

# “System of Systems in the H2 production process automation”

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Process Control & Safety System Specialist

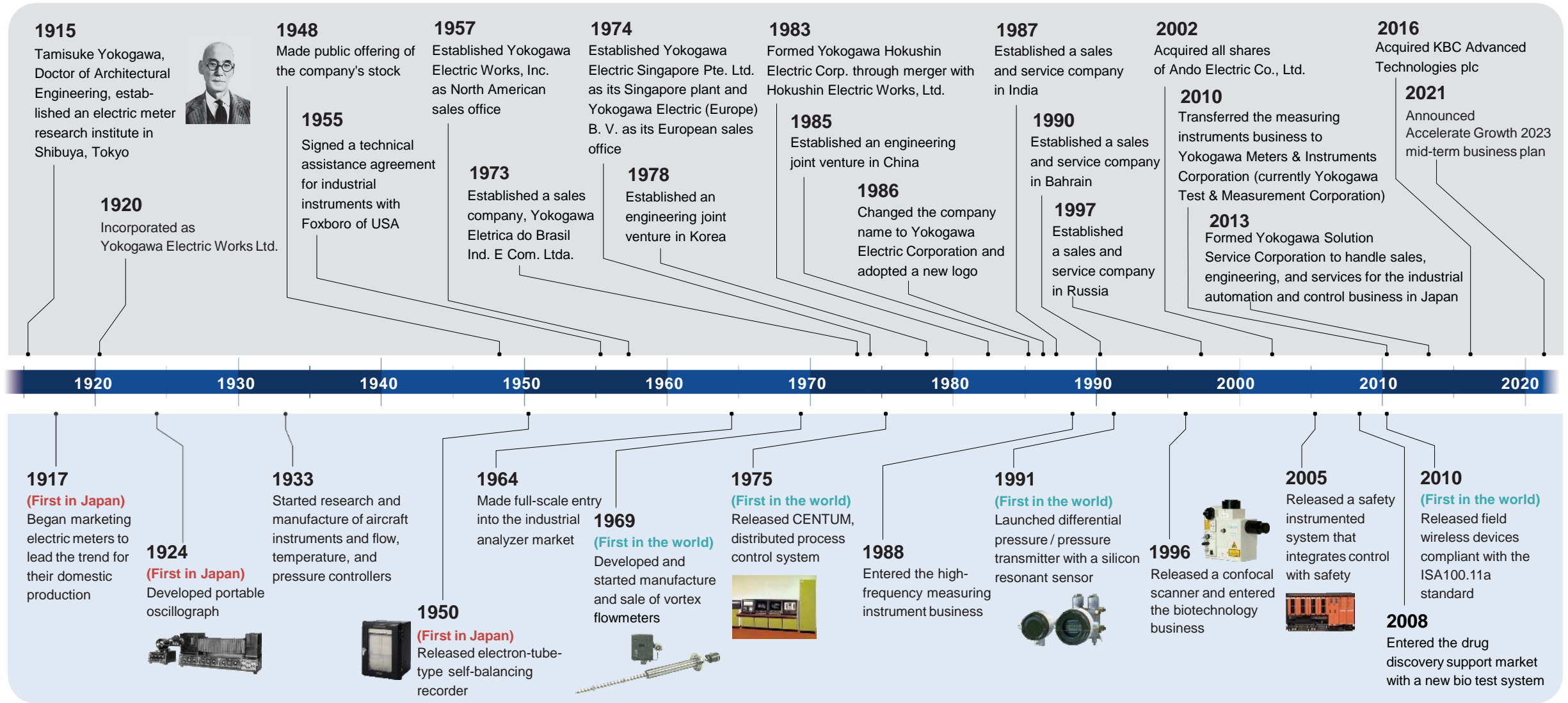
Yokogawa Italy

H2 Expo - 2024

# Contents

1. Introduction
2. Some process units
3. Integration and monitoring
4. Current Project

# A few words about Yokogawa



# Yokogawa Worldwide Business Operations

## Global network supporting business growth

Business sites

**60** countries

Subsidiaries and affiliates

**13** in Japan

**115** outside Japan

\*Includes branches and representative offices

Manufacturing sites

**12** countries



Yokogawa Europe



Yokogawa Electric CIS



Yokogawa China



Yokogawa Electric Korea



Yokogawa Corporation of America



Yokogawa Middle East & Africa



Yokogawa India



Yokogawa Electric International  
Yokogawa Engineering Asia



World Headquarters  
Yokogawa Electric Corporation



Yokogawa America do Sul

Service network

Countries and sites served

**200+**

Service sites

**180+**

Service engineers

**2,500+**

(As of March 31, 2023)

# Yokogawa Products and Solutions

## Energy and Sustainability Business

## Materials Business

## Life Business

### Products and Other Solutions

OpreX is an all-encompassing brand for Yokogawa's industrial automation and control business and comprises five categories based on which Yokogawa provides products, services, and other solutions covering everything from operations to business management.

With these solutions, customers can optimize operations management, production, facility operations, supply chains, and energy use, all of which can help to transform their businesses and maximize the creation of value.

- **Operations management**
  - Integrated performance management
  - Automation of standard operating procedures (SOPs)
- **Production optimization**
  - Advanced process control solutions, operational optimization solutions, autonomous control AI solutions
- **Plant asset management**
  - Facility failure prediction, facility maintenance, and management
  - Safety management solution for hazardous field work
- **Supply chain management**
  - Supply chain optimization, inventory and logistics management
- **Attaining the Sustainable Development Goals (SDGs) / energy management and optimization**
  - Energy management, continuous emission monitoring systems



This segment's products aid in the production of biopharmaceuticals and in the conduct of cell analysis for the R&D of foods and pharmaceuticals.



Collaborative information servers



Distributed control systems



Safety instrumented systems



Programmable logic controllers



Process analyzers  
Process gas chromatographs



Field instruments  
Pressure/temperature transmitters, wireless transmitters  
Coriolis/magnetic/vortex/variable area flowmeters



Film/sheet thickness gauges



Data acquisition systems  
Paperless recorders, data loggers



Distributed temperature sensors



IIoT wireless sensors



Subcellular Sampling System



Nano-point delivery



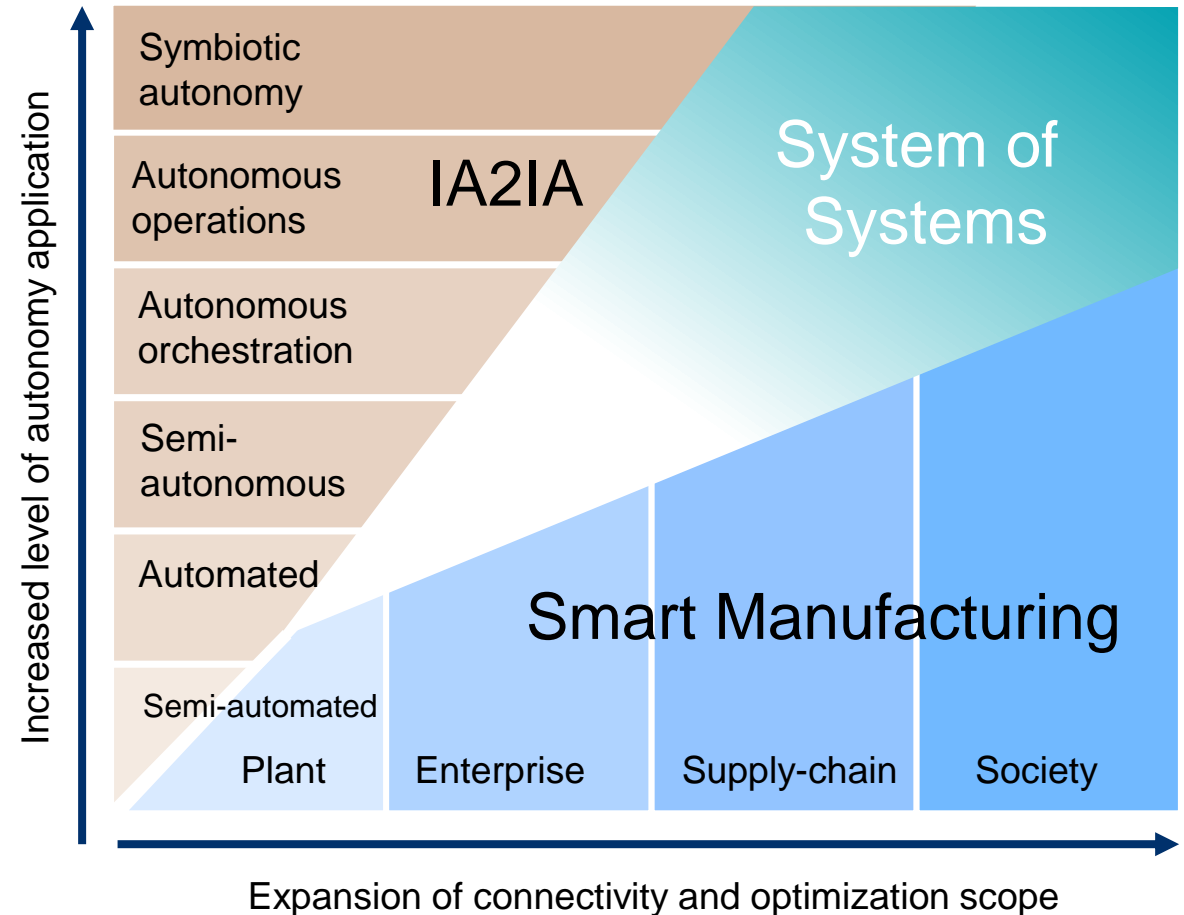
High-throughput cytological discovery systems

# Our Value Provision to Customers 10 years from Now

## Value provided based on the system of systems concept

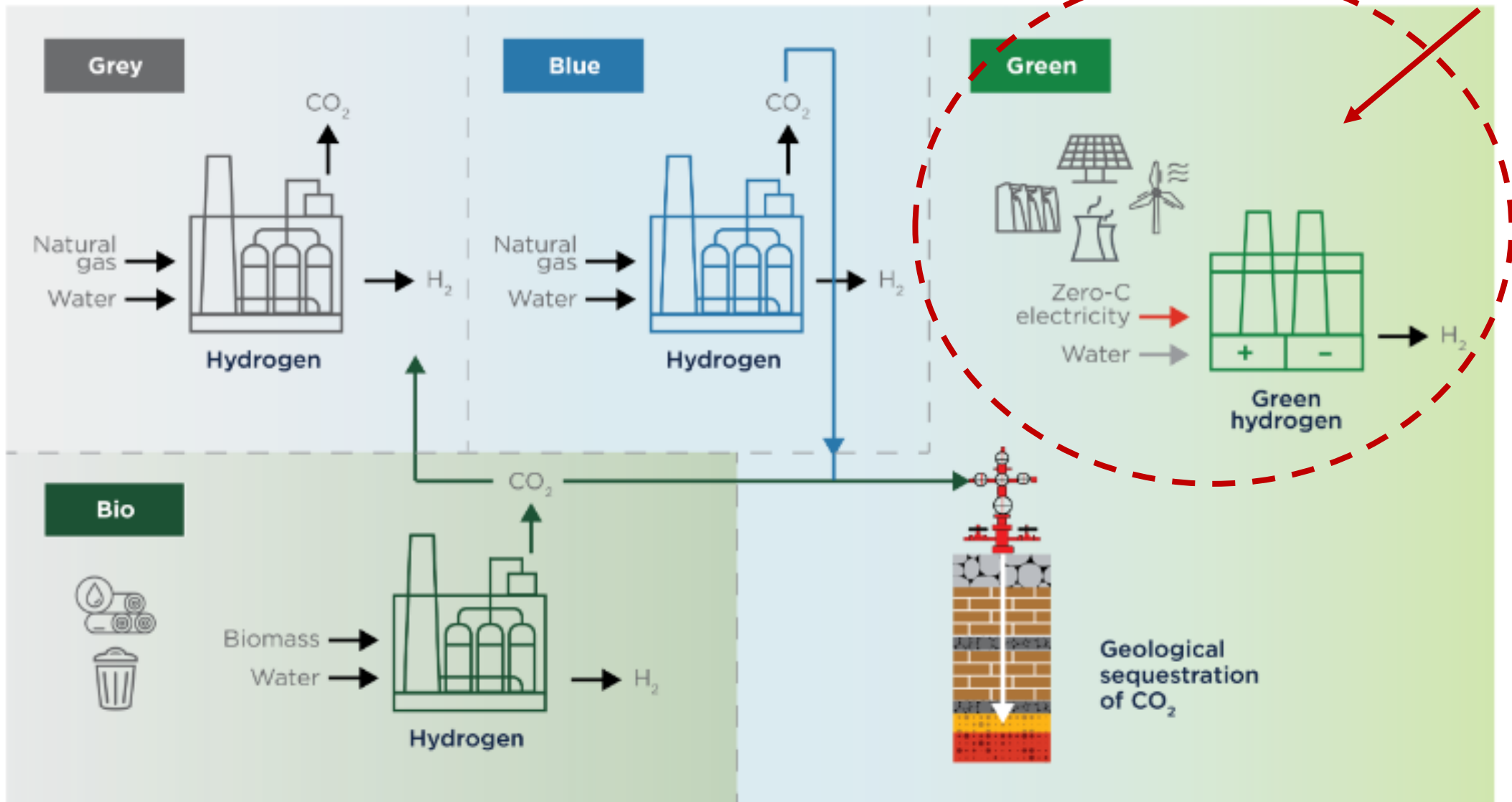
Today, the system of systems (SoS) concept is gaining wide acceptance. According to this concept, systems with operational and management independence work together to achieve system-wide objectives that cannot be achieved alone.

We promote connectivity and create value through overall optimization driven by integration, autonomy, and digitalization, based on two approaches: IA2IA (industrial automation to industrial autonomy), which changes the level of autonomy, and smart manufacturing, which broadens the scope of overall optimization.



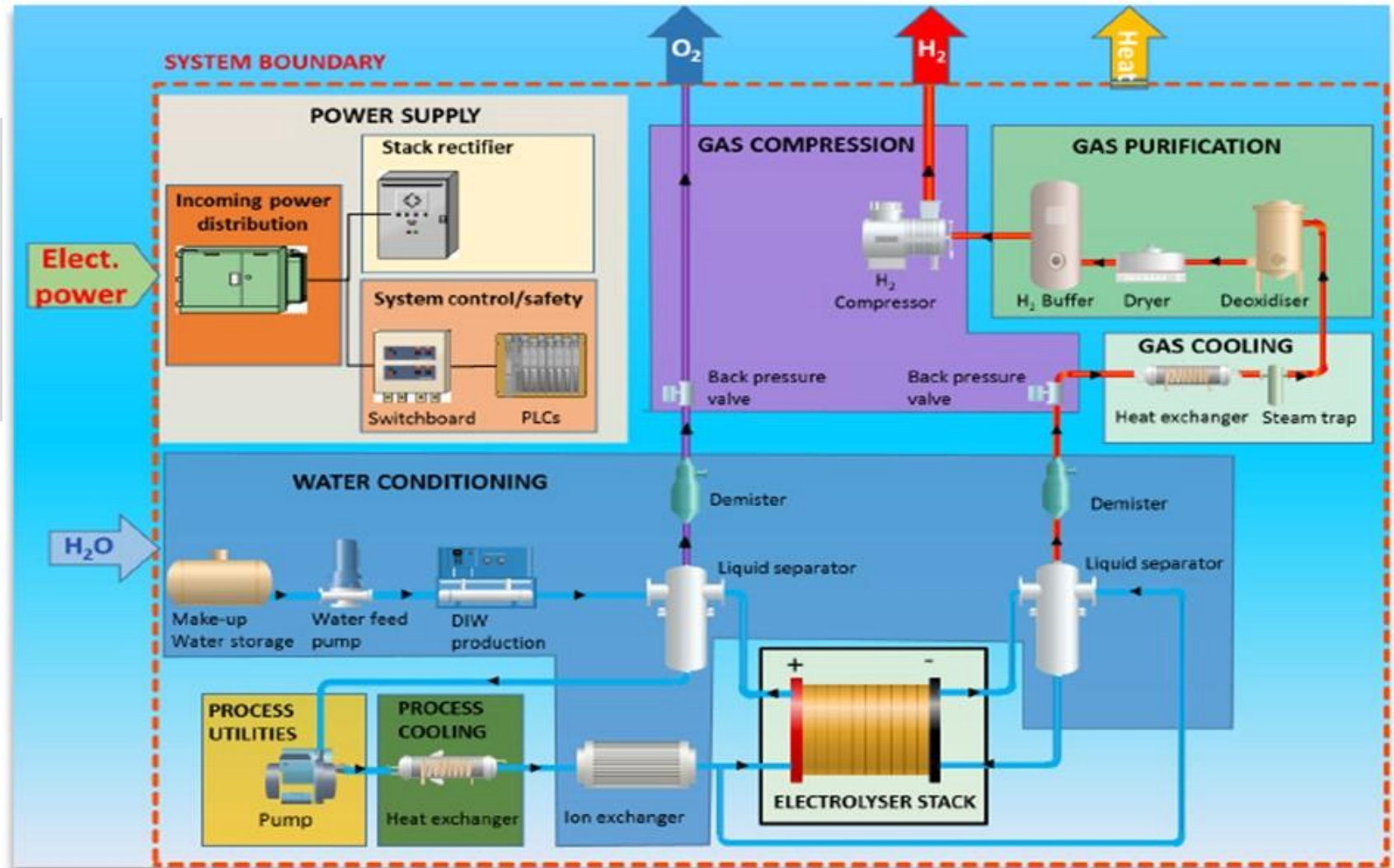
# Introduction to H2

# Hydrogen production overview

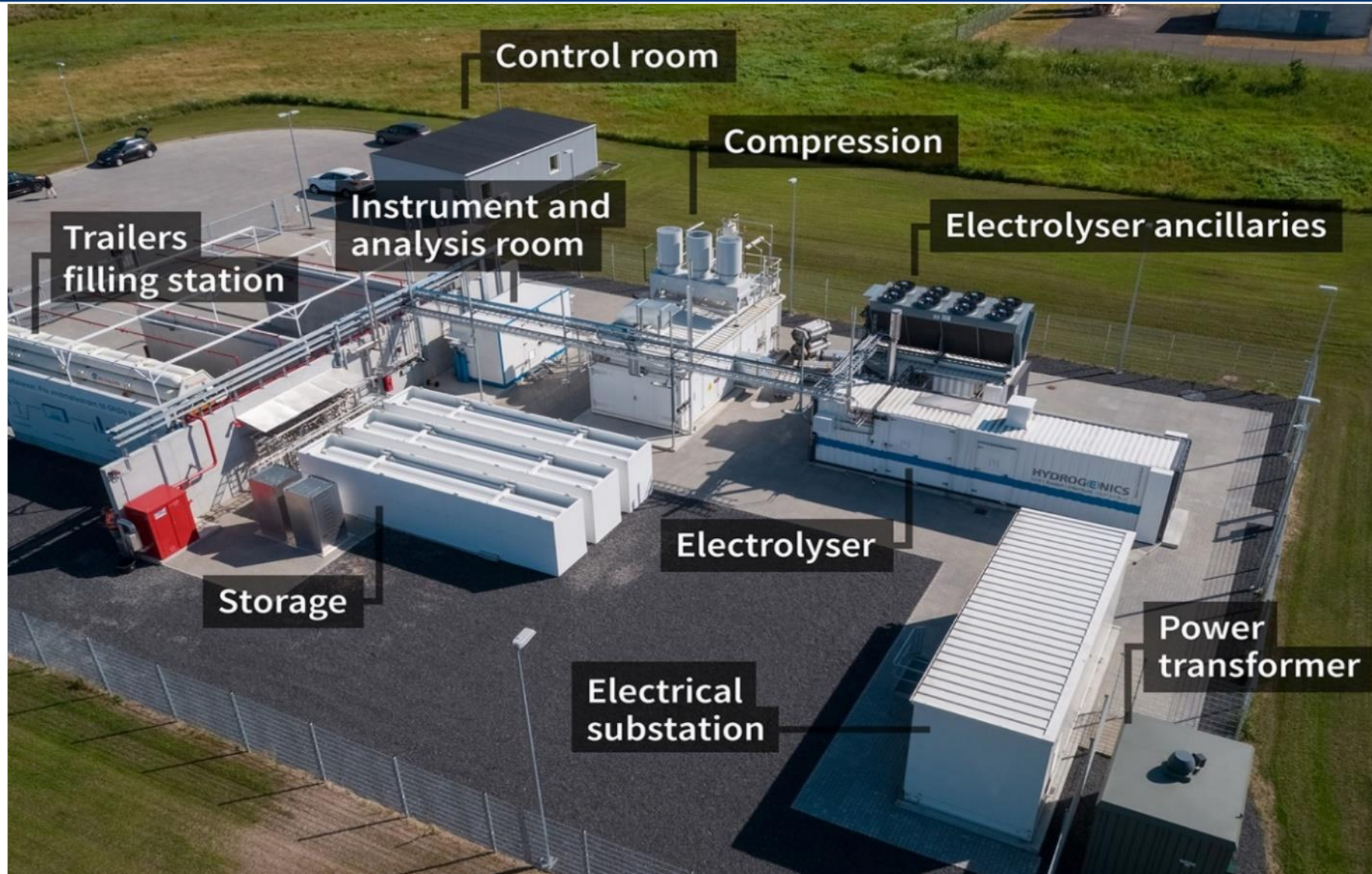




# Green H2 typical production layout



# Hydrogen Production Plant: an example

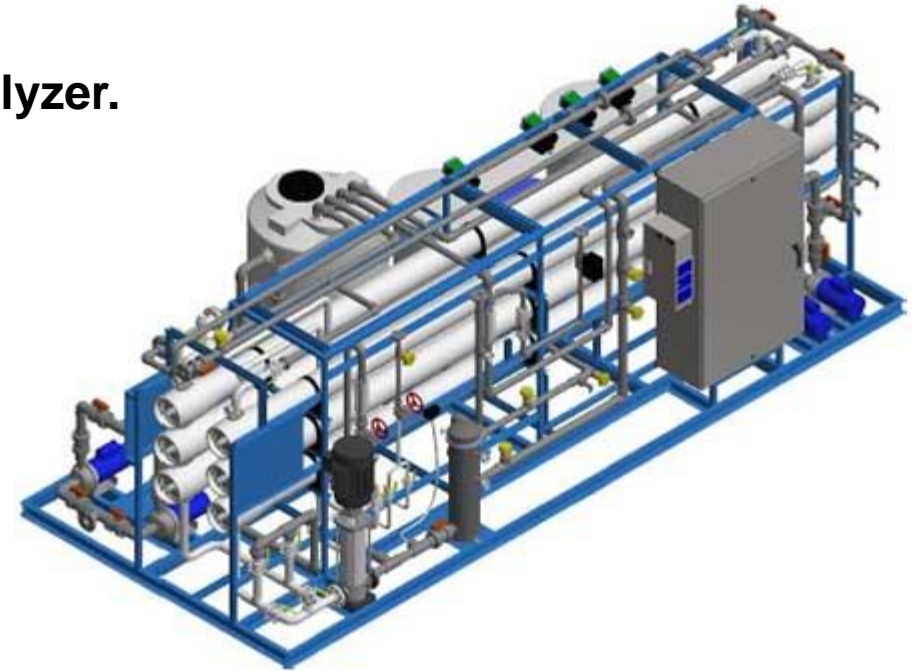
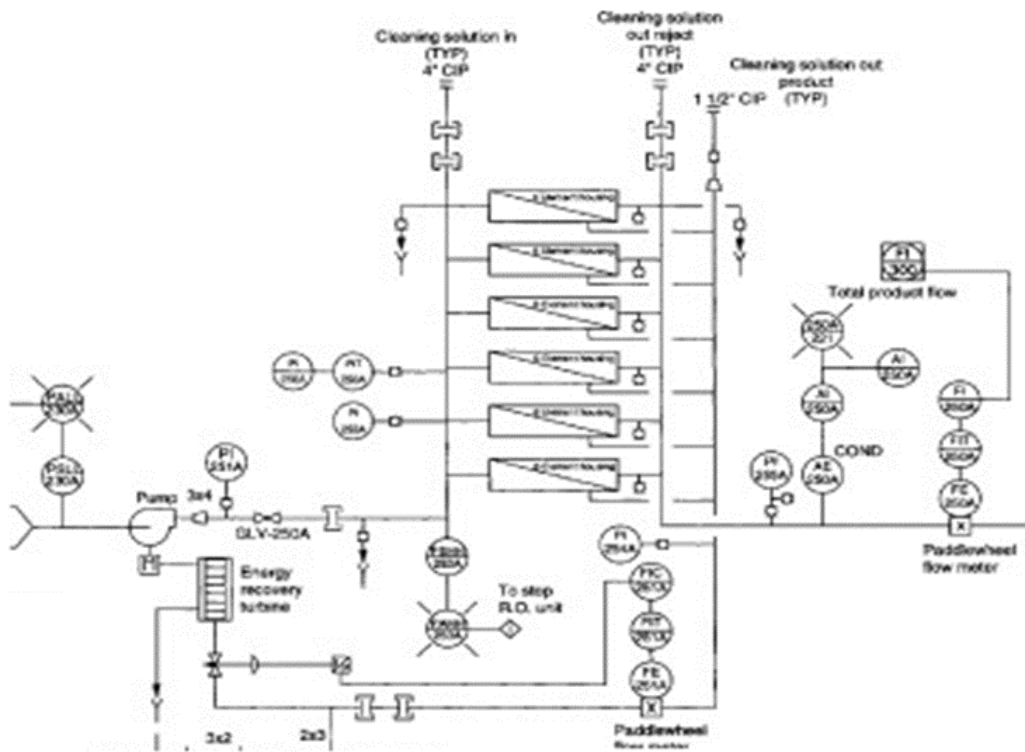


# Process (units) and instrumentation

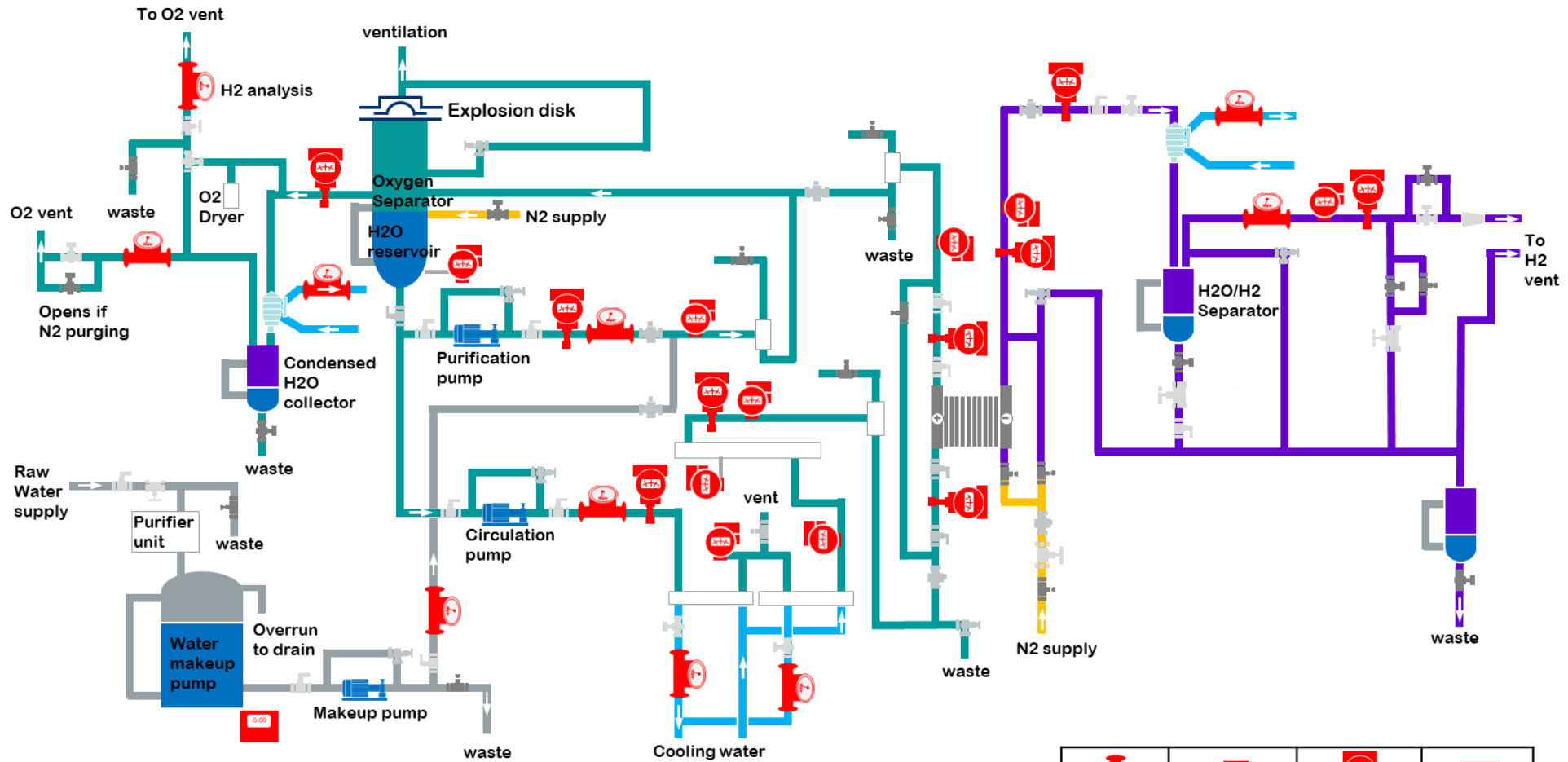


# Water Management – Reverse Osmosis





Membrane removes dissolved ionic species from water, in this way, conductivity is kept under 1 MicroSiemens/cm in order to feed electrolyzer. The optimal temperature must be 70°C



# Electrolyzer: PEM



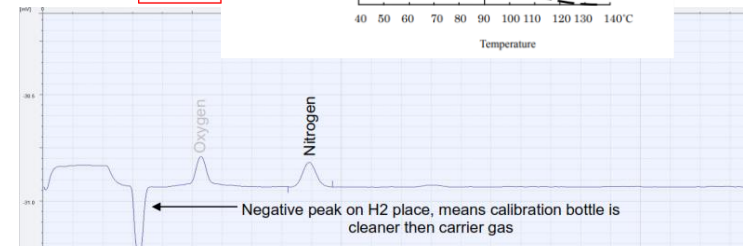
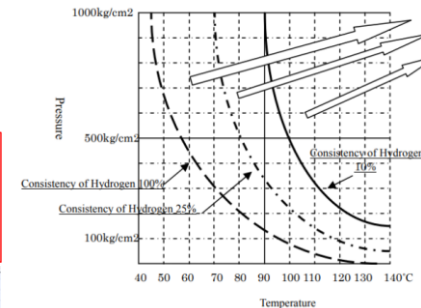
O2	H2	Cooling water	N2	Water

			
Variable Flowmeter	Temperature Transmitter	Differential Pressure Transmitter	Two-wires Liquid Analyzer



# Instrumentation for Hydrogen

- pH measurement
  - Quality measurement of liquid raw material supply
- Tunable diode laser spectrometers (TDLS)
  - O<sub>2</sub> measurement in SIL applications
- Pressure transmitters.
  - With gold coating or Hastelloy HC276 with passive thin film (Cr<sub>2</sub>O<sub>2</sub>) on its surface
- Gas chromatography
  - Nitrogen, CO, CO<sub>2</sub>, Argon, Methane and more



TCD: Thermal Conductivity Detection (no combustion air/fuel needed)



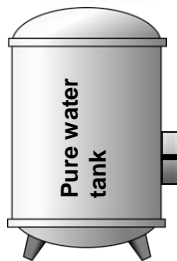
# Measurement and control: an overview

Integrated monitoring + control system at low cost including predictive maintenance and sensor failure diagnosis



① up to 0.1 uS  
Measuring pure water

**FLXA conductivity meter**



② Pure water flow measurement  
(under noise-free by electric cell)

**CA**



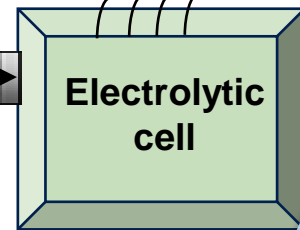
③ Pump condition monitoring

**Sushi Sensor**



④ Electrolytic cell  
cell voltage, temp  
measurement

**GM**



⑥ Hydrogen flow measurement  
with analog input  
Gas density compensation

**Centum-VP DCS**

⑦ Measurement of  
H2 % purity and replace  
purge for safety

**VY**



**TDLs  
Gas analyzer**

⑧ Monitoring oxygen  
concentration in hydrogen  
to prevent explosions

**GD402**



**HART/ModbusGW**

**EJX/EJA**



**ROTAMASS TI**



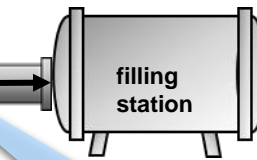
⑨ Measurement of  
trace moisture in  
product gases

⑩ For hydrogen  
measurement  
Gold Plating  
Specifications

⑫ Hydrogen  
quality control



⑪ High pressure  
hydrogen flow  
measurement  
High precision gas  
measurement





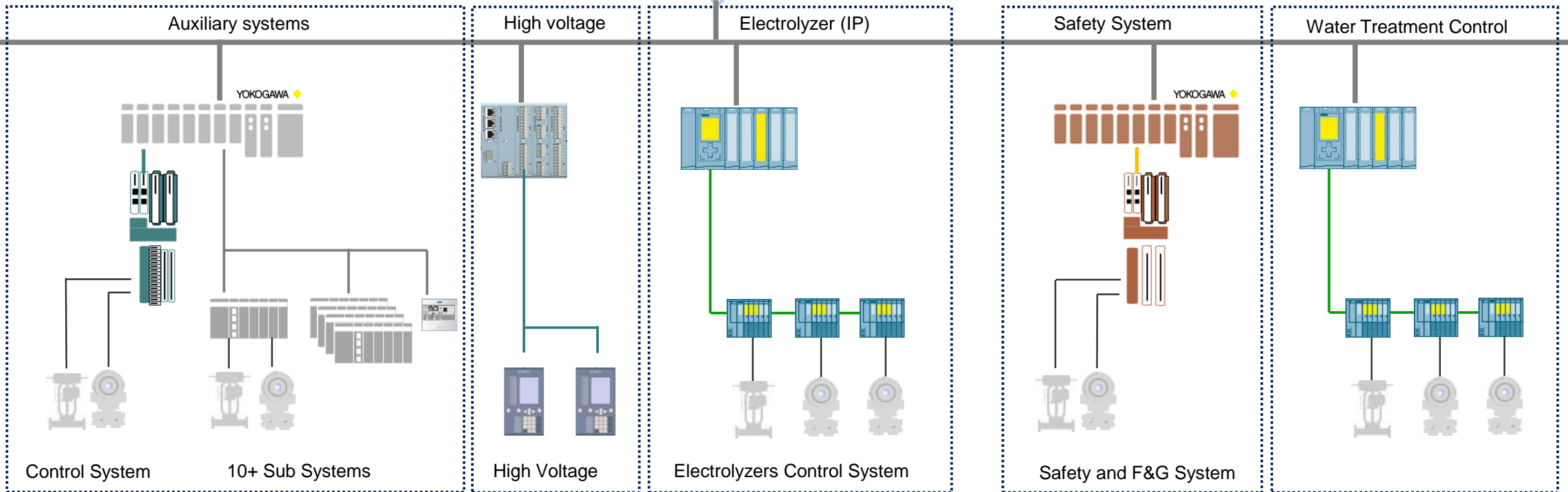
# Overall Plant Supervision: “System of Systems”

# H2 Plant – System of Systems

## Integration Platform

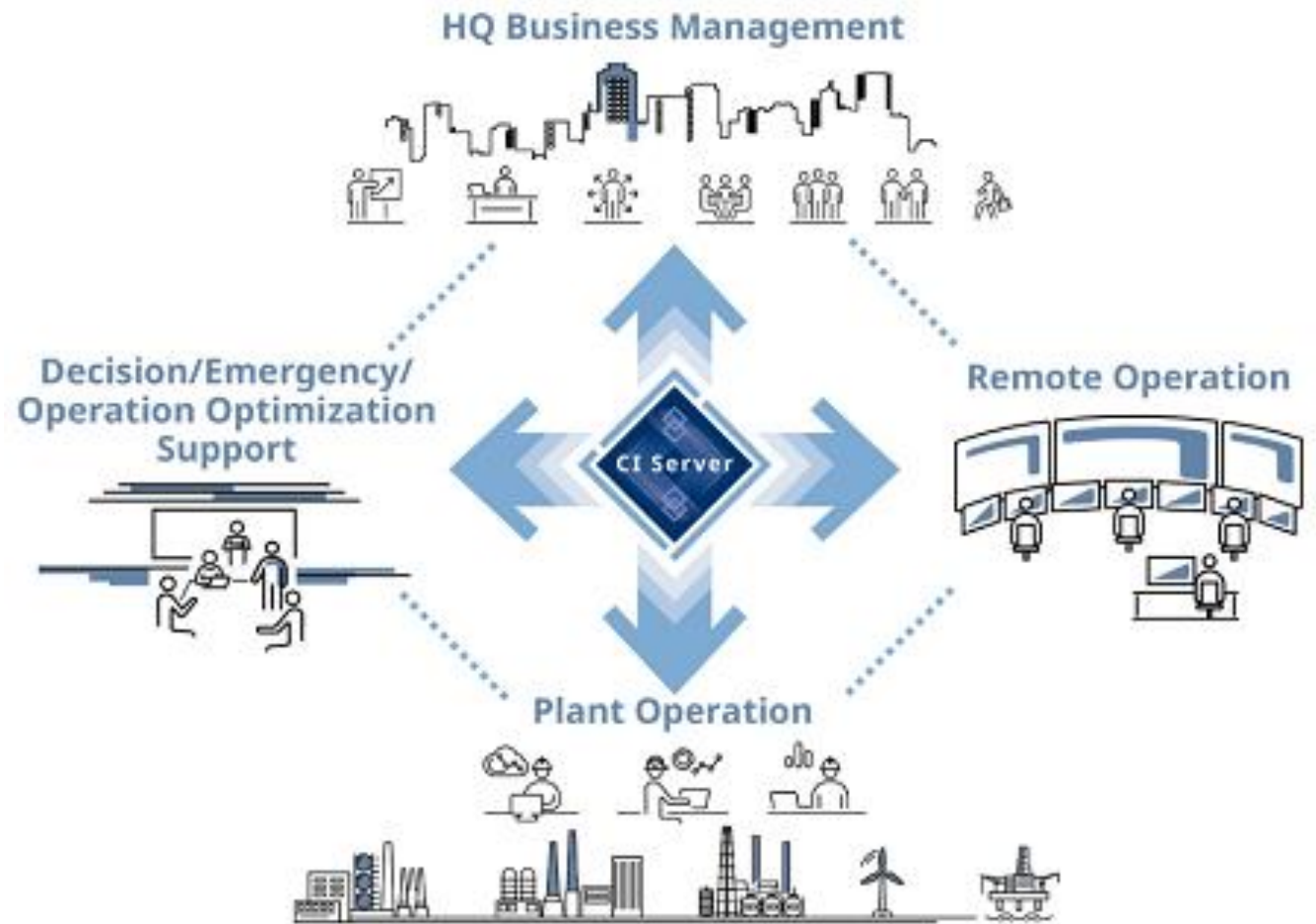


Different packages need coordination and single point of supervision

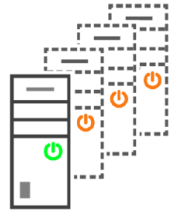


# Yokogawa Integration Platform

- Horizontal integration
  - By integrating equipment and systems on the plant it can connect different systems / sites and facilitates remote operation. Wide range of protocols supported
- Vertical integration
  - Through IT/OT convergence, it can seamlessly transport data to upper-layer systems (Sap, Oracle, SQL, .Net, Python, ... )
- Scalable and Expandable
- Multi-platform
- Robust vs. Cyber attacks
- Compliant with O-PAS and NAMUR MTP standards



# Key Features of CI-Server

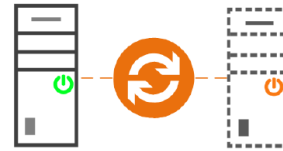


Full redundant disaster recovery concept through **triple** and even **quad** HAC server cluster

## High Availability



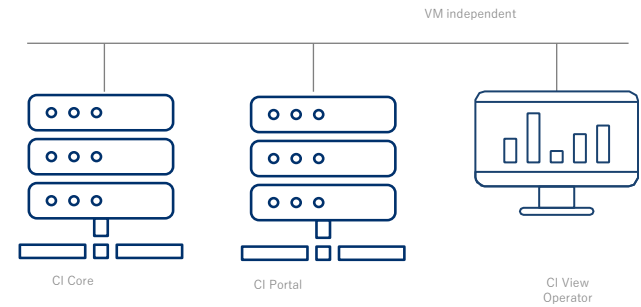
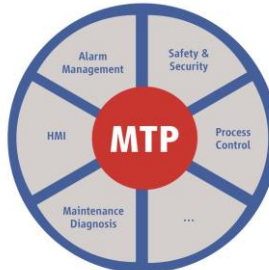
Dedicated or shared **redundant networks** (LAN/WAN) or **quad redundant networks** (LAN/WAN)



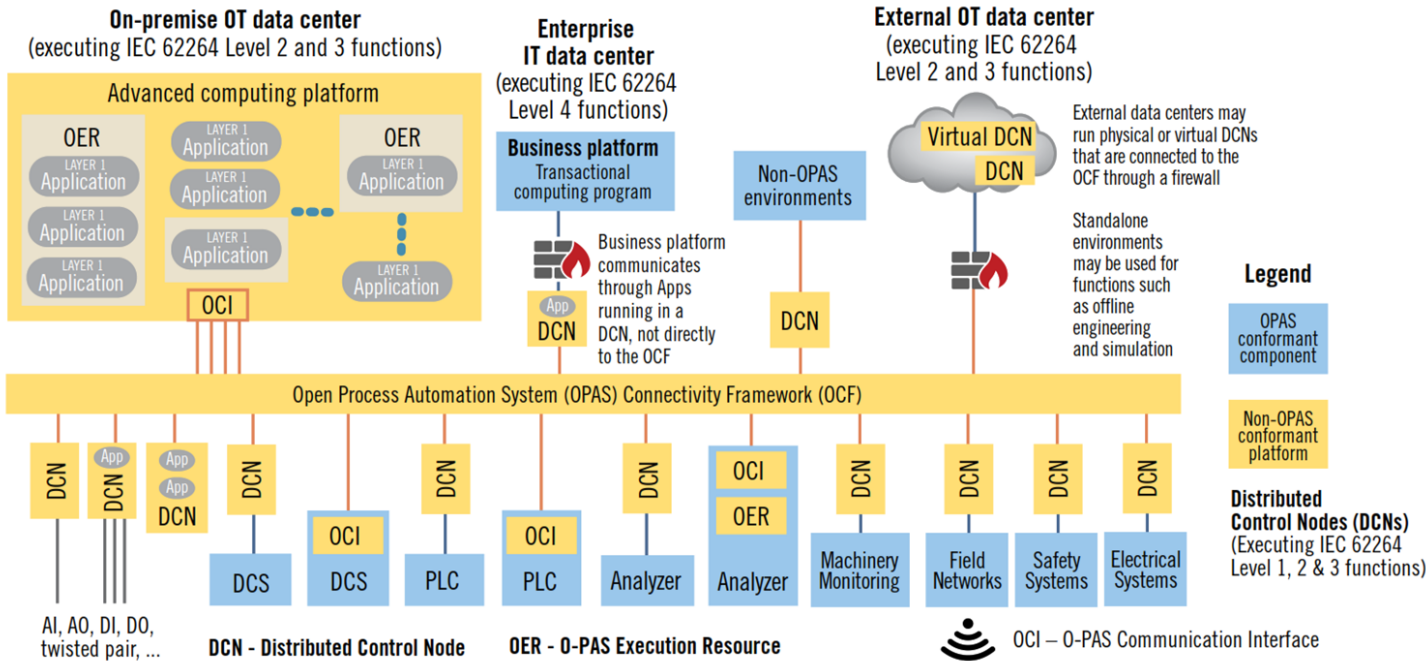
**Automatic synchronization** between active server and hot standby servers

## Cross-Platform

## Open flexibility



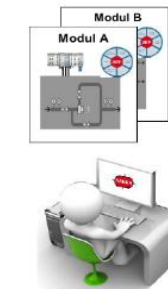
# Open to next trends (MTP, OPA)



## A "standard of standards"

O-PAS part	Subject matter	Referenced standards
Part 1	Technical architecture	IEC 62264 (ISA 95)
Part 2	Security	IEC 62443 (ISA 99)
Part 3	Profiles	n.a.
Part 4	Connectivity framework	IEC 62541 (OPC UA)
Part 5	System management	DMTD (Redfish)
Part 6	Information and exchange models	IEC 62714 (AutomationML) IEC 62682 (ISA 18) IEC 61131 IEC 61499

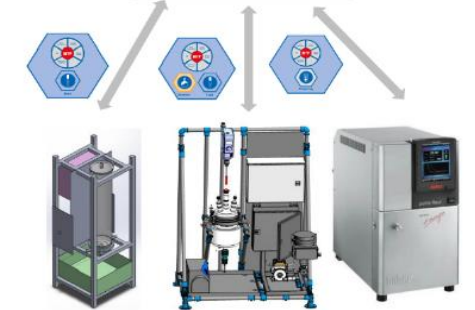
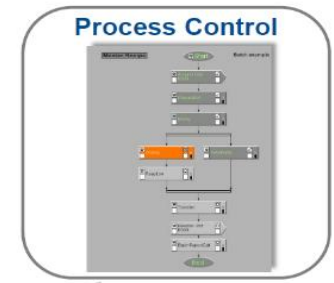
## Module Engineering



**Service oriented communication:**

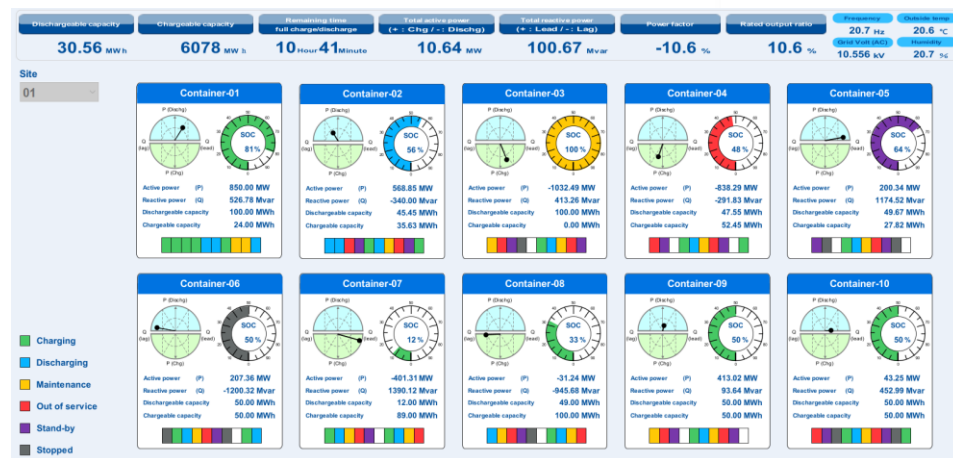
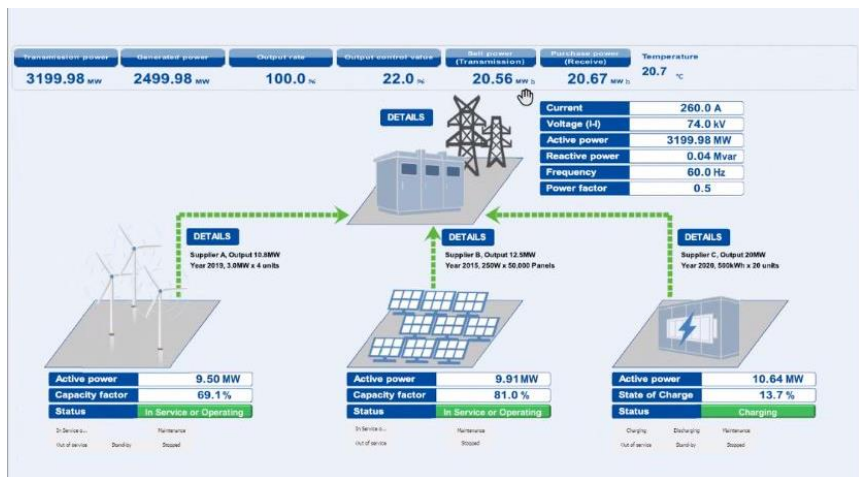
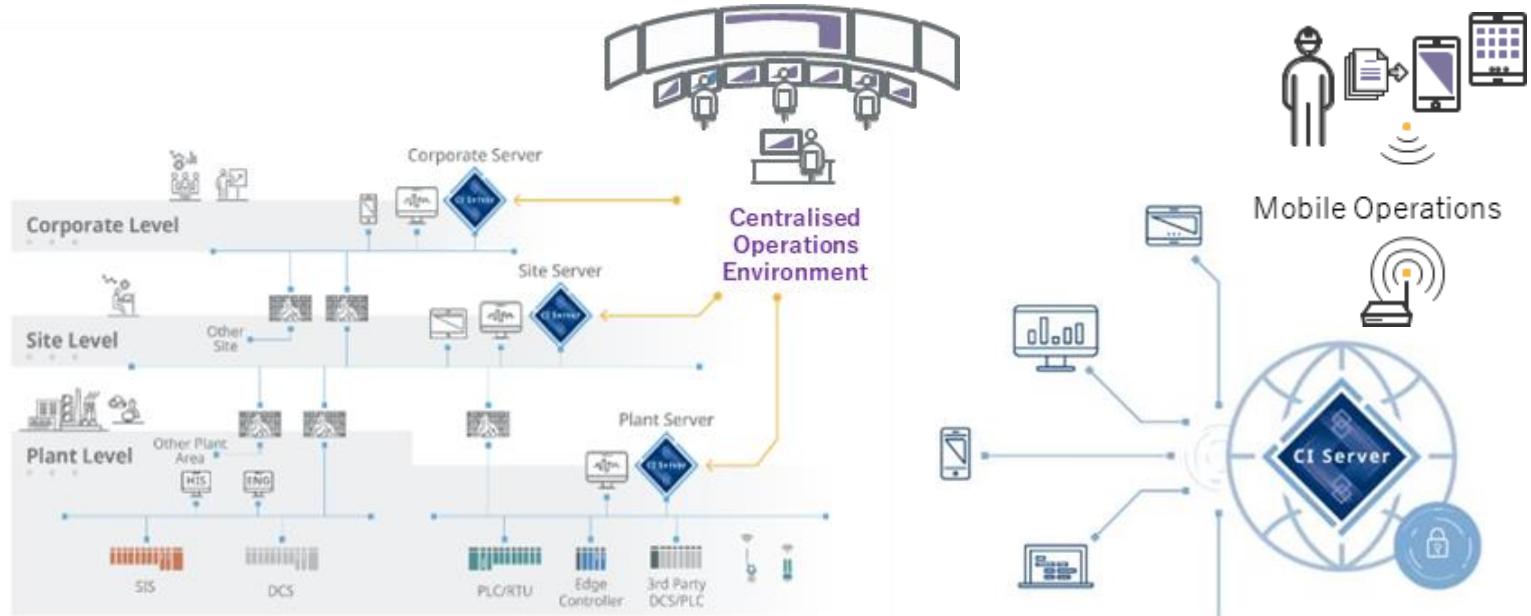
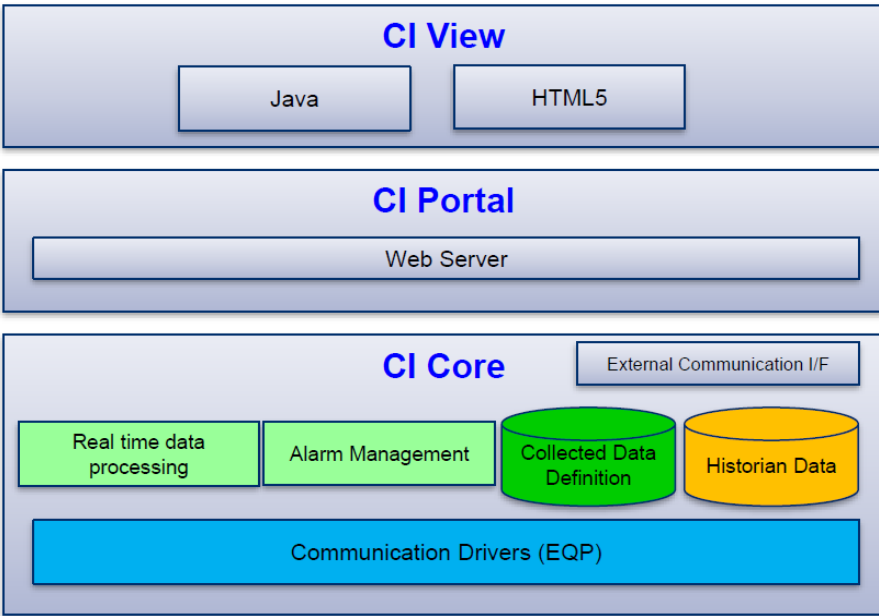
- ✓ defined state model
- ✓ Command (e.g. tempering)
- ✓ Status (e.g. Running)
- ✓ Service properties (e.g. setpoint temperature)

## Plant Engineering

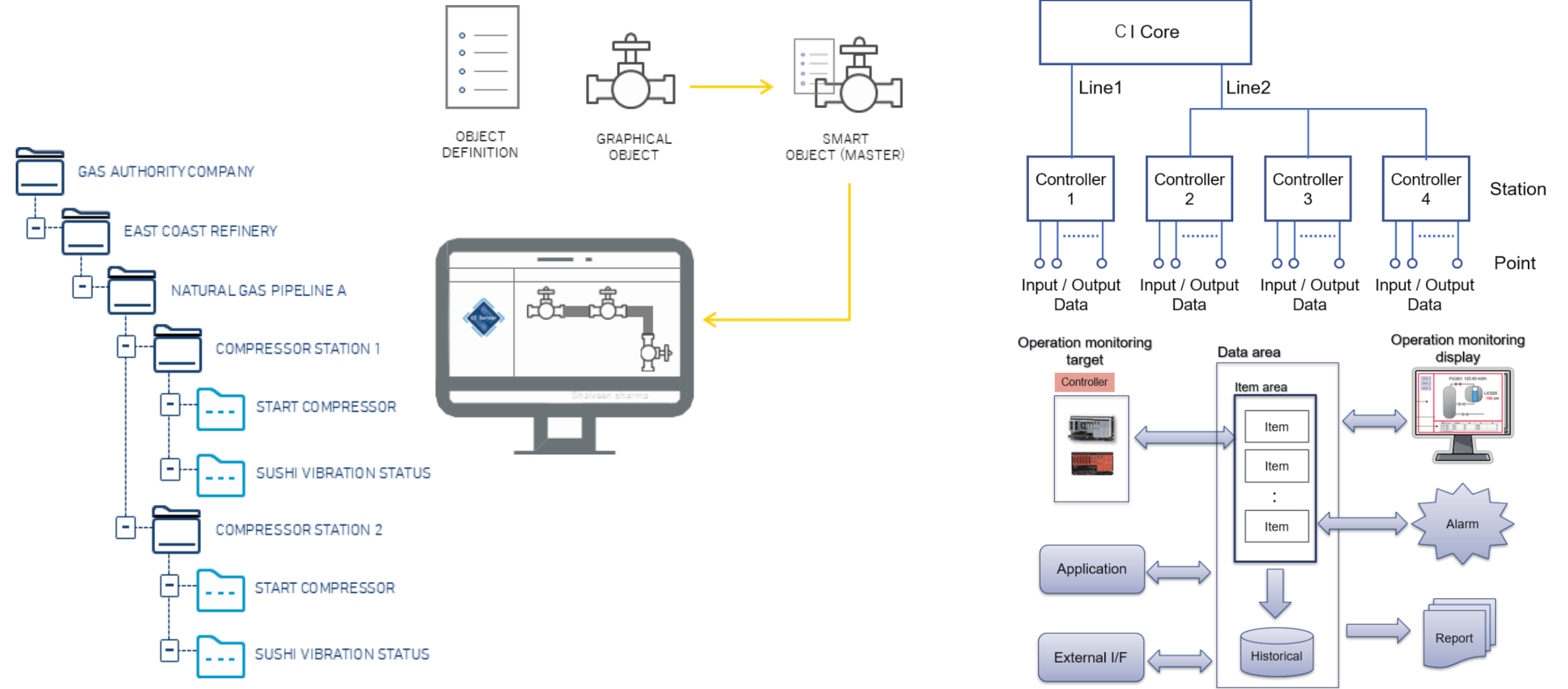




# Plant supervisory platform – Architecture & Graphics



# Designed for information sharing



# Network Security

## ■ Features

- Fits industry standard and customer specific network security framework
- Interoperates with mainstream end point security software

## ■ Immediate benefits

- Allows migration into existing & new network infrastructures



CI CORE to CI CORE encrypted communication

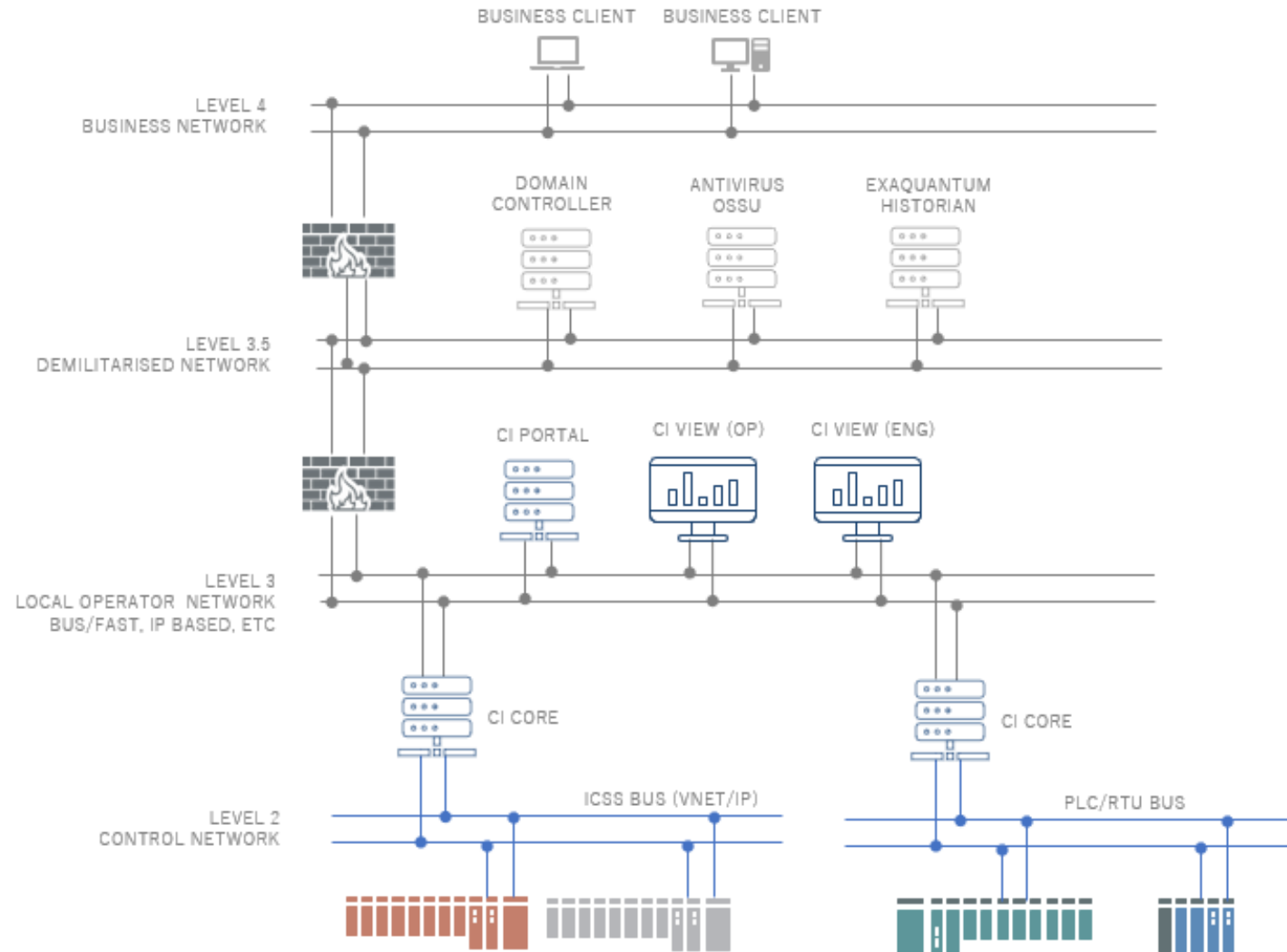


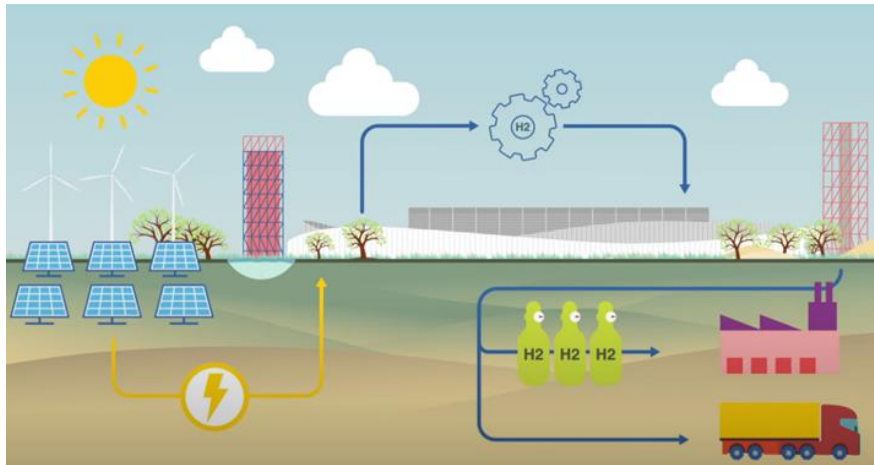
Image: General ISA99 SCADA Network Architecture



# Current project

# YEF-NL Shell Holland Hydrogen I (HH1)

- 200 MW electrolysis-based hydrogen plant
- Production: 50-60k ton/yr green Hydrogen
- Wind energy from off-shore windfarm
- Including visitor center
- Operational ~2024
- Hydrogen supply
  - To Pernis Industrial Area
  - To mobility, Rotterdam city area

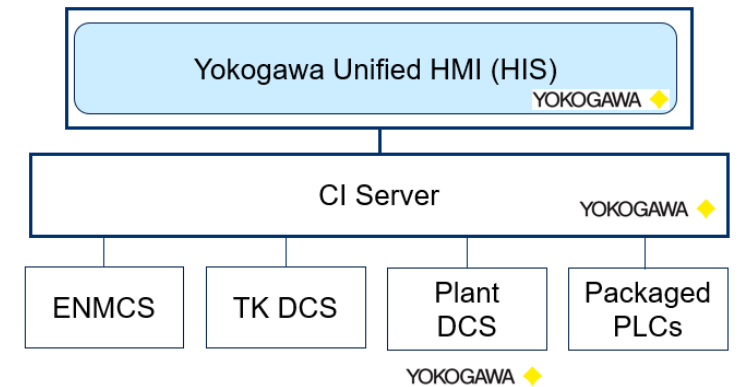


Electrolyser contractor

Electrical contractor (33kV)

Yokogawa selected as MAC, preliminary scope:

- Integrator Scope
- Utility DCS/ESD/F&G
- Analytical scope
- CMMS
- OTS



Yokogawa: “Integrator of All”

# Ongoing Project under current execution by Yokogawa Italy

Client:

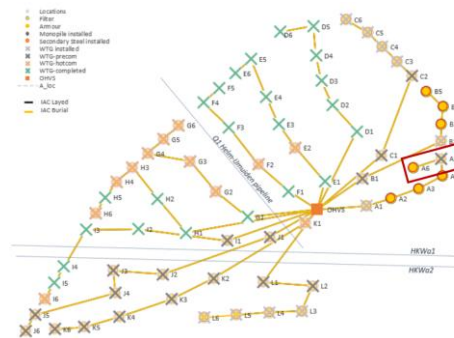
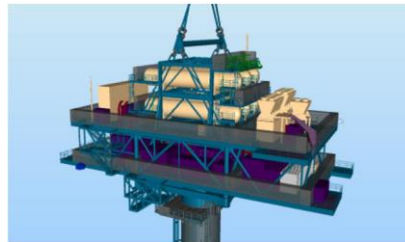
NDA

Scope of Work:

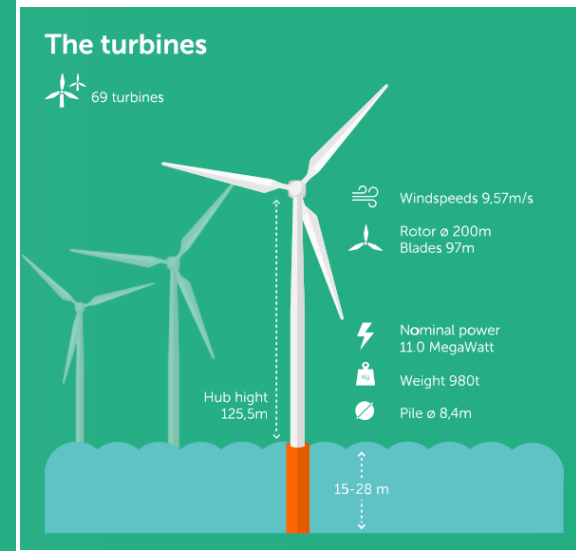
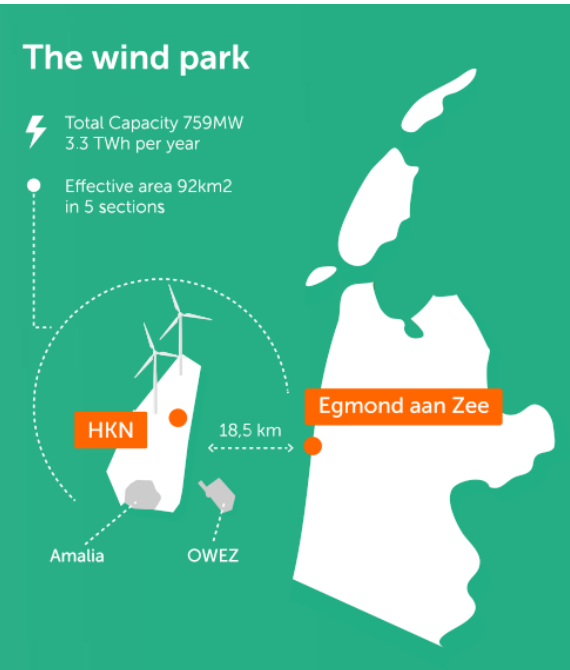
Detailed design, procurement of material and equipment, construction work, transport and installation at sea, commissioning and start-up of the platform.

Technologies to be deployed:

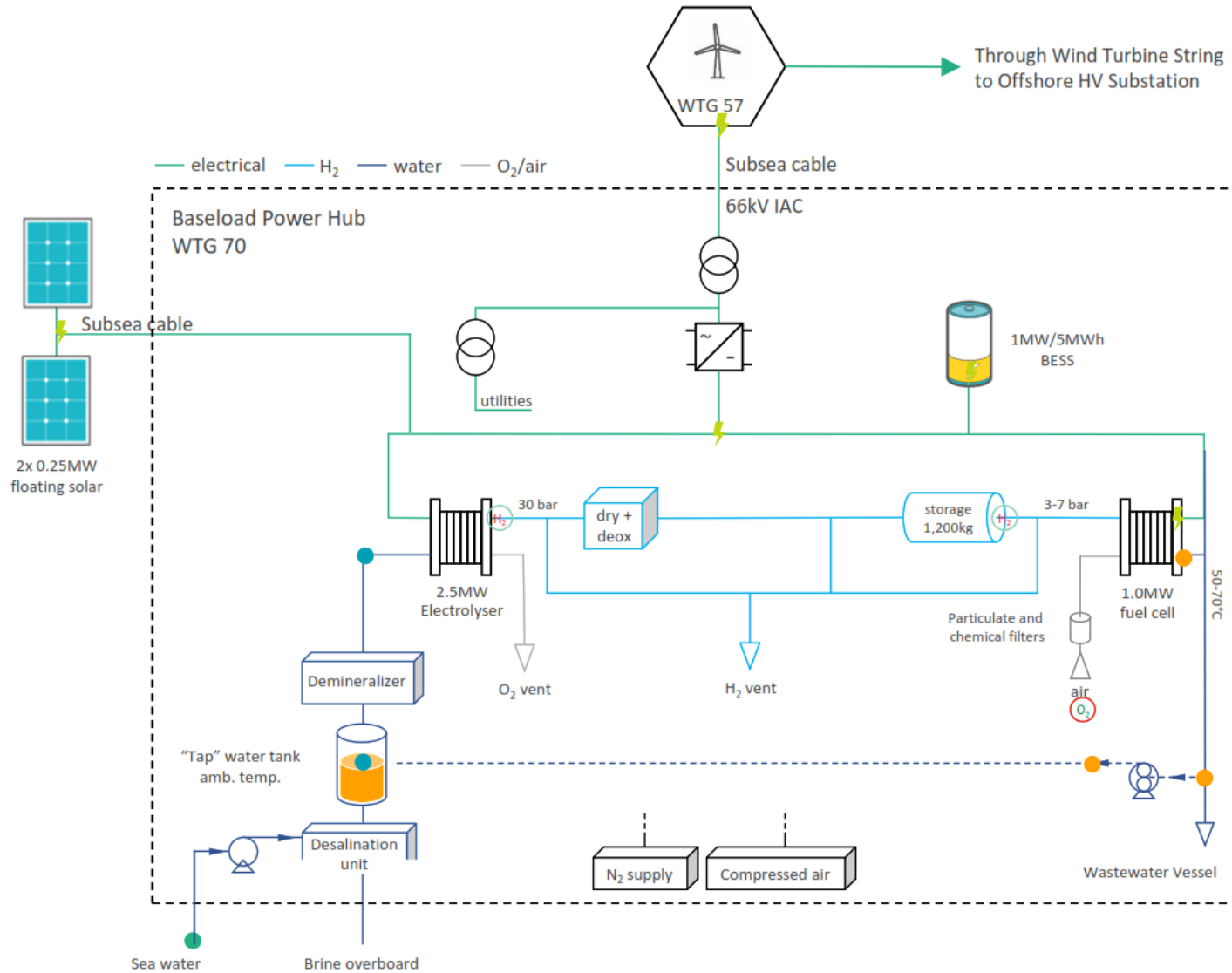
- 1 MWe/5 MWh lithium-ion BESS
- 2.5 MW electrolyser
- 1,200 kg of 30-40 barg H2 gas storage
- 1.0 MWe fuel cell
- Power Management System
- HV Switchgear 66kV
- Transformers 66/6.6 kV/ 480V
- Control System, F&G
- Water Treatment Plant



- Location:** Hollandse Kust Noord offshore windfarm, 18.5 kilometres off the Dutch coast.
- 69 Wind power generators
  - 1 Central Off-shore Unmanaged Platform (operated from on-shore control room)
  - Sub-marine optical fibers network

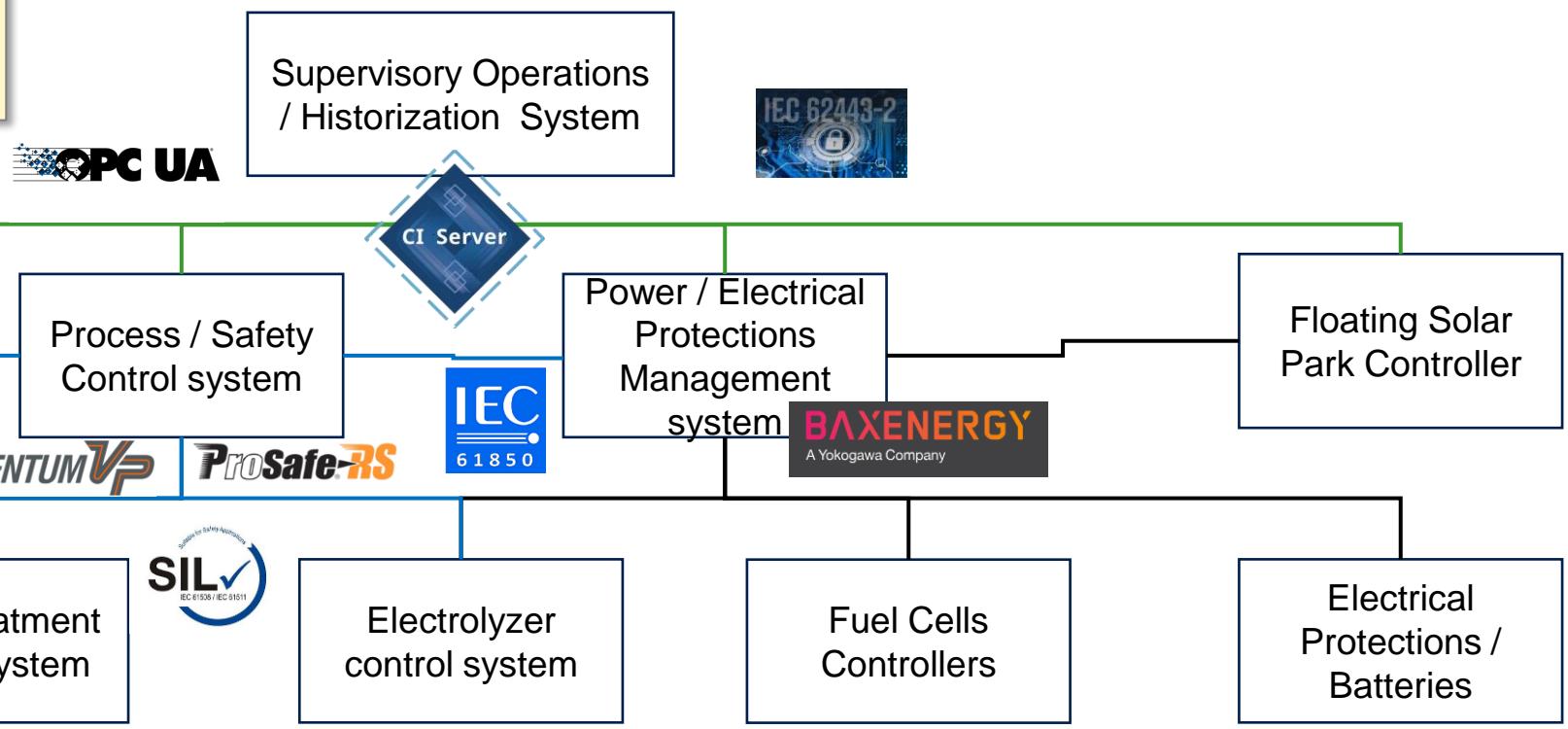


# Symplified Process Flow Diagram



# System of Systems Functional layout

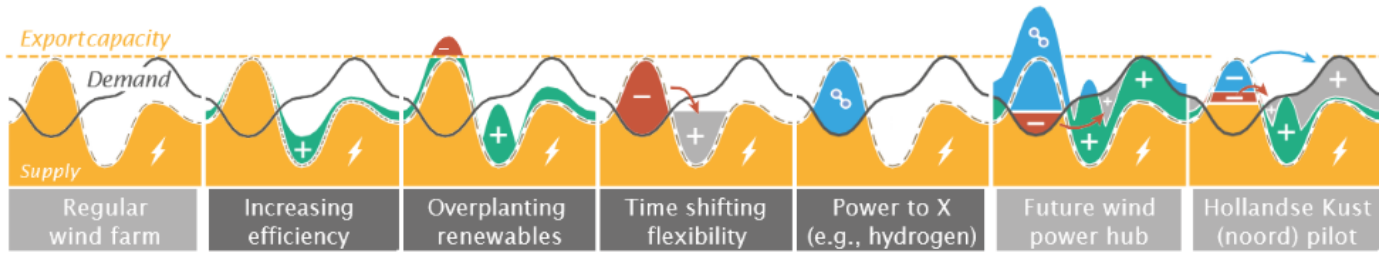
About 900 wired I/O  
More than 2000 communication I/O



Base case electricity production     
 Electricity gained by innovation     
 Electricity lost or stored  
 Power to X conversion (e.g., hydrogen)     
 Electricity gained by discharging storage     
 X(e.g., hydrogen) stored

## Scope:

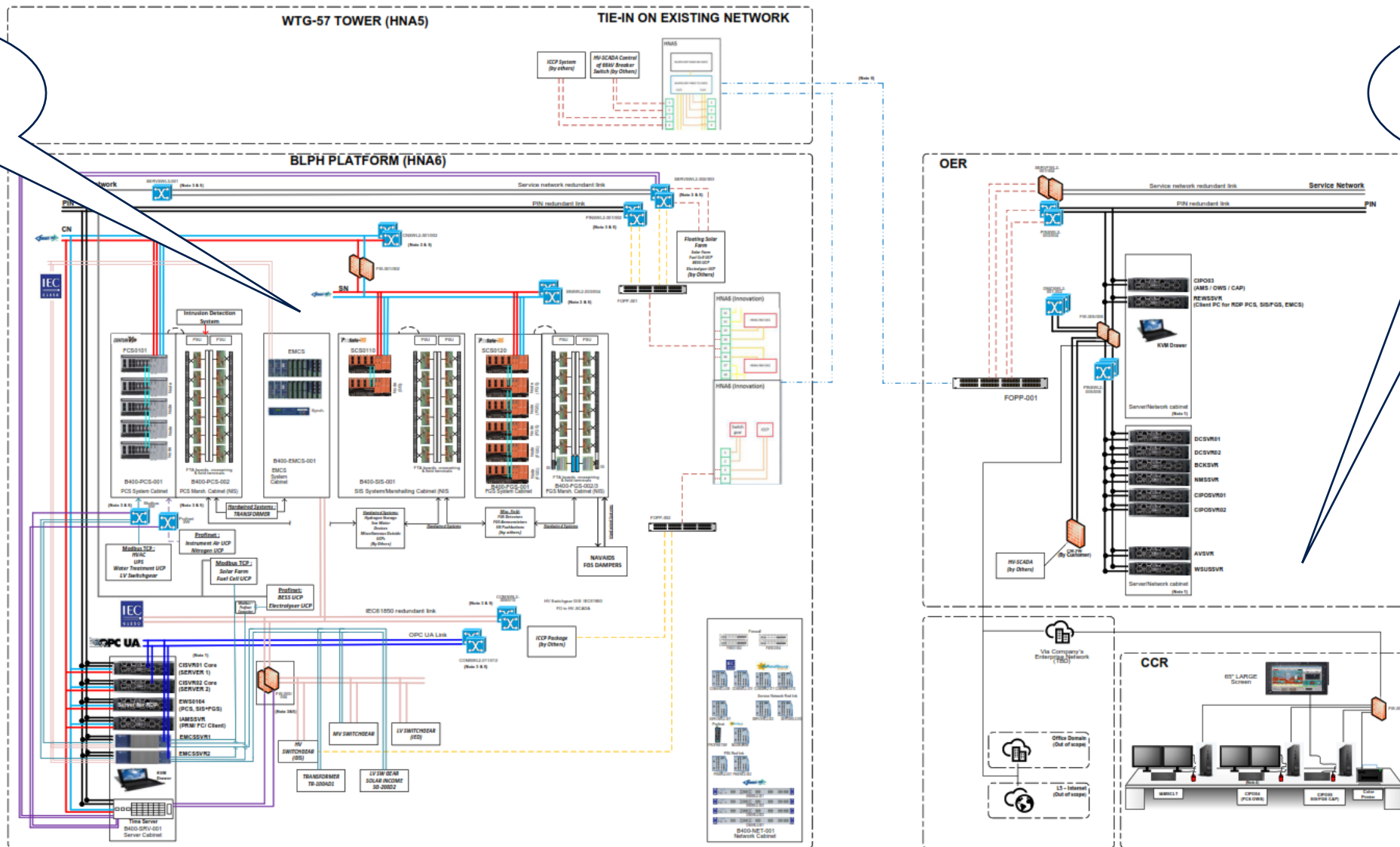
- Wind to power ← unconstant
- H2 storage
- H2 to power (Fuel Cells)



# System (of systems) real architecture

Off-Shore

On-Shore



# Any questions ?



Co-innovating tomorrow™