ALTENSO

POWER FOR ENERGY

Grid Friendly Hydrogen

DERlab/HyLeiT workshop #7

Alexander Unru | 04.08.2025

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SMA group at a glance

Highlights

SMA is the leading specialist for PV-, storage- and hydrogen technology

- Founded in 1981
- Installed inverter base: > 145 GW
- Inverter portfolio for Home, C&I and Utility applications
- > 4,000 employees worldwide
- 20 subsidiaries globally
- Strong R&D focus with > 1,600 patents
- **21 GW** production capacity per year (**40 GW by 2025**)

SMA Altenso is the off-grid, hybrid, storage and hydrogen specialist in SMA

- 100% subsidiary of SMA Solar Technology AG
- 70 employees in Germany, Spain, USA and Australia
- Focus on complex battery and hybrid systems
- On the market since 2020 as a manufacturer of power supplies for electrolyzers
- Components and solution sales, system integration and EPC for battery projects

SMA ALTENSO

Our references in the hydrogen sector

ÄGYPTEN – Ain Sokhna

SPANIEN - Puertollano

USA - Georgia

FRANKREICH - Buléon

ÖSTERREICH - Gampern

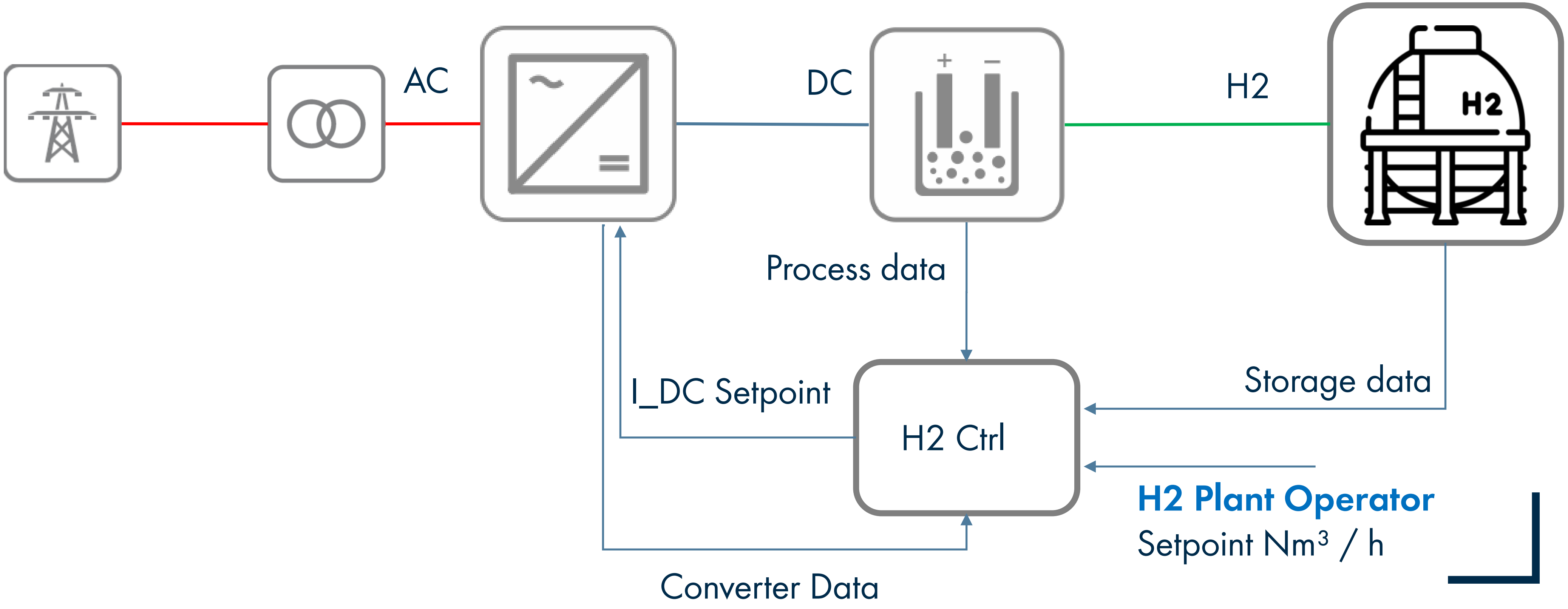
SCHWEIZ – St. Gallen

USA – New York

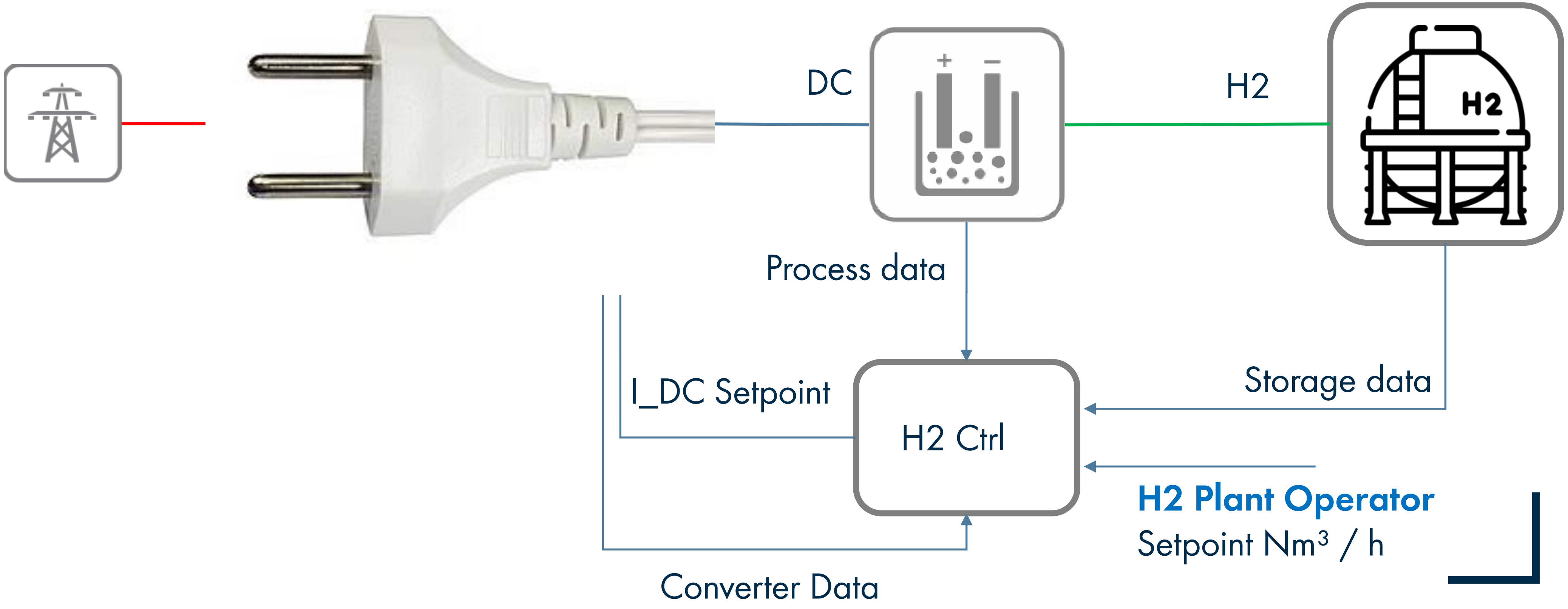
NEUSEELAND - Taupo

More than 80 projects worldwide with over 1 GW
(PEM, Alkaline and SOEC)

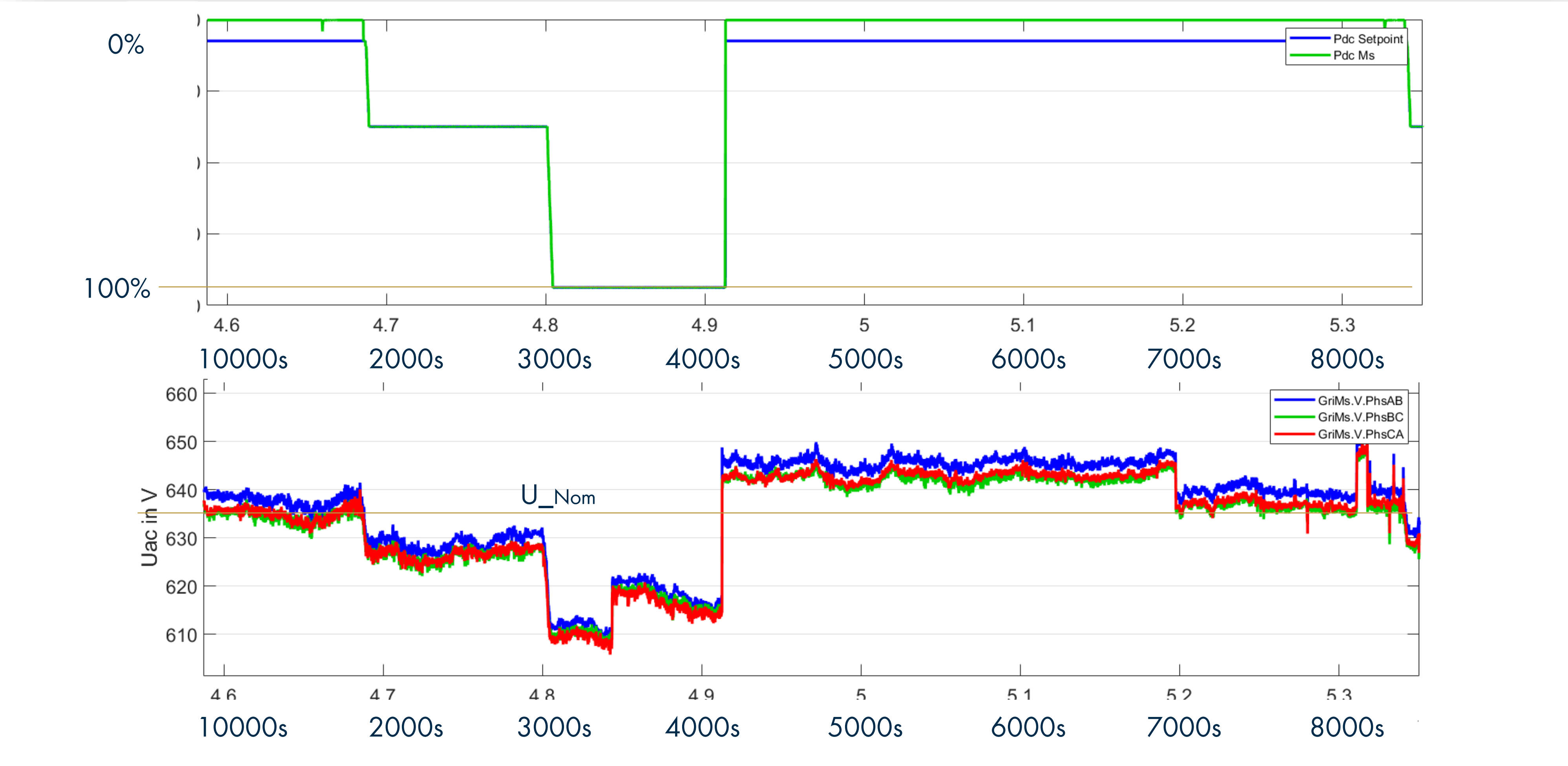
Functional view of H2 production today



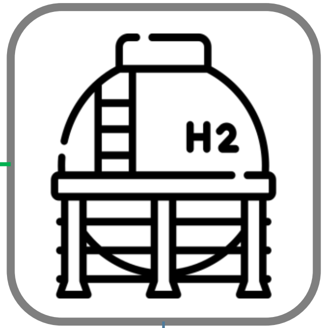
Functional view of H2 production today



Functional view of H2 production today



H2



Storage data

ant Operator

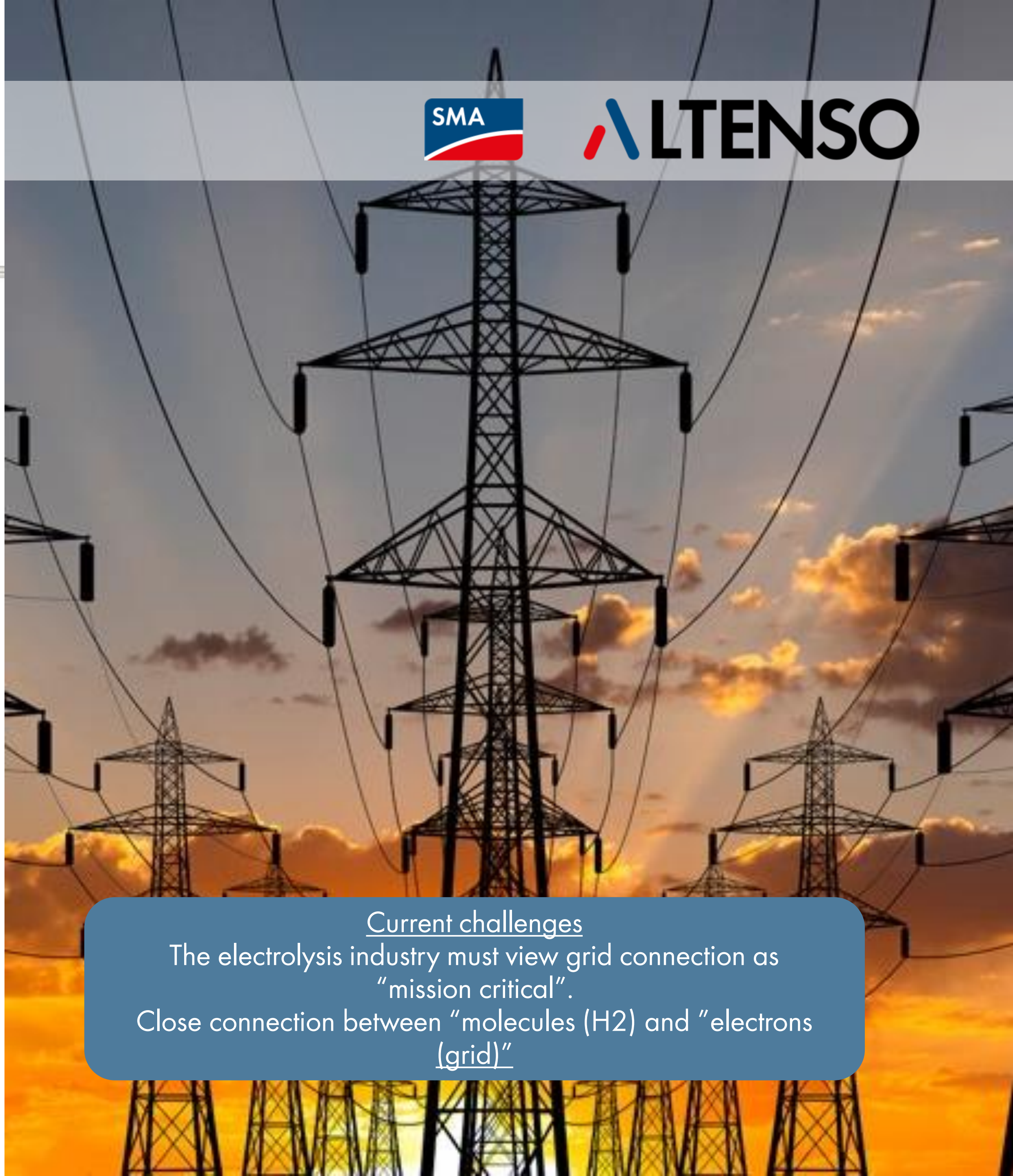
nt Nm³ / h

Status, Measurements (Iac, Uac)

Challenge for the public grids

Electrolyzers

- Very large loads that are installed in load centers that are already heavily loaded
- High consumption of reactive power (transformers, pumps, compressors, etc.)
- Electrolysers require a stable grid (today)



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Challenges in large H2 plants

Traditionally, thyristor rectifiers (SCR) are used because the power electronics are comparatively inexpensive compared to transistor rectifiers. But buing cheap you have to deal with:

- Extreme harmonics → Large filter units required
- High DC ripple → Rapid aging and **lower electrolysis efficiency**
- Poor cos phi → Large capacitor banks required
- No grid services → Critical for large loads
- No grid support possible during grid faults → No active FRT functionality
- Many additional components → Space requirement and high costs
- Small series → No scalability for product roll-out → It‘s always a project specific design

THE SOLUTION: modern power electronics with IGBTs / MOSFETs

1. IGBT = Insulated Gate Bipolar Transistor

Reactive Power Challenge

Using IGBT Rectifiers for power factor correction you can compensate other loads in the plant like

- Power transformers
- BoP Transformers
- Drives
- Cables

Substantial cost savings as you can:

- Avoid capacitor banks
- Avoid shunt reactors
- Save space
- Reduce motor start impacts

Challenge solved with SMA Altenso Power Electronics

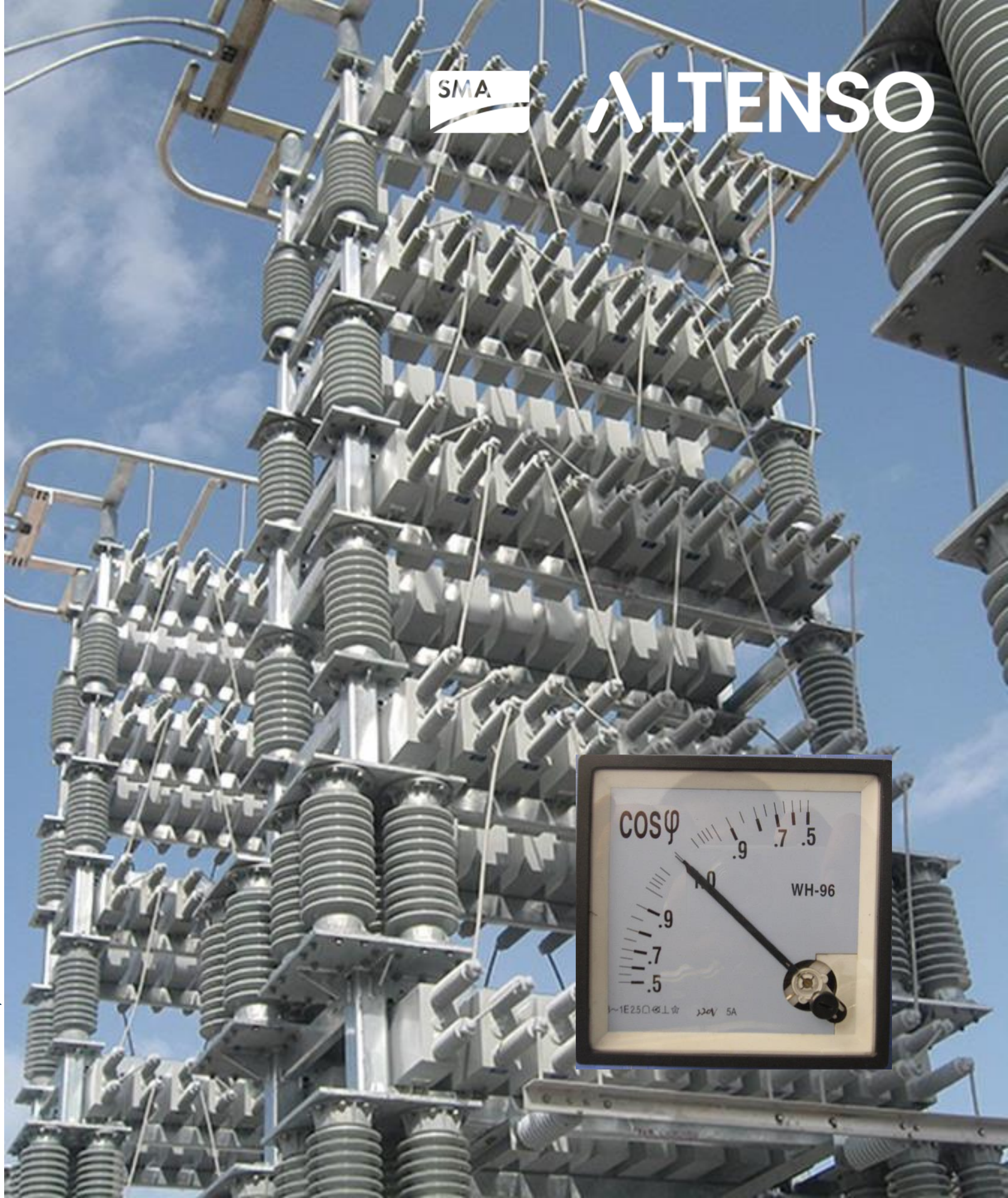


Photo: Eaton.com, 2019

Load Control Challenge

Very large electrolyzers are a substantial burden on the national or regional grid

By operating electrolyzers with dispathable load control you can:

- Create additional revenues by participating in frequency market
- Ease your grid connection as the grid operator can ramp (Limit) your load based on grid congestion up and down

Challenge solved with SMA Altenso Power Electronics

Voltage Control Challenge

Grid voltage depends on active and reactive load in the grid

By operating electrolyzers with SMA voltage support function you can:

- Stabilize voltage on the power grid by
    - Consuming reactive power if voltage is too high
    - Supplying reactive power if voltage is too low

- Substantial benefit for the grid operator as grid becomes better utilized and more stable.
- Additional revenues possible due to grid support
- Cost savings, as no or only a much simpler MV Tap Changer is required

Challenge solved with SMA Altenso Power Electronics

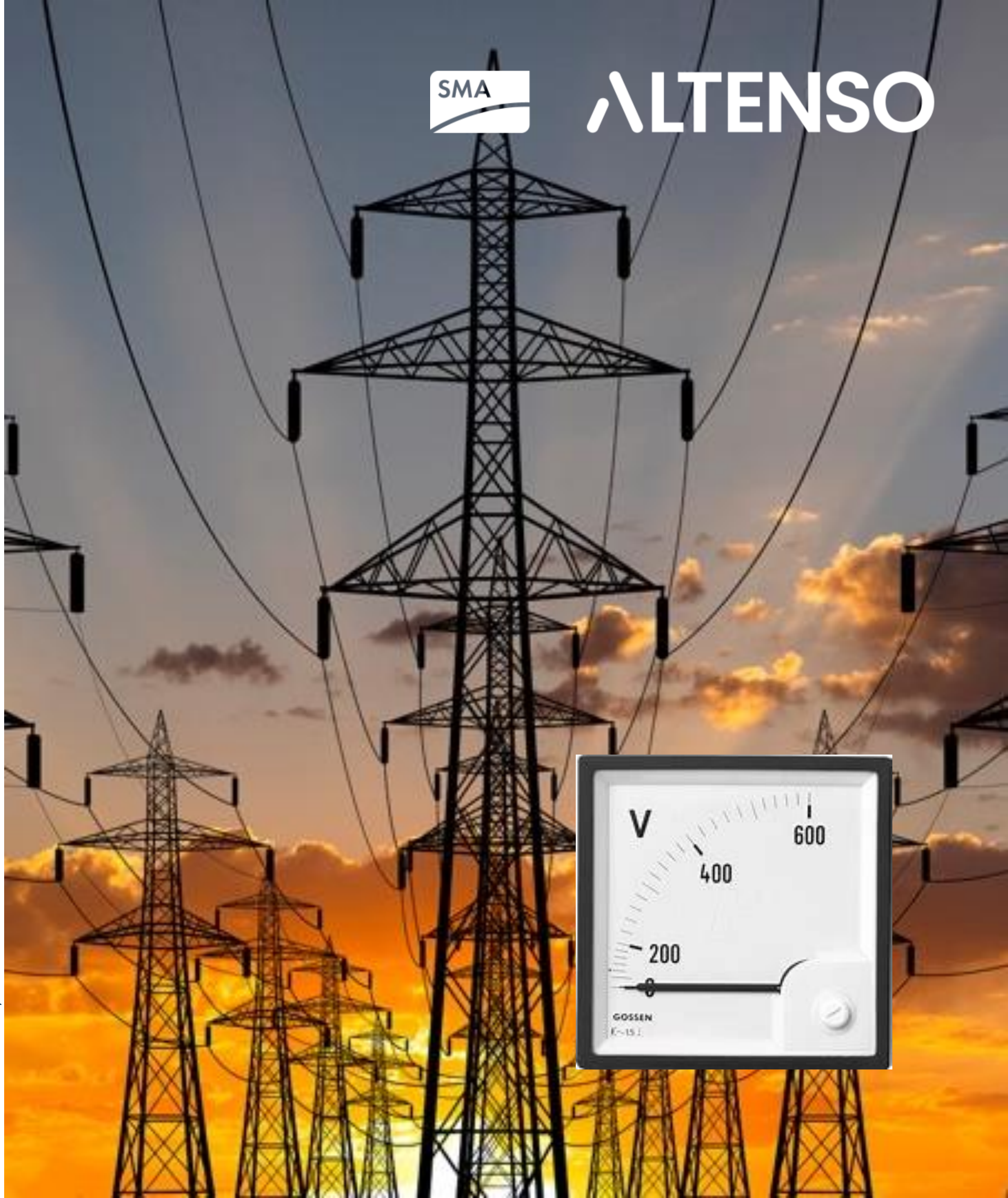


Photo: Eaton.com, 2019

Disturbance Challenge

What if the grid is disturbed and shows a short fault?

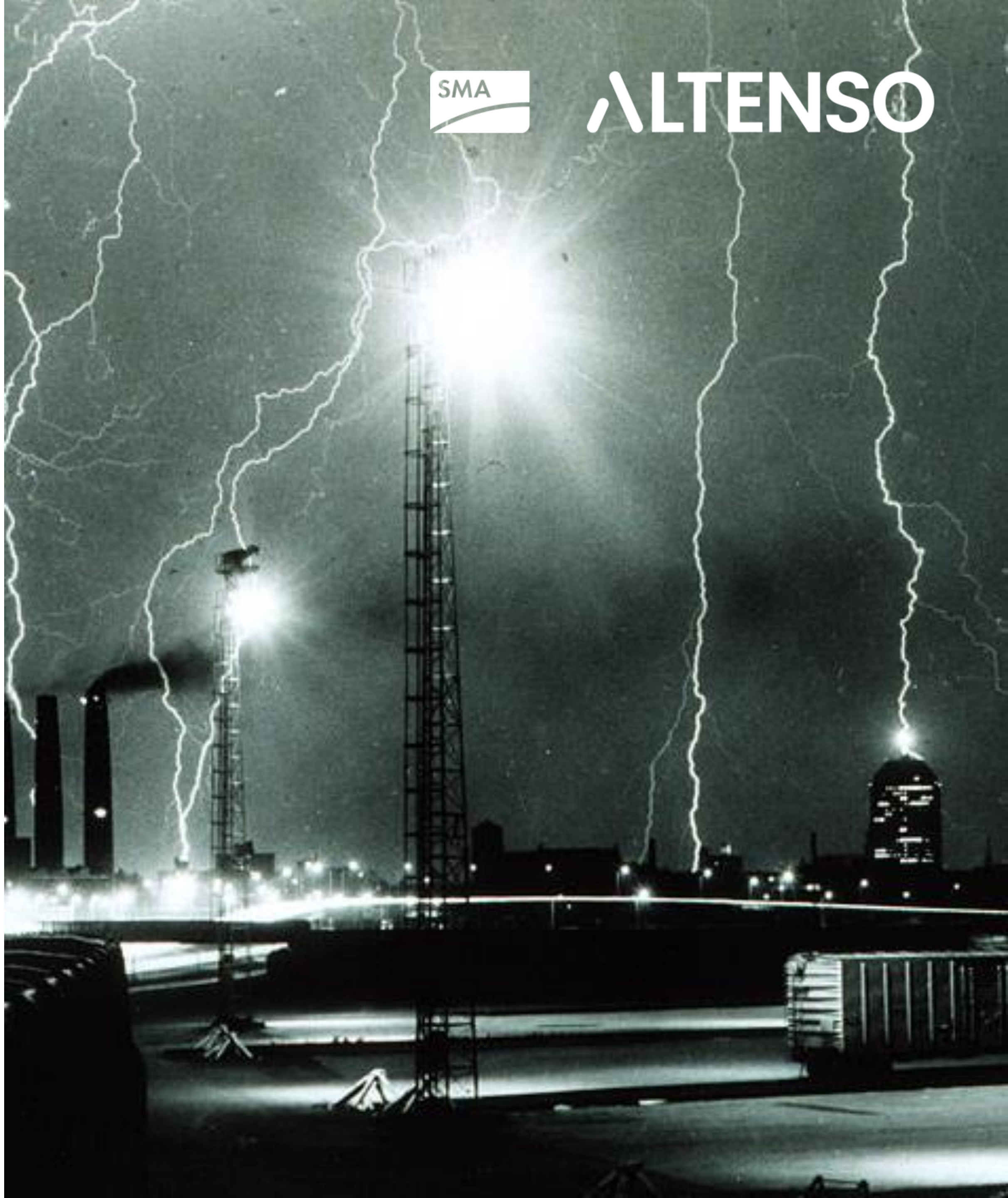
Traditional Power Supplies may turn off

Substantial interruption of Hydrogen Production and Process

Advanced Power Supplies stay on-line

- Plant returns to normal in an instant after fault
- No interruption of Hydrogen Production and Process
- Grid stability improved

Challenge solved with SMA Altenso Power Electronics



THE MARKET

Hydrogen Use TODAY = 90 Mt H_2 /year

Hydrogen Use in 2050[1] = 210 Mt H_2 /year

4,500 GW of renewable energies would be required to produce the Hydrogen Demand at 4,000 full load operating hours per year[2]

This is more, than the installed Solar & Wind power today!

1) Quelle: International Energy Association IEA
2) Volllaststunden des Erzeugers

How to integrate GW of electrolyzers to our Grids?

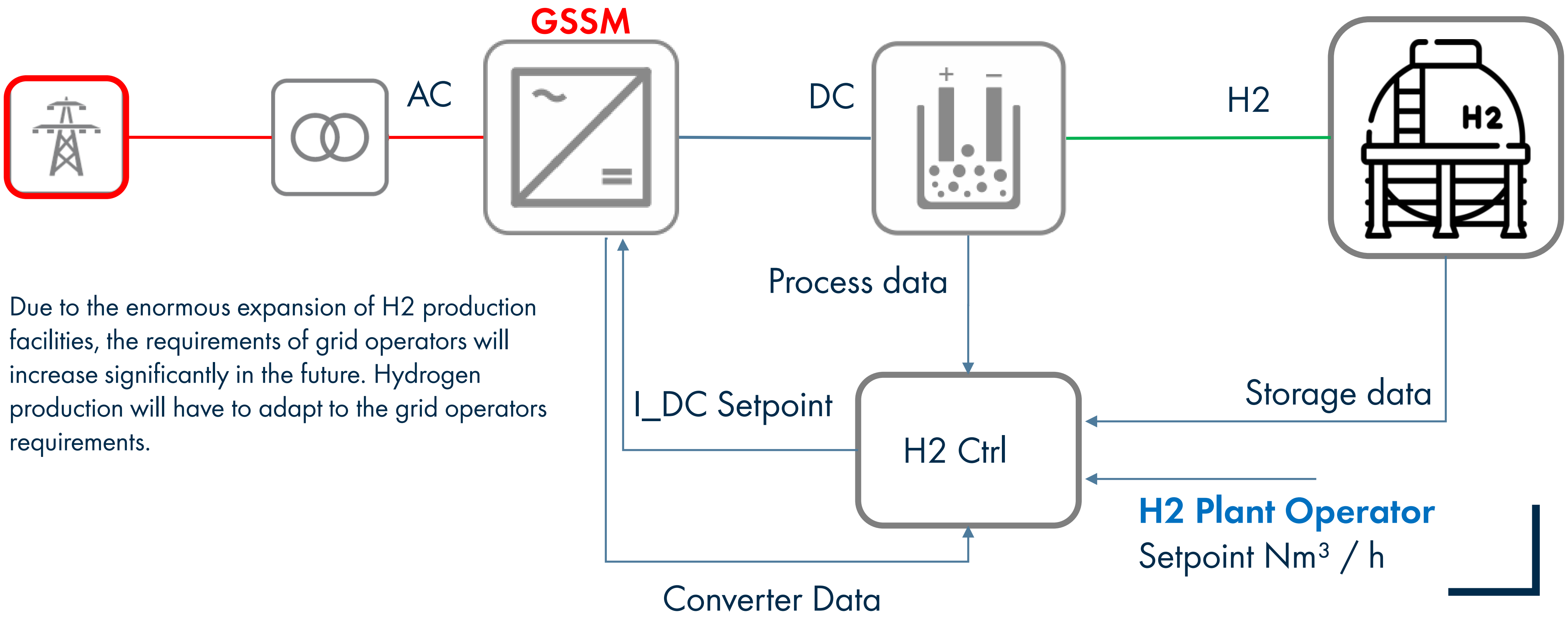
just use a

smarter

(IGBT Based)

Plug…

Functional view of H2 production under the grid operator's regulations → Grid Services vs. H2 Production

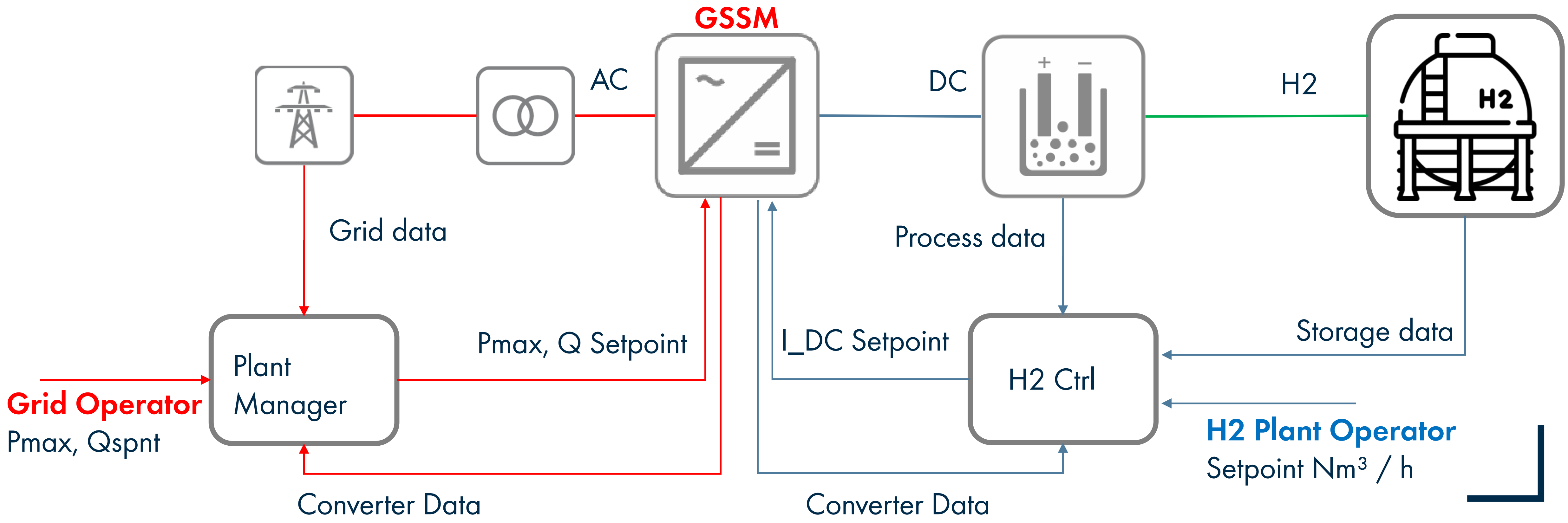


Due to the enormous expansion of H2 production facilities, the requirements of grid operators will increase significantly in the future. Hydrogen production will have to adapt to the grid operators requirements.

Grid Operator
Pmax / Qspnt

GSSM: Grid Service Setpoint Module

Functional view of H2 production under the grid operator's regulations → Grid Services vs. H2 Production



GSSM: Grid Service Setpoint Module

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Today – Grid services possible

- Dynamic reactive power control incl. compensation of the BoP loads for the electrolyzer and the power transformers WITHOUT additional capacitor banks
- Voltage support possibly through active load regulation and reactive power control
- "Utilization instead of curtailment" functionality in combination with renewable energies → assumes normal operation at partial load
- Direct operation on extremely weak grids together with renewable energies possible with grid-supported inverters in the system (e.g. battery + solar + electrolysis)
- FRT Function is possible and can be handle by PEM Electrolyzers (tested in practice)

GRID FRIENDLY HYDROGEN

IGBT based Power Conversion
Key to successful grid connection

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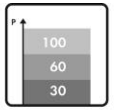
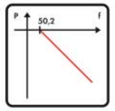
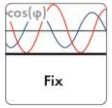
Overview grid management functionalities

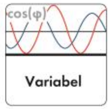


Active power limitation on demand
Target: Stabilizing the grid by managing the active power generation (via remote signal)

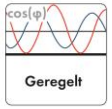


Frequency-dependent control of active power
Frequency based active power management
Target: Stabilizing the grid by managing active power generation/consumption (via frequency control)

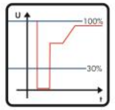




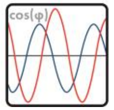
Reactive power control
Reactive power supply by fix cos phi, cos phi (P) or Q (U) …
Target: Stabilizing the grid by reactive power control

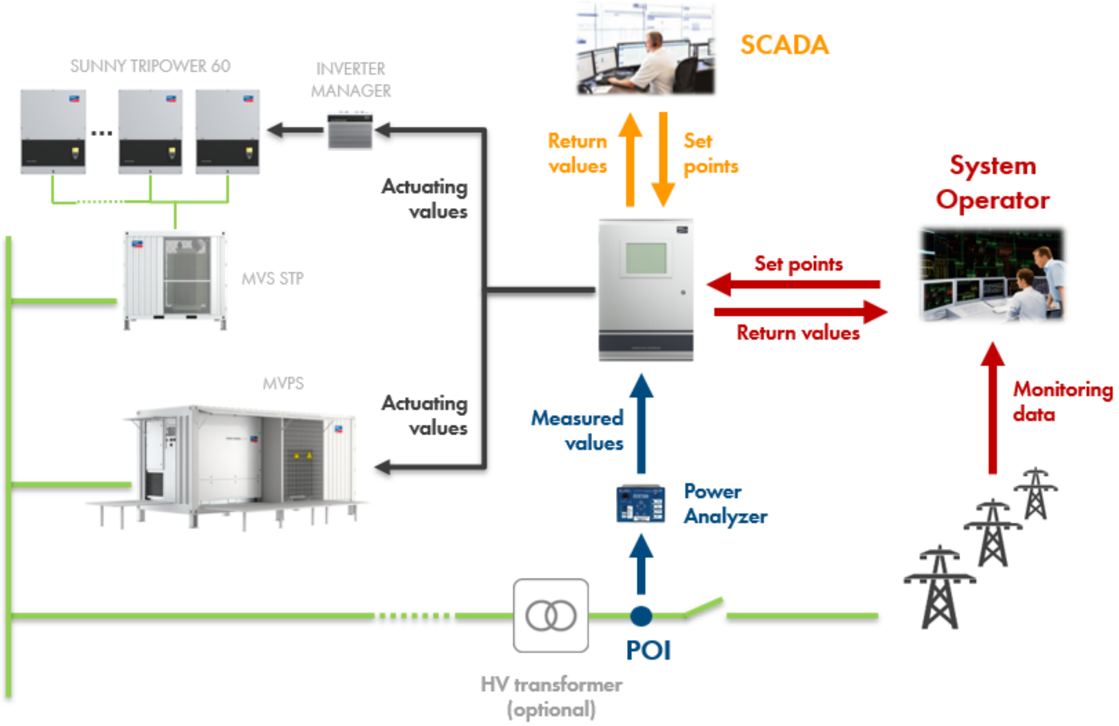


Fault Ride Through / Dynamic grid support
During a grid failure the inverter stays on the grid and supports the voltage by defined behavior (FRT, LVRT, HVRT)



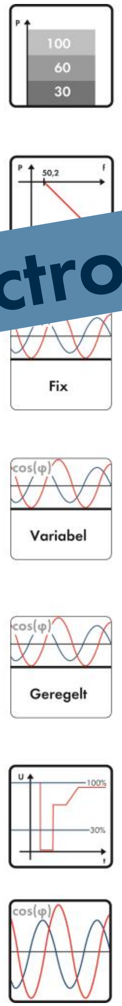
Fast recovery to pre-event operating point
Target: Stabilizing the grid during grid failure





IGBT based Power Conversion
Key to successful grid connection

Overview grid management functionalities



Active power limitation on demand
Target: Stabilizing the grid by managing the active power generation (via remote signal)

Frequency-dependent control of active p
Frequency based active p
Target: Sta… active power
(via frequency control)

and we do all of this in an electrolysis-friendly way

Reactive power control
Reactive power supply by fix cos phi, cos phi (P) or Q (U) …
Target: Stabilizing the grid by reactive power control

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During a grid failure the inverter stays on the grid and supports the voltage by defined behavior (FRT, LVRT, HVRT)

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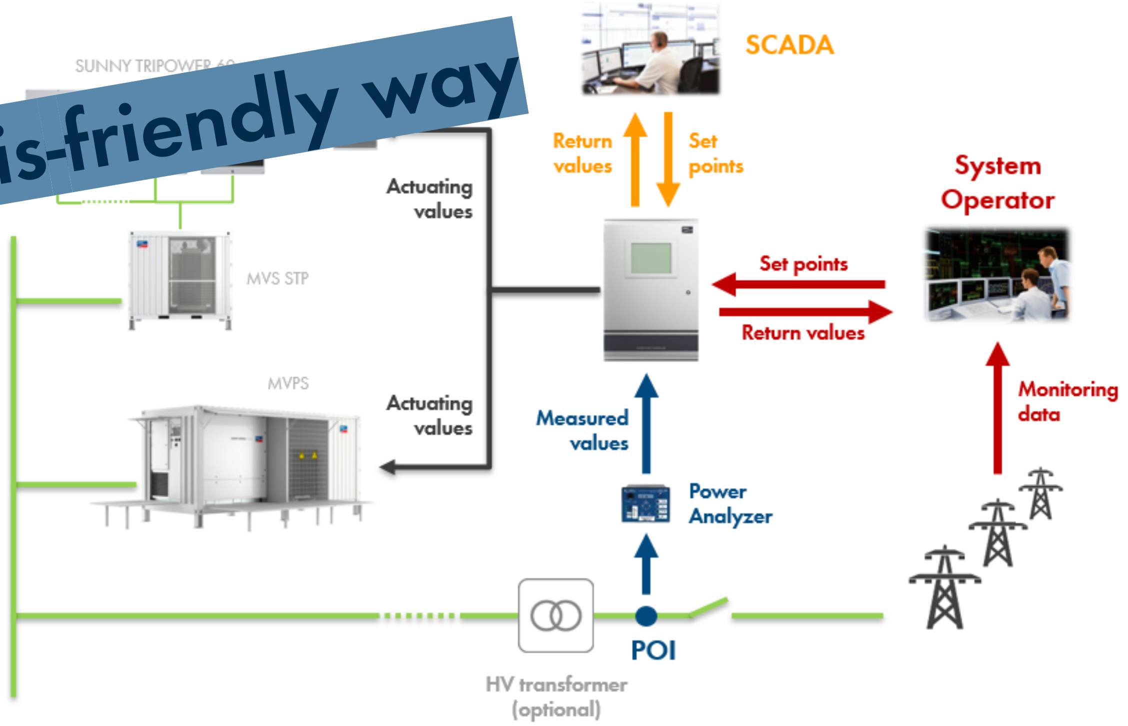
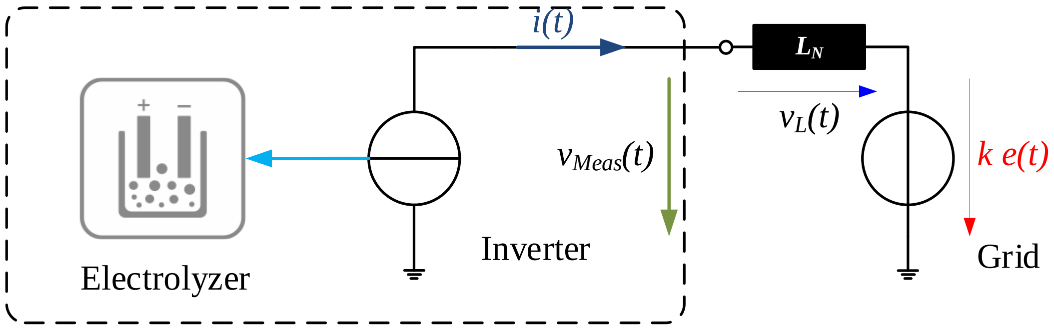


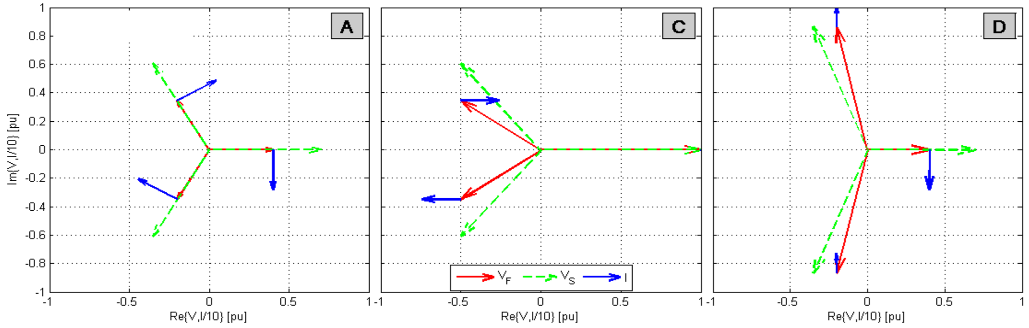
Modelling for –> Grid Study's

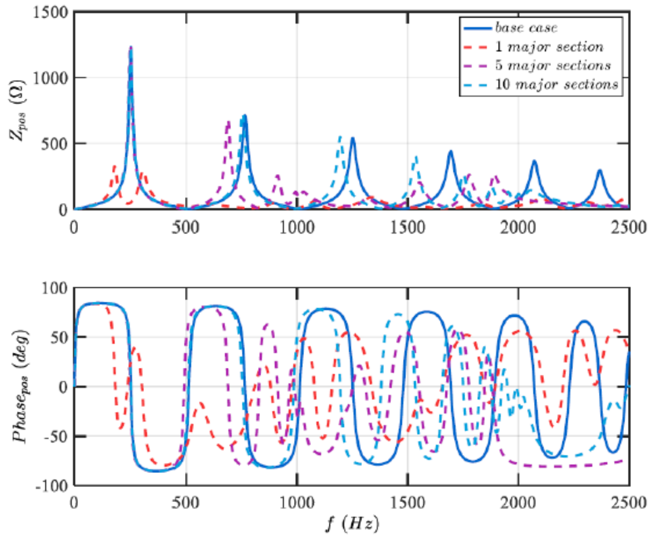
Power Factory

PSSE

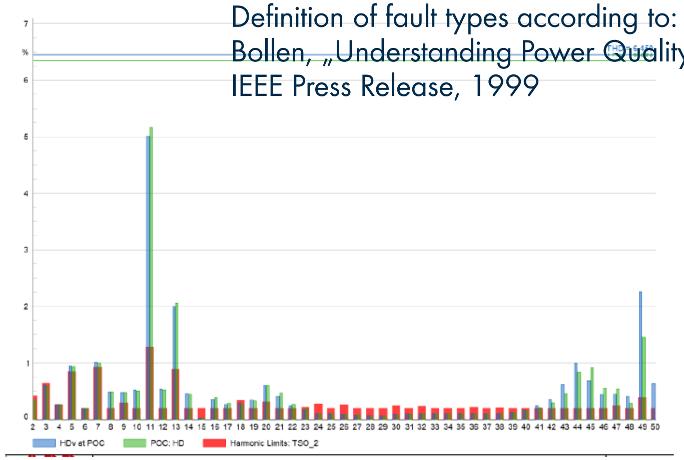
PS CAD → Dynamic Model incl. Electrolyzer behaviour.





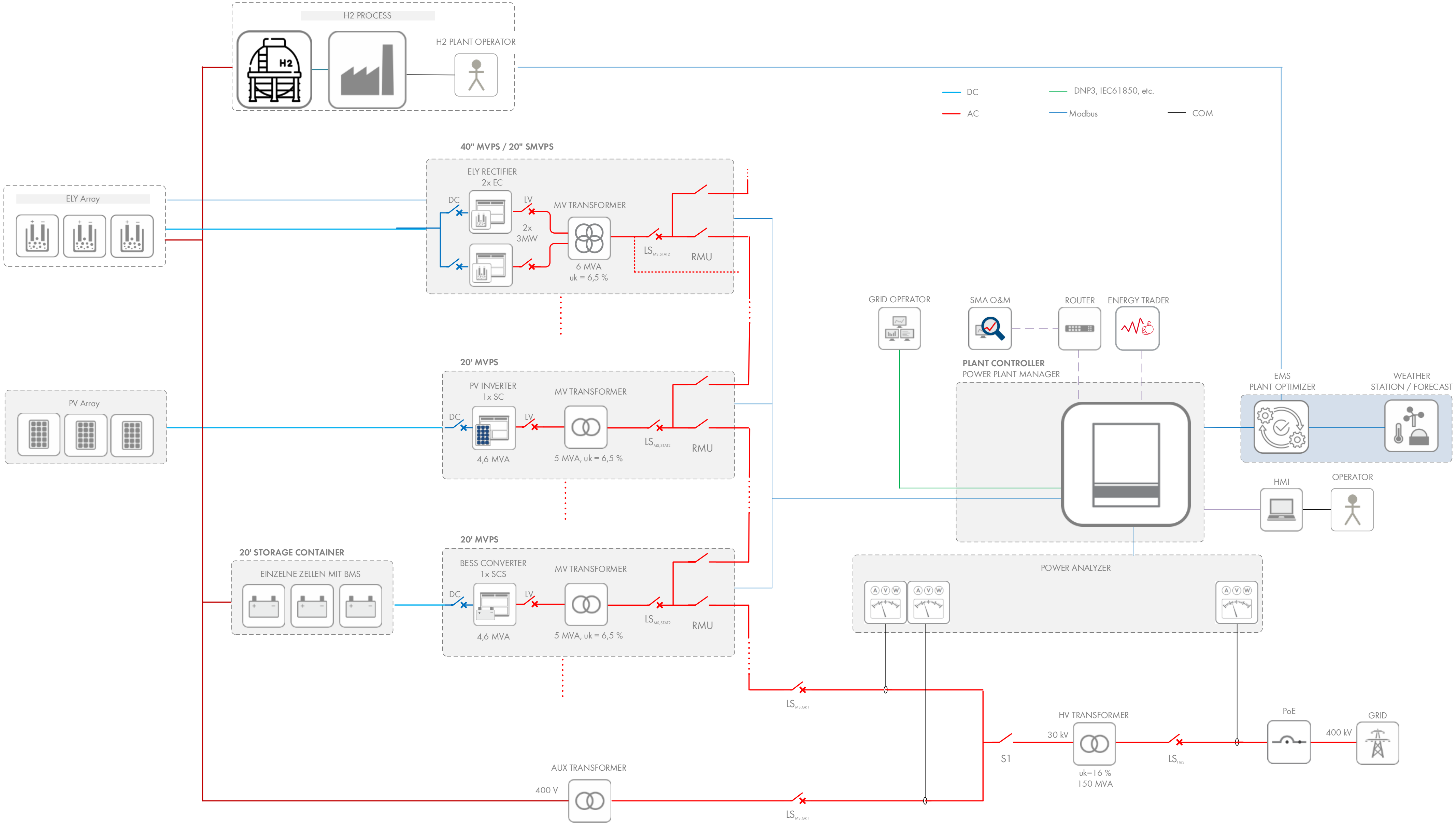


Definition of fault types according to: Math. H. J. Bollen, „Understanding Power Quality Problem", IEEE Press Release, 1999

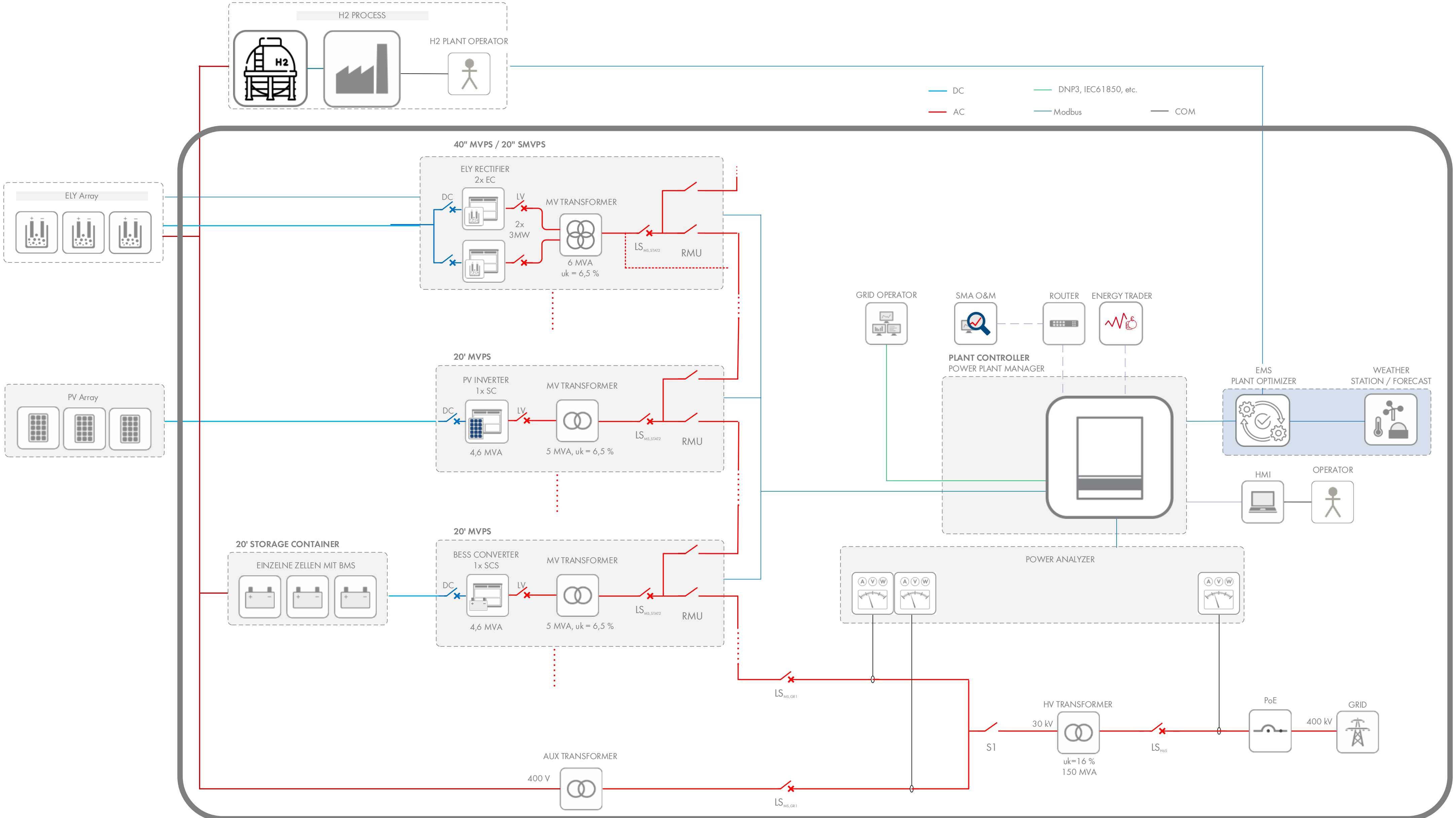


We manage the electrons

ALTENSO STORY



ALTENSO SCOPE



Key to successful integration

- Large Scale Serial Production to reduce quality problems
- Complete integrated System from Medium Voltage (4.16 kV – 35 kV) to DC Output
- Expertise in grid connections through > 150 GW installed solar, battery and electrolyzer systems
- Advanced Power Electronics with minimal grid impact
- Integrated System Controller
- Integrated Safety chain

Most Electrolysis Project focus on Hydrogen only. DON’T!

A car without street is useless as is an electrolyzer without grid connection

World Standard – HC Container PCU

40’

20’

20 or 40 foot **Stackable** High Cube ISO-Container station

A containerized Turnkey solution

40’ → 2.6 MVA – 7 MVA

20’ → 1.3 MVA – 4.5 MVA

- Ring Main Unit Switchgear
  - Maximum operator safety with Internal Arc (IAC FL/A 20 kA 1 s)
  - MV Metering
- MV Transformer (Oil type or Dry Type)
  - Integrated Oil Containment
  - Oil/Water Separator Filter (Petro-Pipe)
  - Transformer protection
- AUX Transformer for self consumption
- LV Distribution Panel
  - UPS (500 W 1 h 24 V_{DC})
  - All communication & protection systems
- Standard Electrolyzer Interface (SIL 2)

Summary

- Key to successful connection is to properly consider grid impacts
- Serial Production Systems guarantee best scalability at minimum complexity
- Don’t just look at CAPEX, consider permits, operation, maintenance and commissioning and focus on minimum LCOH
- Serial standardized designs maximize plant safety
- **Transistor based electrolyzer rectifiers can provide grid services → taking into account the operational limits of the electrolyzer**

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With the right design, large loads such as electrolyzers can help the grid!

GRID FRIENDLY HYDROGEN

It just depends on choosing the right Front-End.

Thank you

Alexander Unru

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