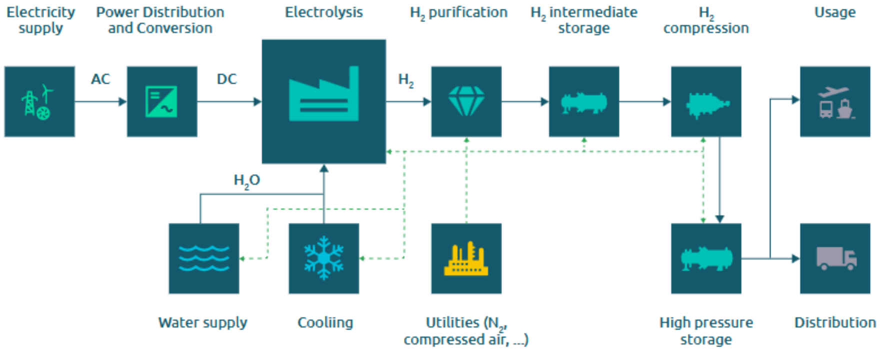
Nota: 1) PLC = Programmable Logic Controller
2) DCS = Distributed Control Systems

CHALLENGES IN HYDROGEN VALUE CHAIN (2/2)

What's new in automation for hydrogen ?

Green hydrogen is not new, but large-scale hydrogen production is a relatively immature field that requires substantial investments in knowledge, technology, and money. With more plants, the technology and knowledge mature with better efficiencies, longer operation times, higher plant availability, and ultimately, a lower cost. Achieving these objectives will be a journey.

From a hydrocarbon process industry perspective, green hydrogen plant automation is different because there is no main process to automate. A green hydrogen plant is composed of multiple modules, such as an electrolyzer system, voltage system, compressor system, and water system. During a plant's construction, these modules are delivered individually and must be integrated into an ecosystem for efficient and safe operation. Most modules are delivered with individual controls and perhaps a safety system, and replacing all these automation systems with one central control and safety system would not make sense. However, we must determine how to integrate and operate all these systems.



Example of multi-module setup for H2 electrolysis + HRS distribution

The automation of modular plants is new, so limited blueprints are available. Multiple stakeholders are involved, such as the owner, cloud provider, EPC, and vendors of the different modules. Because of the many stakeholders, one strategy is required for operations, maintenance, safety, automation, integration, and cybersecurity.

To merge modular systems and plant performance monitoring, a traditional supervisory control and data acquisition system (SCADA) or Distributed Control System (DCS) is no longer sufficient. Per the Purdue enterprise reference model (ISA-99), both systems (SCADA and DCS) are not designed to simultaneously achieve both vertical and horizontal data integration.

Horizontal integration: refers to the combination of the different systems on-premise with the electrolyzer system, the compressor system, and the voltage system as the main systems. Often, these systems have different interfaces/protocols such as OPC UA, Profibus DP, Modbus TCP/IP, or IEC61850.

Vertical integration: refers to integration with the business domain, cloud, or remote center where cybersecurity is crucial in supporting different architectures and protocols. A typical interface with the cloud is, for example, MQTT.

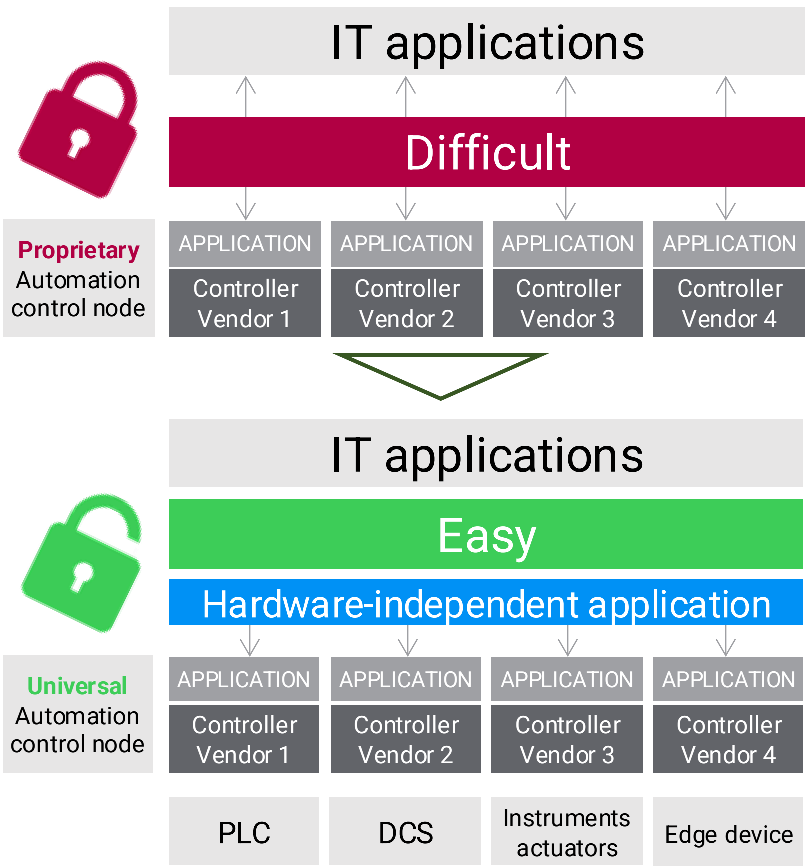
For large sites, horizontal and vertical integration are often separated through different systems. However, for a green hydrogen plant, separate solutions are too complex and expansive. New integrated solutions are required. Integration doesn't only refer to data and Human Machine Interface (HMI) but also to alarms and safety. To operate the plant efficiently and safely with a minimal number of operators, or even remotely, the operators must have one unified interface that includes the integration of alarms and safety overrides from the different systems (modules).

Credits : Siemens, Yokogawa

GENERAL PRINCIPLES OF AUTOMATION (1/2)

Conceptual principle

Universal automation enables decoupling automation software applications from the hardware, thus greatly lowering system complexity.

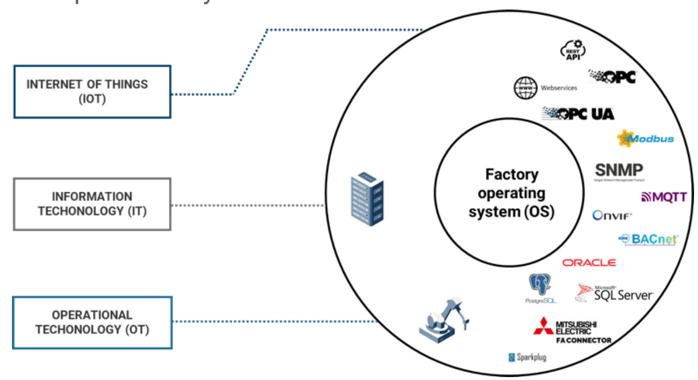


Credits : Mitsubishi Electric, Schneider Electric

Technology foundations

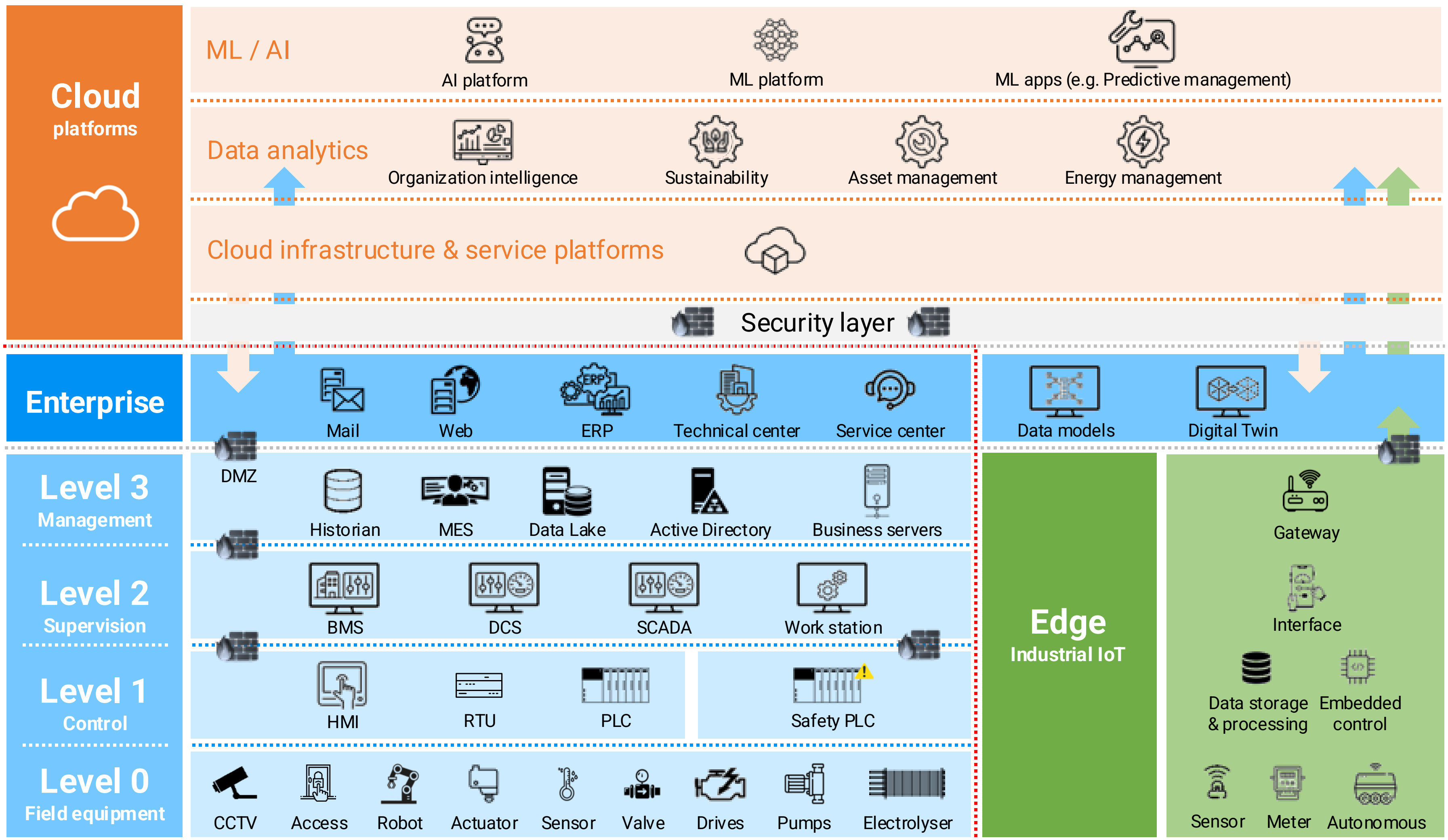
Universal automation rests on 2 key technology foundations :

- **Universal connectivity & standardized data models (OPC UA)** : At the heart of universal automation, OPC UA addresses the need for standardized data connectivity and interoperability for both horizontal and vertical data communications. An example of horizontal communications is Machine-to-Machine (M2M) data connectivity among shop floor systems. An example of vertical communications is device-to-cloud data transfer. In both cases, OPC UA provides a secure, reliable foundation, robust enough to facilitate standards-based data connectivity and interoperability. OPC UA allows either to use predefined data models or to create user-specific data models in a fully interoperable way.



- **Digital automation platform** : All IT/IoT applications seamlessly communicate with OT hardware thanks to a software-centric platform that abstracts all underlying equipment. This middleware logic allows to collect, pool and contextualize all the data generated by different information sources in a structured data model, transforming business operations into a true scalable digital platform.

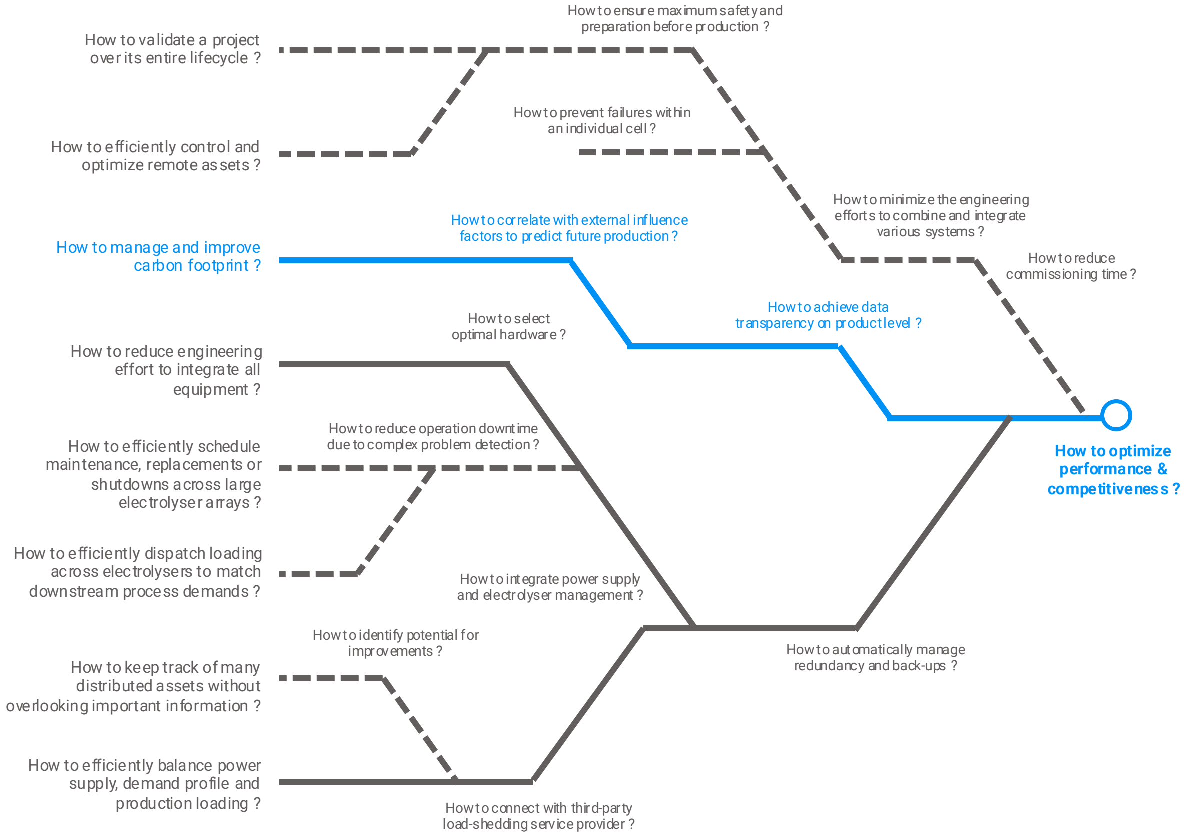
GENERAL PRINCIPLES OF AUTOMATION (2/2)



Purdue scale – ISA99

END-TO-END AUTOMATION SOLUTIONS

Many challenges in hydrogen can be solved with a few transverse automation solutions

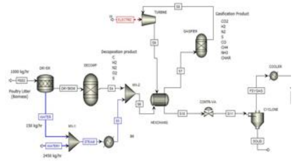


SOLUTIONS

1. HARMONIZATION
2. STANDARDIZATION
3. MODELLING & SIMULATION
4. MEASUREMENT
5. SAFETY COMPLIANCE
6. CYBERSECURITY
7. **SUSTAINABILITY**
8. ENERGY MANAGEMENT
9. DECENTRALIZED CONTROLS
10. ASSET LIFECYCLE OPTIMIZATION
11. UNIFIED ORCHESTRATION

Sources : Adaptation from Siemens

MODELLING & SIMULATION



“End-to-end simulation of P2X processes”

Front end engineering challenges

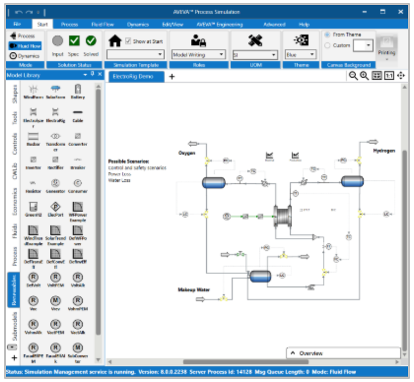
In the early stages of a hydrogen/P2X project, a lot of complex “engineering questions” arise:

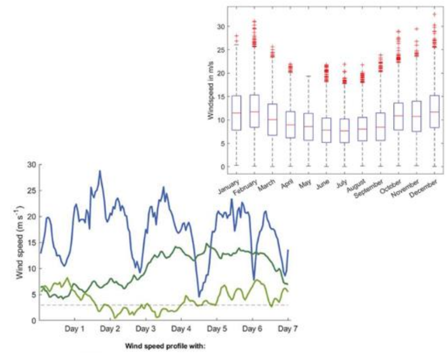
- What do we build?
- Where do we build?
- How big should it be?
- How much will it cost?
- How much profit will we make and when?

Basic engineering starts with simulations building on the conceptual design, but adding the precision required to deliver the necessary package units for both cost estimation and vendor selection. Simulations cover a large variety of use cases:

- Feasibility studies with stochastic inputs modelling (wind & solar inputs)
- Economic analysis & sustainability metrics
- Load control & PPA strategies
- Design optimization
- Unified engineering environment for P&ID, 3D and project execution applications

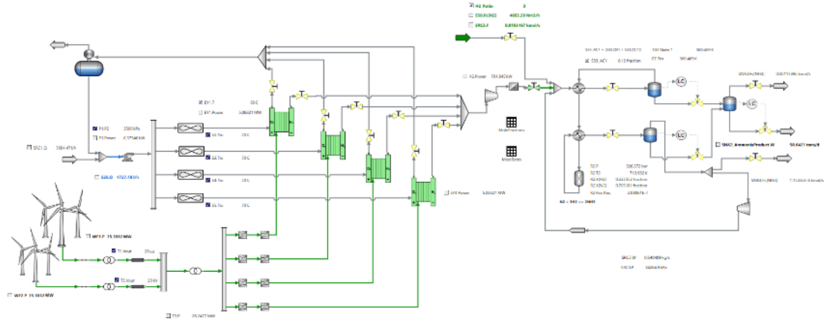
The data generated by the simulations is passed on to a series of engineering toolsets facilitating preliminary P&IDs, preliminary data sheets, 3D layouts etc.:



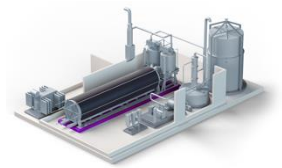


Integrated process design

Among other uses cases, digital twins are extremely helpful to design integrated P2X processes at equipment level. When operating a large-scale industrial process, high uptime and continuous process operation are critical for reactor stability and efficiency. However, renewables are inherently intermittent. Designing the end-to-end, power-to-molecules system that balances capex on renewable energy sources, buffer stores, and reactor uptime is the largest driver of LCOx of the plant.



ASSET LIFECYCLE OPTIMIZATION / DIGITAL TWIN (1/2)

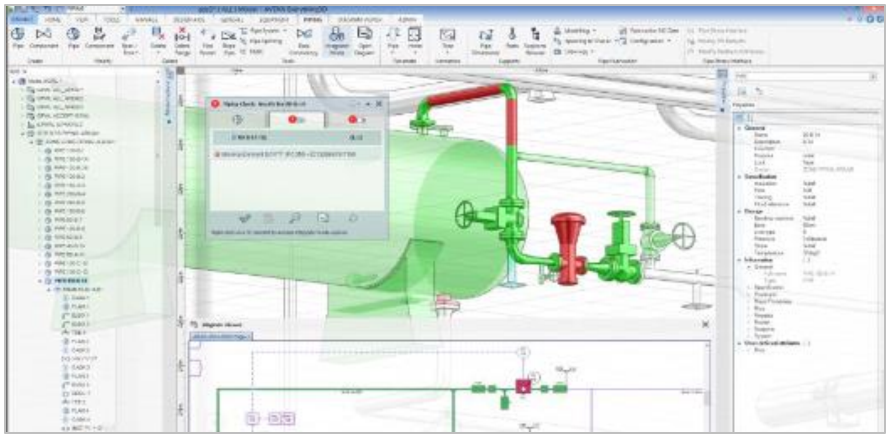


> "Reduces engineering cycle times and optimize LCOH"

Introduction to digital twins

Hydrogen developers are looking for ways to solidify their business cases and digital twins can play a significant role in this regard : Hydrogen developers can use **digital twins** to improve the economic viability of renewable projects and meet increasing demand.

By **replicating real-world plant operations in virtual simulations**, engineers and operators can fine-tune designs, identify potential issues early on, and streamline production processes. This not only **reduces commissioning times but also slashes production costs, making hydrogen production more economically viable**.

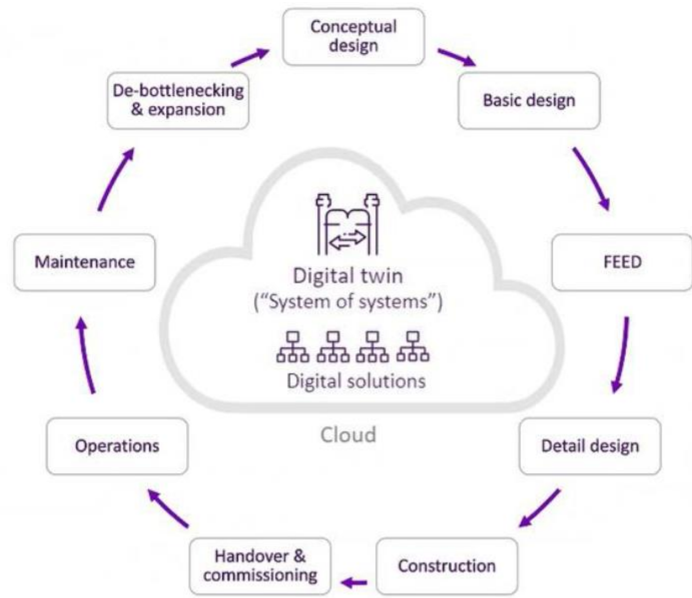


Credits : McKinsey, Schneider Electric/Aveva

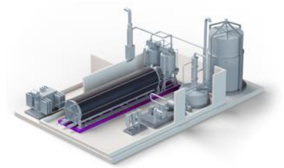
A digital twin is a virtual representation of a physical product, system, or process used to understand and predict the physical counterpart's performance. Digital twins are used to **simulate and optimize the product and production system before investing in physical prototypes or implementing an active plant.**

Digital Twins unify the Engineering Data Environment along with the Operational Data Environment into a **single integrated data environment** built within the digital automation platform (and thus connected with all underlying hardware assets and overlying business IT applications).

The power of the digital twin comes into effect when the details are added. Each step of the process can include endless details to get the most out of the digital twin and optimize the entire process.



ASSET LIFECYCLE OPTIMIZATION / DIGITAL TWIN (2/2)

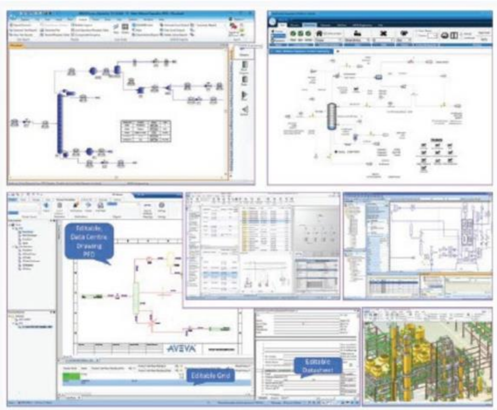


"Reduces engineering cycle times and optimize LCOH"

Integrated engineering

The power of a digital twin lies in its ability to **quickly evaluate plant complexities, identify optimized setups, and compare alternatives** against a set of constraints (for example, regulatory requirements for green hydrogen).

For instance, digital twins can **simulate** and compare the performance of multiple types of electrolyzers under different conditions, which will increase the confidence in the planned design of the plant. For some projects, it might be beneficial to "oversize" the electrolyzer capacity while others may require more flexibility to balance electrolyzer capacity with storage capacity.

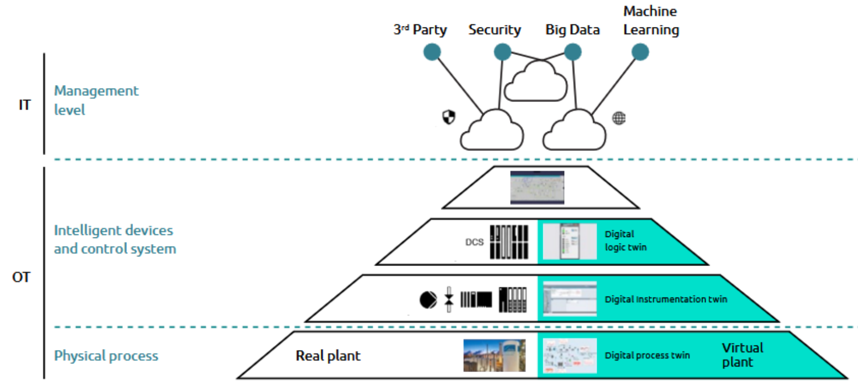


Integrated engineering in the cloud environment allows for multi-discipline teams to collaborate across 1D, 2D and 3D from one data-centric location.

Integrated operations

Digital twins can deliver benefits far beyond initial design and development, too. When properly set up during plant design, digital twins can form the basis of a variety of use cases **throughout the plant's life cycle**, including operations & maintenance.

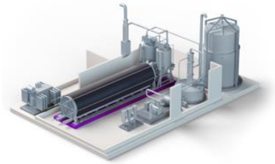
Plant design and operations are initially considered and optimized together with a digital twin, providing greater clarity of the operation and maintenance needs of the plant to **enhance planning**. This technology can also provide greater **cost certainty on the plant's Opex** in advance.



A well-designed automation system architecture is crucial to make use of the digital twin in operation, as the data from the plant is needed to use the digital twin to increase performance or to use it for asset optimization, condition-based maintenance, and maintenance execution. Through this integration the digital twin is used in daily plant operation and maintenance and consequently always stays up to date.

Credits : McKinsey, Schneider Electric/Aveva, CapGemini/Siemens

ENERGY MANAGEMENT (1/2)



“Optimize the choice of energy source and reduce LCOH”

Energy management : problem statement

The price of hydrogen depends on 70% of the cost of electricity. The remaining 30% depends on the related CapEx and OpEx elements. Therefore, it is essential to source reliable and cost-competitive renewable electricity for any renewable hydrogen project.

But hydrogen production also needs to take into account downstream constraints associated with the use of hydrogen (load profile of industrial processes, load profile of ammonia plant etc.) and the guarantee of supply continuity for downstream users.

Putting all these constraints together adds a great deal of complexity to the management of hydrogen production plants. This is where state-of-the-art Energy Management Systems (EMS) are becoming useful.

Optimizing the choice of energy source(s)

Renewable hydrogen production can source power from a mix of different sources with different price and characteristics (which vary at an infra-hourly pace).

There are different parameters to consider (direct vs. virtual, baseload electricity vs. actual production payment, cross-border issues, location of assets, PPA tariff structure, temporal coherence between RE generation profile and consumption profile, etc.) that are essential to provide adequate renewable electricity in renewable hydrogen projects.

Electrical distribution for renewable hydrogen plants

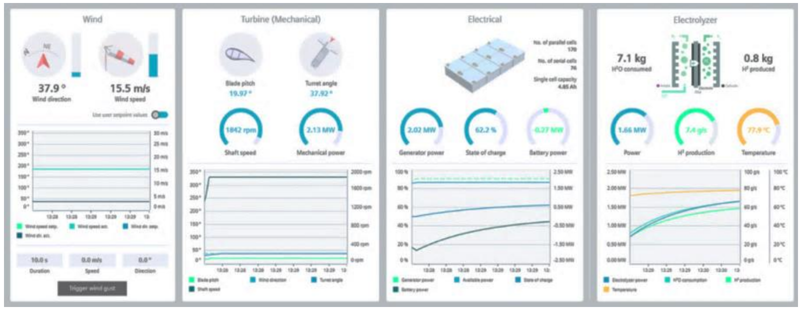
For a robust and timely connection to these electricity sources, renewable hydrogen plants need optimize their electrical distribution system by optimizing the electrical architecture, maximizing the use of standard equipment and using compact equipment to promote modularity.

Besides, a complete regulation of active and reactive electricity, as well as the voltage of heterogeneous renewable systems and the rapid and stable control of the connection point to the network is required.

👉 **These aspects are detailed in the "power supply" section of the Gimelec hydrogen guide**

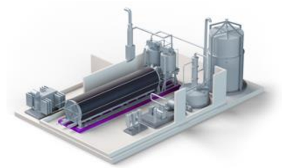
Energy Management Systems

Energy Management systems are digital solutions built on top of automation systems, coupling hydrogen production with renewable energy generation, the electrical grid and downstream hydrogen users, with a common goal of minimizing energy consumption, reducing system operating costs and maximizing the green hydrogen production of the plant, while meeting sustainability objectives and operational KPIs.



Sources : Schneider Electric, Siemens
Crédit images : Siemens

ENERGY MANAGEMENT (2/2)

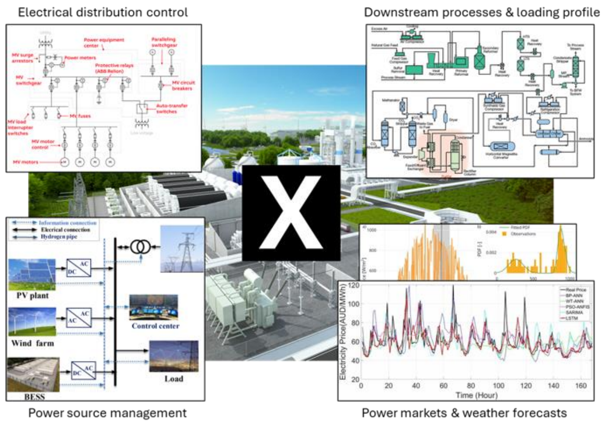


“Optimize the choice of energy source and reduce LCOH”

Main EMS connections

The EMS leverages data connections mostly with:

- Third-party data services providers (e.g. power market analytics, weather forecasts …)
- The digital twin including renewable energy generation, the electrical distribution system, the electrolyser and all downstream processes (compression, storage, conditioning etc.),
- The EMS data concentrator to calculate the kg of renewable hydrogen per day and €/kg,... and set up specific KPIs such as RED2 or RFNBO.
- The asset performance maintenance system.



Sources : Schneider Electric, Siemens, ABB

Main EMS building blocks

The EMS is composed of 3 main building blocks :

1) An online platform for connecting, monitoring and controlling all all DERs (Distributed Energy Resources), electrical distribution, electrolyzer stack and electrolyzer BoP from a single interface. The platform provides:

- → Transparency over energy consumption and sustainability performance
- → Continuous improvement of energy efficiency
- → Achieve and maintain ISO 500001 certification

2) Planning tools that forecast energy consumption & calculate the corresponding energy supply schedule

- → Purchase the right level of power in liberalized power market and minimize costs
- → Predict complex/variable energy demand with temporary peaks more accurately
- → Design the most effective production plan given power/energy constraints

3) Holistic energy supply & demand optimization tools using predictive control algorithms taking into account:

- → Renewable energy and its forecasts,
- → Existing power purchase agreements (PPA)
- → Wholesale market and its forecasts,
- → Electrolyzer characteristics and life cycle,
- → H2 demand, storage capacity and production forecasts,
- → Decision to export energy,
- → Decision to use process flexibility (NB : having an EMS is a prerequisite for implementing load shedding strategies with third-party flexibility aggregators)

CYBERSECURITY (1/2)

"Ensuring operations continuity while integrating digital technology to maximize results"

Why cybersecurity matters ?

In today's hyperconnected world, industrial plants are a constant target of cyberattacks and hydrogen production plants are no exception, with attacks on availability (DDoS[1]) and ransomware being the most common threats.

Hydrogen plants thus require adequate protection to ensures continuity of operations while integrating digital technology to maximize business outputs. Besides, hydrogen plants must comply with critical infrastructure regulations.

Potential damage scenarii

DDoS[1] attacks, aiming to disrupt system and data availability by blocking services or overloading the network, pose a major problem in cybersecurity. Similarly, **ransomware**, where attackers encrypt a company's data and demand payment for its release, has increased substantially.

However, the impacts of these attacks extend far beyond immediate operational disruptions: security breaches, including the potential for sabotage, pose a serious safety risk to humans and the environment. While intellectual property theft undermines competitive advantages, ransomware extortion can lead to significant financial losses. Moreover, customer trust and market position are profoundly affected by reputational damage.

Unique vulnerabilities of hydrogen facilities

The vulnerability of hydrogen production plants and other industrial facilities stems from the **increasingly tight integration of OT and IT systems, lifting the previous shielding of OT environments against cyberattacks**. However, hydrogen facilities face specific additional challenges due to their high degree of modularity. The production process consists of a multitude of units that must communicate seamlessly with each other.

Unlike conventional production plants or power plants with standardized layouts and common security protocols, **hydrogen plants often lack a unified security layout**. Many of these plants are scaled up from pilot projects or laboratory environments, inadvertently neglecting basic cybersecurity measures during the transition. The absence of standardized plant designs and a coherent security approach makes these plants particularly vulnerable to cyber threats.

Industrial cybersecurity strategy

To protect hydrogen production plants from cyber threats, it is crucial to pursue a layered defense-in-depth strategy. This concept, recommended by the international standard IEC 62443, involves implementing **multiple layers of protection** to safeguard a network or system against attacks.

Since no single security measure can provide complete protection, this strategy overlays diverse security mechanisms to create a multi-layered defense. An attacker must overcome multiple hurdles to compromise the system, significantly reducing the likelihood of a successful intrusion. This approach is divided into three critical levels, each tailored to specific vulnerabilities and risks: plant security, network security, and system integrity.

Sources : Schneider Electric, Siemens, Weidmüller
Nota : 1) DDoS = Distributed Denial of Service

CYBERSECURITY (2/2)

"Efficient cyber protection requires a comprehensive and extensive approach to security"

Fundamentals about industrial cybersecurity

1. Cybersecure automation starts with ensuring compliance with international standards such as IEC 62443. These guidelines recommend a multi-layered approach, including network segmentation, encrypted communication, user authentication, and role-based access controls. By ensuring that only authorized users and devices can interact with critical systems, cybersecurity risks can be significantly minimized.

2. Cybersecure automation requires the use of pre-secured components which can be either IEC 62443-certified products or ANSSI-qualified products (products that have been validated by the ANSSI for use in critical infrastructure).

Integrated multi-layer approach to cybersecurity

To protect industrial plants from internal and external cyber attacks, all levels must be protected simultaneously – from the plant management level to the field level and from access control to secure data communication.

Sources : Schneider Electric, Siemens, Weidmüller

A cybersecure system cannot only be the result of assembling multiple products protected against cyberattacks. Specific analysis and configuration across the entire IT/OT solution is necessary to ensure a comprehensive protection. Cybersecurity should be seen as a multi-layered security concept that ensures comprehensive and extensive protection for industrial facilities. It's based on plant security, network security, and system integrity as recommended by IEC 62443.

Plant security : Protects physical access of persons to critical components. It starts with conventional building access and extends to securing of sensitive areas by means of key cards. In addition, plant security comprises the integration of processes and guidelines as well as continuous monitoring of the security status of production facilities

Network security : Protection of the automation network against unauthorized access, especially at connection points to other networks (office or Internet). Network segmentation is providing additional security. Data transmission can be protected by using a VPN, e.g. for worldwide remote access to distant plants via Internet or mobile networks.

System integrity : Securing system integrity means to protect automation systems and controllers like controllers, SCADA and HMI systems against unauthorized access or to protect the know-how contained therein. It also comprises user authentication and their access rights as well as system hardening against attacks.

Industrial Security Services : Experts in automation, digitalization and cybersecurity provide industrial cybersecurity assessment services, following an end-to-end approach, starting with the evaluation of the security status over the implementation of security measures up to continuous monitoring and security management.

SAFETY COMPLIANCE

"Ensuring highest safety compliance in the absence of extensive industry feedback"

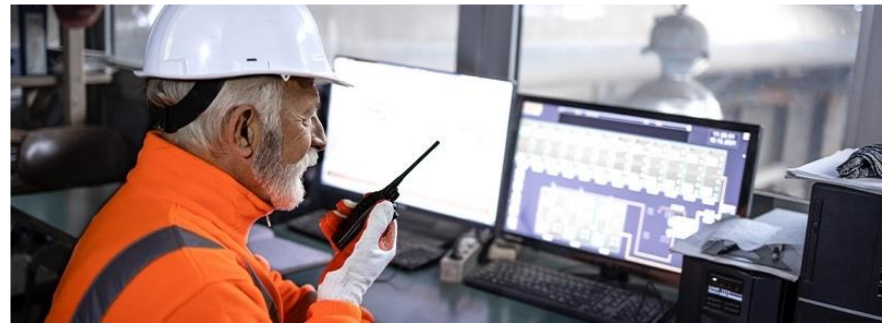
Fundamentals about hydrogen safety

The hydrogen industry is young, and the technology is still developing. One growing area is the efficient and safe operation of electrolysers, fuel cells and high-pressure equipment. Due to the explosive nature of hydrogen, this is a very important task.

- Although hydrogen is not new to the oil & gas industry, hydrogen poses a greater risk than other molecules usually encountered in oil & gas environments : lower explosive limit, higher LCV, more inflammable, more energy released, colorless and odorless.
- Although existing hydrogen processes (SMR, refining, ammonia) usually don't pose a high inherent risk for personnel (long proven technologies, extensive feedback), new hydrogen applications (electrolyser plants, containerized solutions, high-pressure refueling stations …) have limited feedback and pose higher risks.
- Although some incumbent players in the industrial gases arena have decades experience manipulating hydrogen, there are many new players in hydrogen which don't necessarily have deep industrial and automation background.

Balancing the promise and peril of hydrogen calls for a comprehensive understanding and careful implementation of functional safety, more regulatory oversight and a deep seated culture of safety.

At plant level, continuous evaluation and adaptation of safety measures, regular training for operating personnel and constant monitoring of technical systems and environmental conditions are required.



Higher emphasis on SIL2/3 functional safety solutions

Contrary to SMR facilities which don't require high SIL-rated SIFs and fast response SIS logic solvers, new hydrogen facilities will require a larger proportion of SIL2/3 SIFs. Raising greater awareness on SIL2/3 solutions is paramount for educating new players in the field of hydrogen.

Sources : Siemens, Festo, ABB
Image credits : Pilz, Siemens

SUSTAINABILITY MANAGEMENT (1/2)

"Enabling traceability, compliance targets and carbon intensity"

Problem statement

Digital solutions play a crucial role in enhancing real-time monitoring and data tracking for low-carbon hydrogen traceability across the entire value chain. Comprehensive traceability is essential for market entry strategies and securing public subsidies. It provides transparent and verifiable proof of the low-carbon nature of hydrogen produced, ensuring compliance with regulation and meeting customer demand.

- **Carbon intensity thresholds:** Rather than solely categorizing hydrogen based on its production pathway, establishing numeric targets for carbon intensity (certified independently) shifts the focus to rigorous lifecycle assessment (LCA) of associated emissions. In both the EU and the US, specific thresholds define what qualifies as "clean" hydrogen: 3,38kgCO_2eq/kgH_2 and 4,0 kgCO_2eq/kgH_2 respectively. These thresholds serve as minimum compliance targets.
- **EU Renewable Fuel of non-biological origin (RFNBO) directive:** Site-specific variables, such as plant design, operating conditions, feedstocks carbon intensity, and the carbon intensity of the electrical grid, influence hydrogen actual carbon intensity. In the EU, hydrogen can qualify as RFNBO only if it satisfies three criteria: additionality, temporal correlation and geographic correlation.
- **EU Carbon Border Adjustment Mechanism (CBAM):** For hydrogen importers, the EU's CBAM which will be fully implemented from January 2026 onwards, involves calculating and reporting the carbon intensity of imported hydrogen using an EU-specified methodology.

Credits : CapGemini/Siemens

Importers will register with national authorities, purchase CBAM certificated based on the relevant weekly average auction price of EU-ETS allowances (€/ton CO_2 emitted), declare embedded emissions and surrender corresponding certificates annually.

Digital building block for managing sustainability

Achieving traceability for clean hydrogen and derivative products is thus essential but there are many data requirements across the value chain, some of which include high-frequency data at the point of production from process control software, LCA tools and smart contract ledgers:

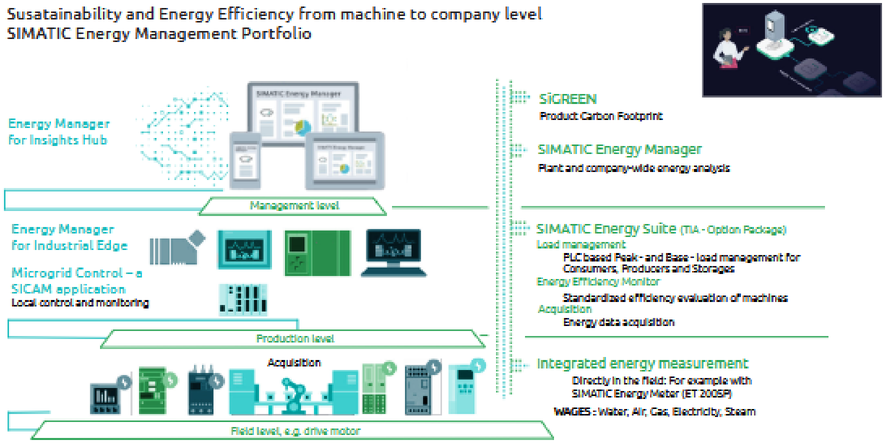
- **Process control tools** leverage data from on-site industrial sensors and control systems to provide visibility into the energy requirements and emissions associated with various operating conditions and plant configurations. This detailed data also serves as the foundation for LCA and certification
- **Life Cycle Assessment (LCA) tools** take the data directly from data historians in the process control software and digital twins, then analyse the GHG emissions associated with the hydrogen production, the feedstock and utilities used, distribution and ultimate use. Ultimately, the best practice for LCA tools is to provide carbon intensity calculations across all relevant domestic and international standards, so that certification of regulatory requirements and end-user benefits can be certified by independent certification bodies.
- **Smart Contract Ledgers:** Once the environmental attributes of hydrogen are independently certified, associating those attributes to specific products creates an immutable record of hydrogen production, transportation and distribution. Each supply step can be securely documented, ensuring transparency and accountability. Smart Contracts automate transactions and compliance checks, verifying hydrogen's carbon content criteria before market entry.

SUSTAINABILITY MANAGEMENT (2/2)

"Enabling traceability, compliance targets and carbon intensity"

Product Carbon Footprint (PCF) management solutions

Product carbon footprint management solutions consolidate the data and calculate the PCF connecting companies with all their suppliers. Due to increasingly stringent regulatory requirements, industrial companies are faced with the major challenge of seamlessly tracing the entire PCF. This can only be achieved through continuous data exchange along the entire value chain and requires digital solutions that all connected companies can trust.



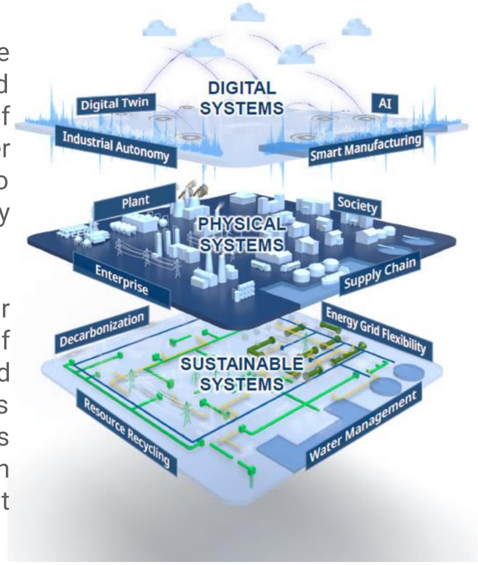
System-of-systems (SoS) approach

With the increasing governmental and societal pressure to increase sustainability, firms are responding with additional efforts to collaborate across established systems to improve sustainability performance, such as Environmental, Social, and Governance (ESG) goals and other activities to minimize waste and emissions.

For this type of inter-industry collaboration, the operational data of each company or plant must be connected and integrated in a cybersecure manner. By connecting these data, it is possible to devise measures to reduce CO2 emissions and ensure operational compliance. An SoS (System of Systems) approach makes this possible. For example, waste heat from one company can be recovered for use by a different company. This improves sustainability and overall profitability.

The SoS concept will become increasingly important as the world needs to utilize multiple sources of renewable energy, and as broader decarbonization initiatives need to be undertaken collaboratively among companies.

Managing flow synergies and their associated benefits in terms of emissions and associated regulatory reporting requirements draws on seamless connections between the digital automation systems of the different stakeholders.



Credits : CapGemini/Siemens, Yokogawa/Processing Magazine

Companies providing Automation Solutions

This white paper presents the challenges and constraints for automation in the hydrogen sector.

→ Discover the solutions offered by **GIMELEC members** to meet these needs: 8 of our experts present their offer.

→ This directory also allows you to find out more about the GIMELEC companies active in automation.
Click here to access the GIMELEC directory

→ For solution providers covering the entire hydrogen value chain (production - storage - transport - distribution - applications), find the Panorama of H_2 Solutions proposed by France Hydrogène online.

→ On the Vig'hy hydrogen observatory, you will also find the online directory of **France Hydrogène members**: 450 French hydrogen industry players covering the entire value chain: major industrial groups, SMEs, start-ups, laboratories and research centres, associations, competitiveness clusters and local authorities.