

Hydrogen Performance Suite

Driving innovation, reducing costs, and
enhancing operational efficiency



Index

Unlocking Efficiency with the Hydrogen Performance Suite	3
Market Challenges for Green Hydrogen	4
From Challenge to Opportunity: The HPS Approach	5
Core Functionalities of the Hydrogen Performance Suite	7
Data Inputs and Outputs	10
Deployment and Deliverables	11
Supporting Services	11

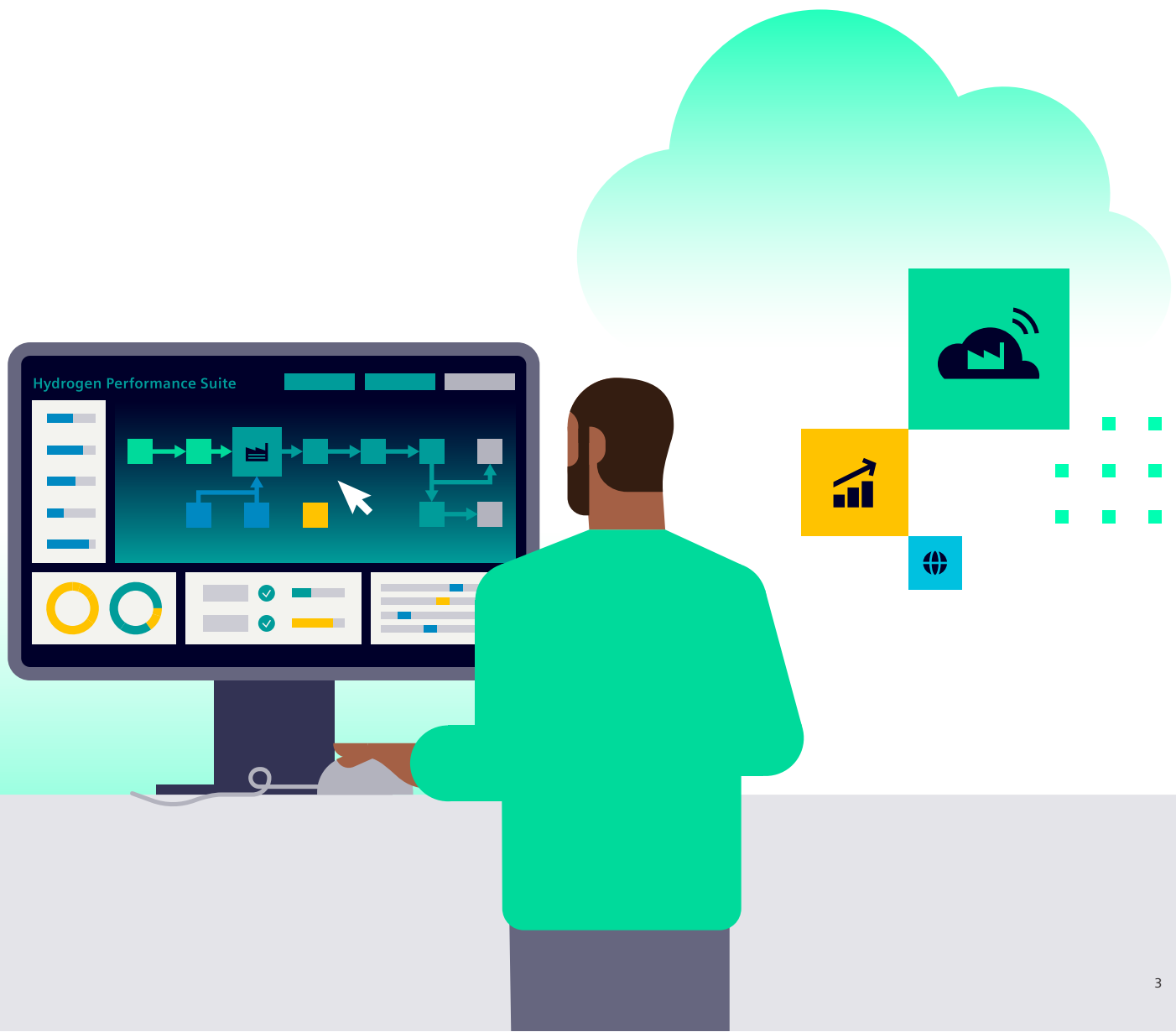


INTRODUCTION

Unlocking Efficiency with the Hydrogen Performance Suite

The Hydrogen Performance Suite (HPS) is a cutting-edge software solution developed by Siemens to meet the complex operational needs of green hydrogen producers. As a digital platform, HPS combines physics-based simulation models with live plant data through an integrated Digital Process Twin. This approach enables plant operators to enhance asset reliability, reduce operating costs, and optimize hydrogen production in real time.

In 2024, HPS received international recognition when ABI Research ranked it the leading software for green hydrogen production, citing its performance across innovation, implementation, and overall leadership. This whitepaper provides a comprehensive overview of HPS's core features, functionalities, and business value.



Market Challenges for Green Hydrogen

While hydrogen is a critical element in the global energy transition, the path to widespread adoption is hindered by several structural and operational barriers. One of the most significant is the **high capital expenditure (CAPEX)** required for establishing large-scale hydrogen facilities, including electrolyzers, renewable generation assets, and supporting infrastructure.

In addition to upfront costs, **operating expenditures (OPEX)** present ongoing uncertainty due to fluctuating electricity prices, renewable intermittency, and maintenance demands. Green hydrogen also faces strong price competition from fossil-derived alternatives like grey hydrogen and natural gas.

On the technical side, producers must overcome challenges such as the need for **reliable storage, transportation, and distribution infrastructure**; managing strict **safety protocols in high-output environments**; integrating **emerging technologies** at scale; and addressing the **shortage of skilled personnel** with hydrogen-specific experience.

These challenges require solutions that not only enhance transparency and planning, but also adapt in real time. HPS addresses these needs with predictive modeling, data-driven automation, and fully integrated system visibility.

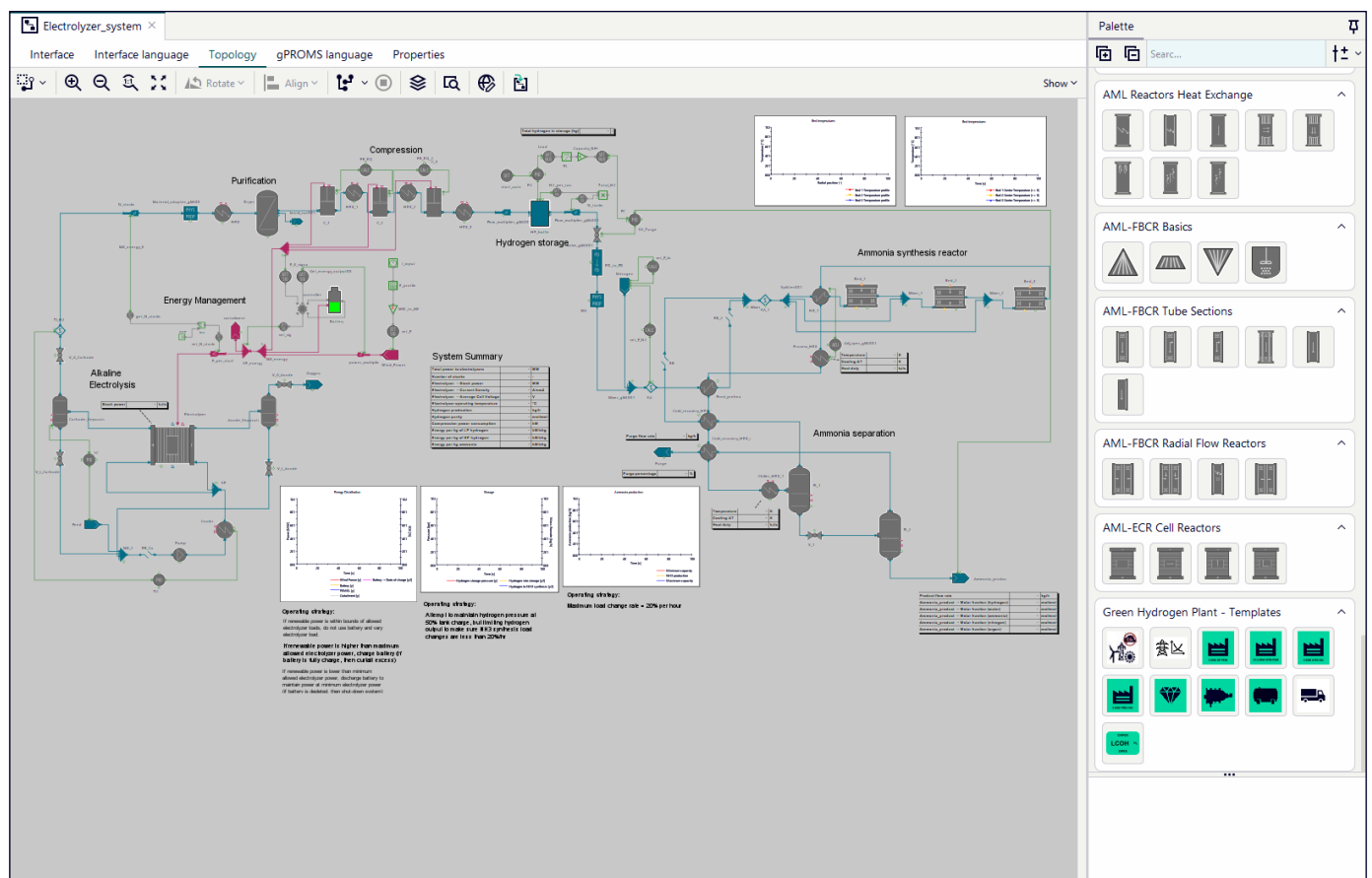


From Challenge to Opportunity: The HPS Approach

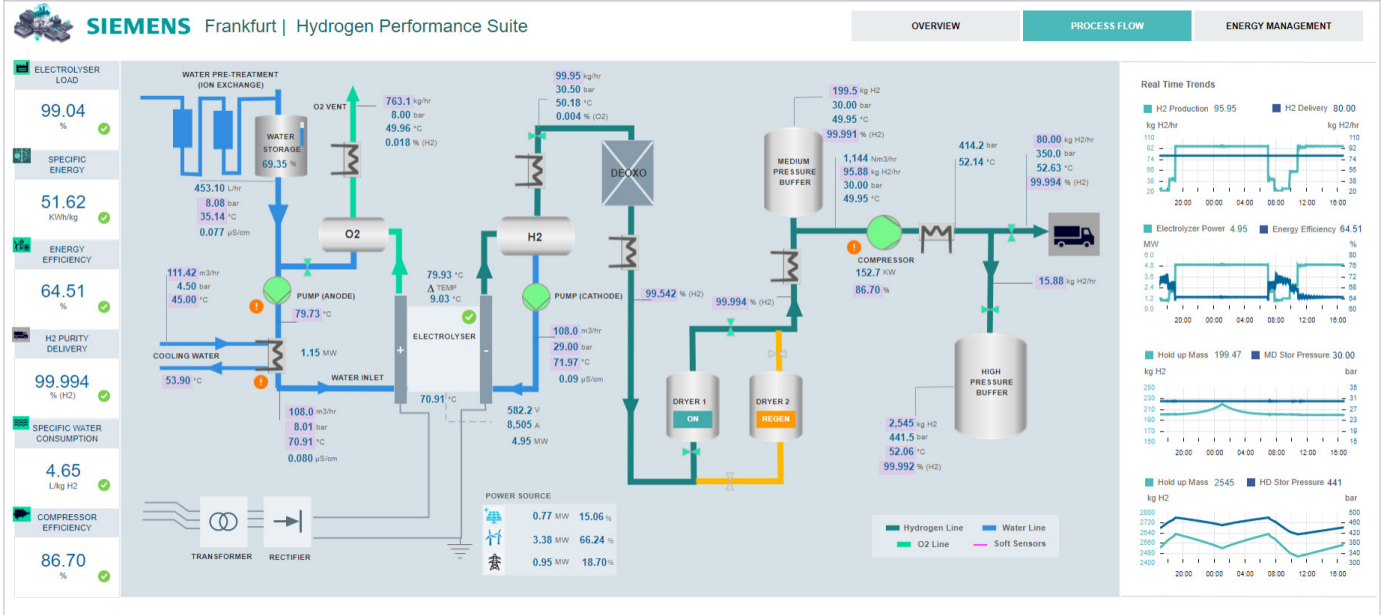
The Hydrogen Performance Suite enables plant operators to convert operational complexity into competitive advantage. Central to its functionality is a high-fidelity Digital Process Twin, which simulates plant performance under real conditions and provides actionable insights to optimize production, energy use, and asset efficiency.

By incorporating inputs such as weather forecasts, energy pricing, asset availability, and hydrogen demand, HPS dynamically adjusts production plans and recommends ideal operating conditions. These data-driven insights help operators move away from conservative safety margins and instead make real-time decisions with confidence.

Field implementations have demonstrated up to 15% gains in energy efficiency, improved asset uptime, and substantial reductions in the Levelized Cost of Hydrogen (LCOH).



Offline: Building the Process Twin



Online: Deploying for Digital Operations

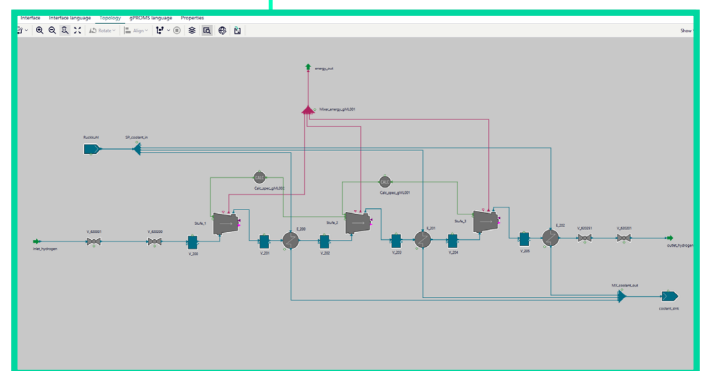
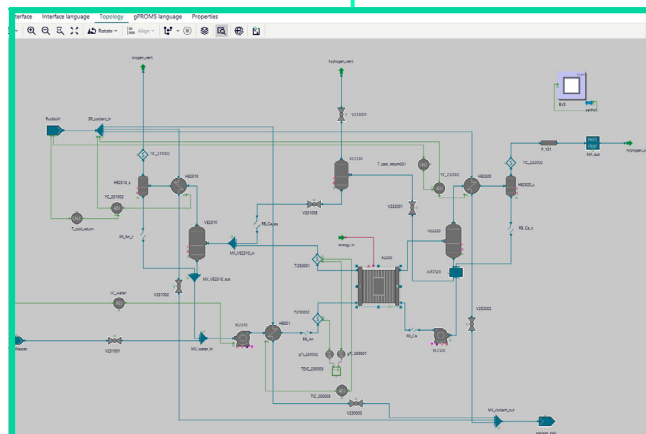
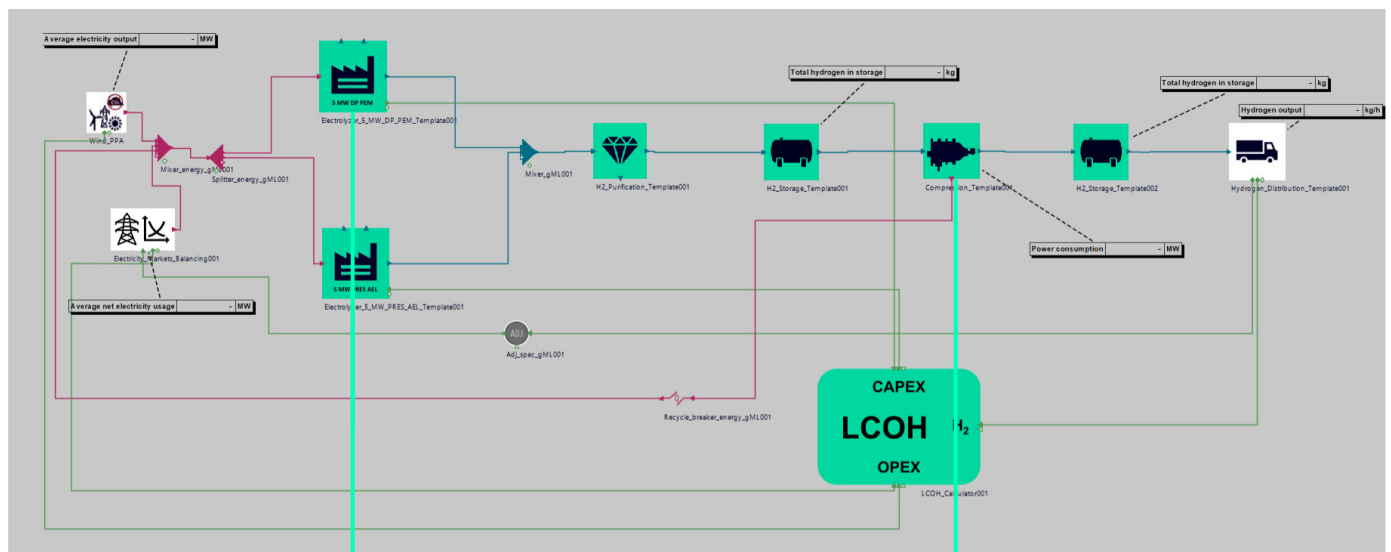


Core Functionalities of the Hydrogen Performance Suite

Simulation, Monitoring, and Operational Insights

At the core of HPS is its simulation and monitoring engine, which leverages Siemens' gPROMS modeling environment. This enables dynamic, real-time simulation of key assets such as electrolyzers, purification units, compressors, and storage tanks. The platform supports multiple electrolyzer types –including PEM, alkaline, AEM, and solid oxide – ensuring broad compatibility across plant configurations.

By continuously comparing simulated data with live operational values, HPS provides insights into system efficiency, degradation, and equipment performance. The system flags anomalies when deviations are detected and adapts internal efficiency curves to align with actual operating conditions. This ensures the model stays accurate over time and supports high-quality decision-making.



Pre-configured plant templates contain the same high-fidelity models but are pre-configured for easy use.

Production Planning and Scheduling Optimization Ensuring alignment

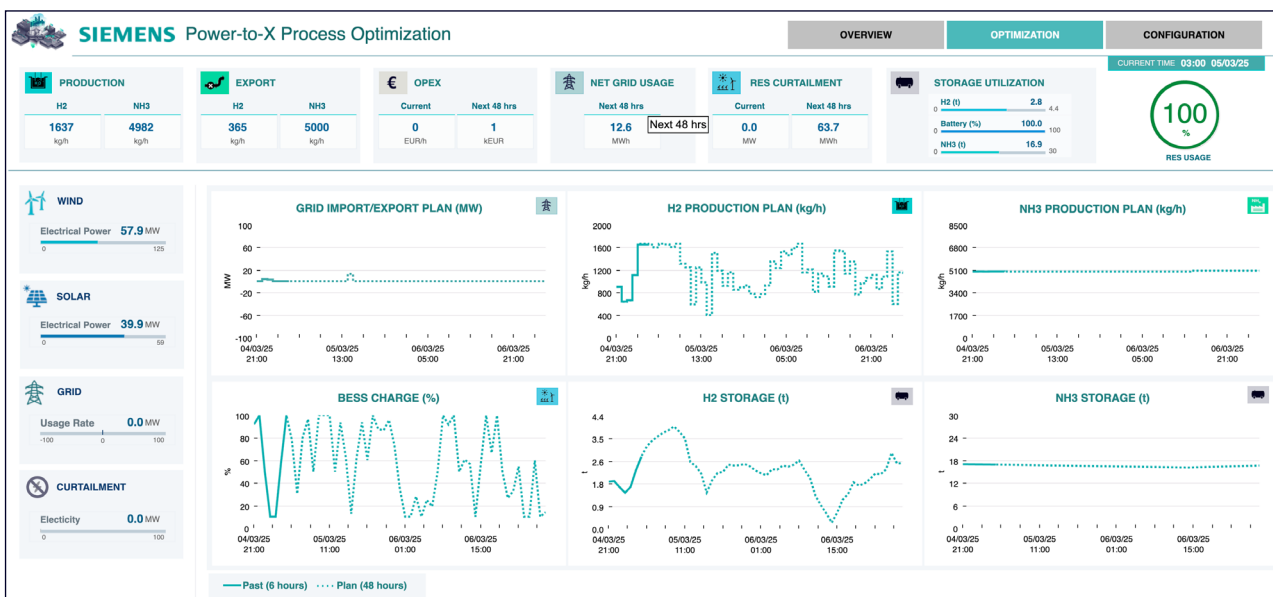
HPS supports multi-layered production scheduling designed to match plant performance with operational goals and market conditions. The system offers three main scheduling modes:

- **Day-ahead and week-ahead planning:** generates optimal schedules based on updated forecasts for hydrogen demand, energy availability, weather, electricity prices, and asset status.
- **Intraday optimization:** Hourly re-evaluation of the current plan based on new data.
- **Scenario-based planning:** Simulation of specific plant conditions and inputs, enabling proactive contingency management.

All plans are operator-approved and can be manually adjusted.



Example 1: Power-to-X Production Optimization



Examples 2: Power-to-X Production Optimization



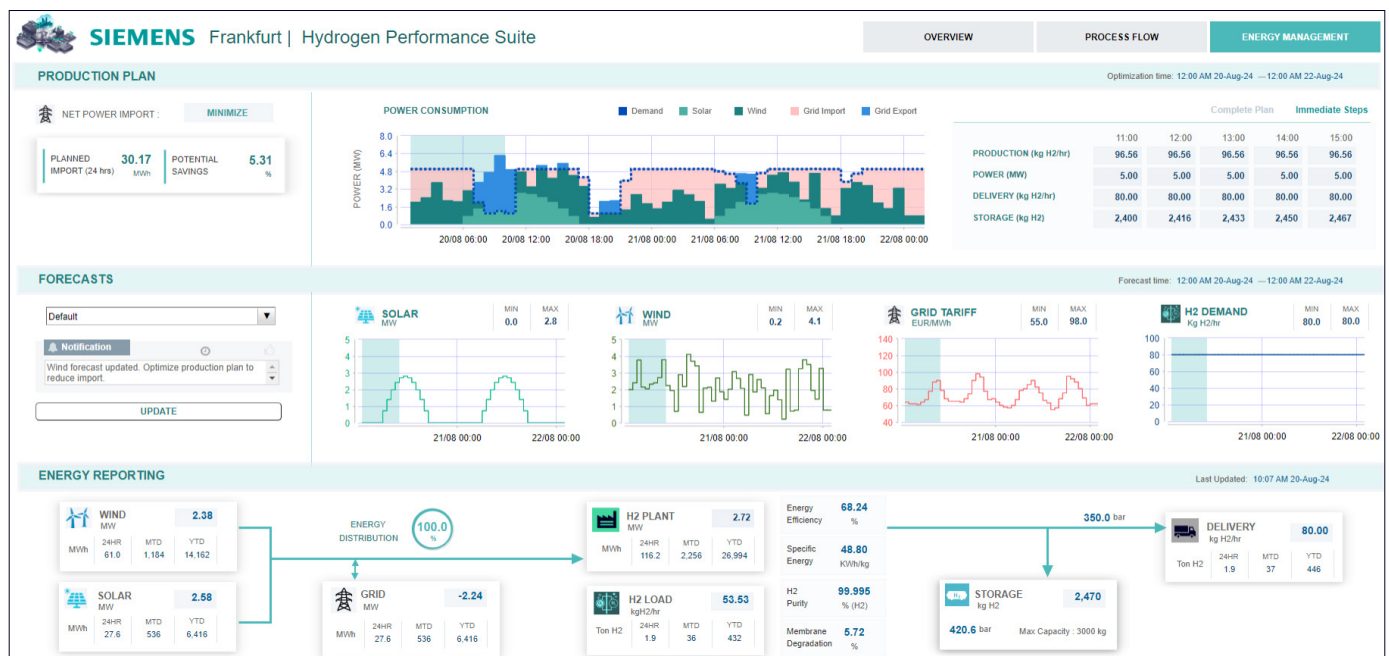
Real-Time Load Management (Optional Module)

In its extended configuration, HPS includes a closed-loop electrolyzer load optimization module. This feature continuously calculates and implements the most energy-efficient load distribution across multiple electrolyzer stacks.

By analyzing asset performance, ramp rates, and system constraints, the module ensures that electrical power is allocated in a way that maximizes overall efficiency.

The optimization results are transmitted directly to electrolyzer controllers and the plant's Power Control System (PCS) for execution.

The result is automated, intelligent load balancing that reduces energy consumption and minimizes system-wide OPEX while maintaining full compliance with operational constraints.



Example: Power-to-X Production Optimization



Data Visualization and Decision Support

HPS provides intuitive dashboards tailored to the needs of operators, engineers, and plant managers. These interfaces offer clear visualization of live and historical KPIs, asset performance trends, predicted versus actual production, alerts for anomalies, and actionable recommendations. The dashboards combine sensor data, simulation outputs, and optimization logic for informed decision-making.



Seamless Integration and Secure Deployment

HPS integrates into any modern IT/OT landscape via secure, bi-directional communication. Supported systems include Distributed Control Systems (DCS), Energy Management Systems (EMS), SCADA platforms, and process historians such as OSIsoft PI.

The solution can be hosted on customer-provided or Siemens-managed virtual machines and is fully compliant with standard cybersecurity practices.








Scalable, Modular Architecture

HPS is modular by design, supporting phased rollouts and flexible licensing. Whether deployed at a single plant or across multiple sites, it scales with business needs and supports future integration with Power-to-X systems or other process innovations.

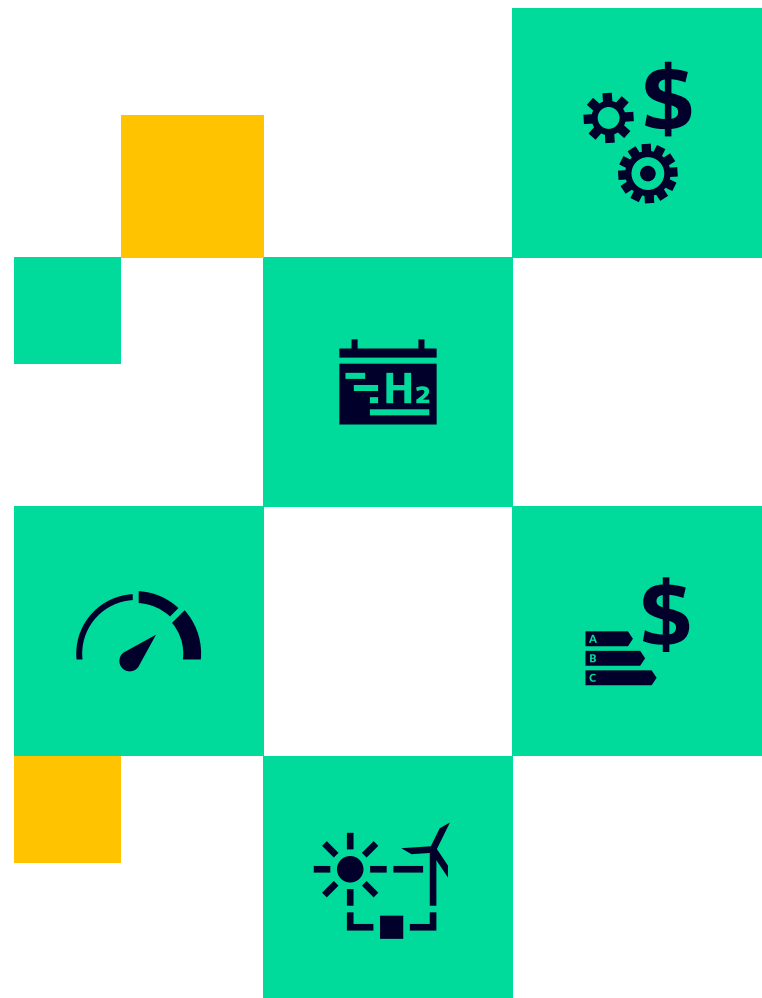
Data Inputs and Outputs

HPS processes a wide range of plant data, forecasts, and sensor values, including electrolyzer parameters (voltage, current, load), temperature and pressure measurements, storage levels, and system statuses. It also considers forecast data such as hydrogen demand, energy pricing, and maintenance schedules.

From this data, HPS Generates the following assets:

-  Optimized electrolyzer load profiles
-  Hydrogen production forecasts
-  Energy distribution insights
-  Efficiency metrics and cost-per-kg H₂
-  Operating profit estimations and historical logs

Discrepancies between planned and measured values are automatically reconciled through internal curve adjustments.



Deployment and Deliverables

HPS is deployed on secure virtual machines – either hosted by Siemens or the customer. Interfaces to control systems are pre-configured for compatibility and tested during commissioning. Standard deliverables include the operational software suite, a secure database for KPIs and logs, access to dashboards, and validated system interfaces.

Supporting Services

Software Components

The standard software package includes:

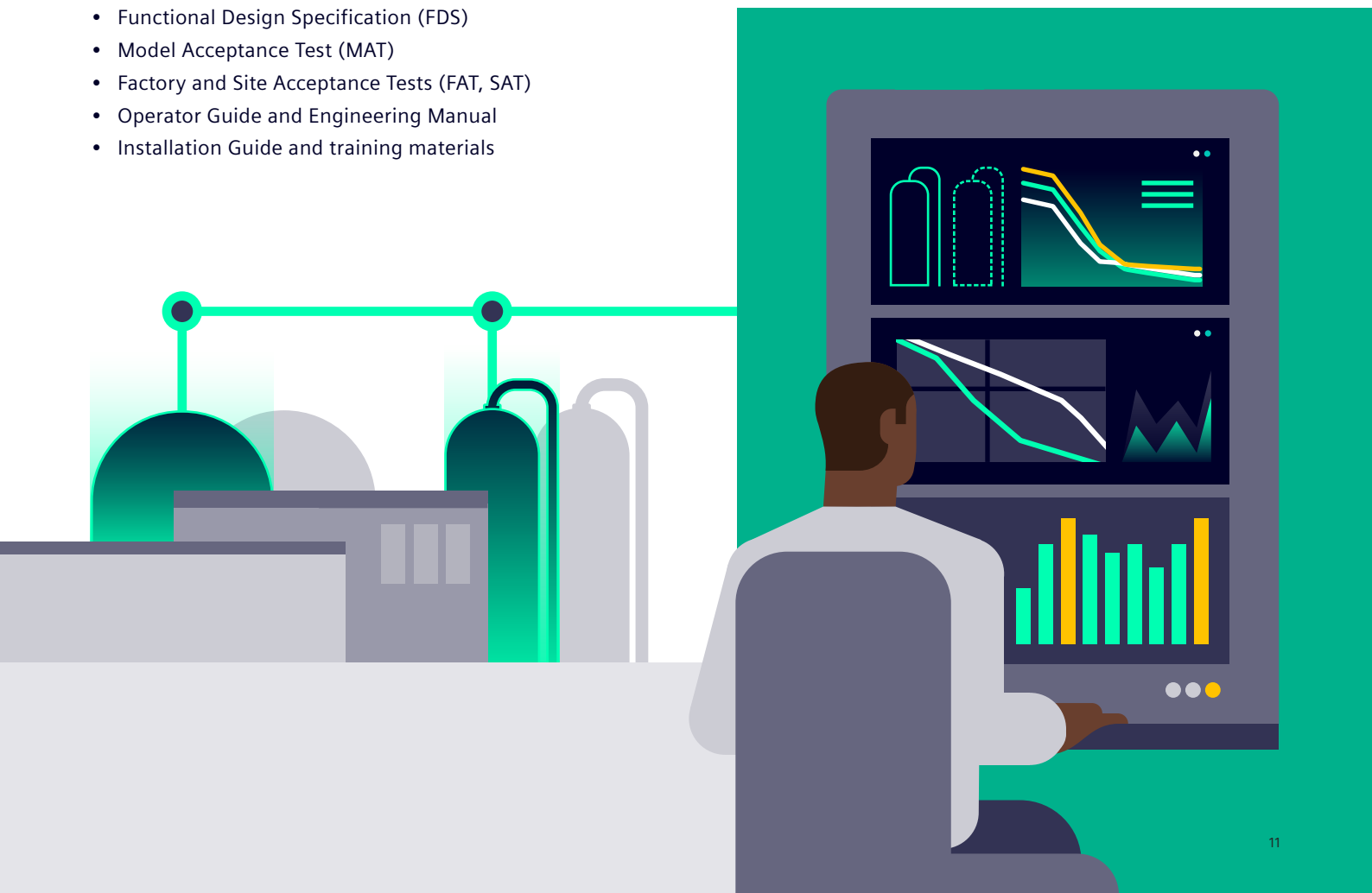
- Siemens Hydrogen Performance Suite
- SQL Server Standard with reporting services
- AlwaysUp high-availability wrapper (no extra costs)

Training and Enablement

Siemens provides comprehensive onboarding including live training sessions, simulation exercises, and full documentation. Key users are involved throughout the project for knowledge transfer and support continuity.

Documentation

- Functional Design Specification (FDS)
- Model Acceptance Test (MAT)
- Factory and Site Acceptance Tests (FAT, SAT)
- Operator Guide and Engineering Manual
- Installation Guide and training materials





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