Market overview and requirements from a manufacturer's point of view

Leitprojekt H$_2$Giga

HyLeiT

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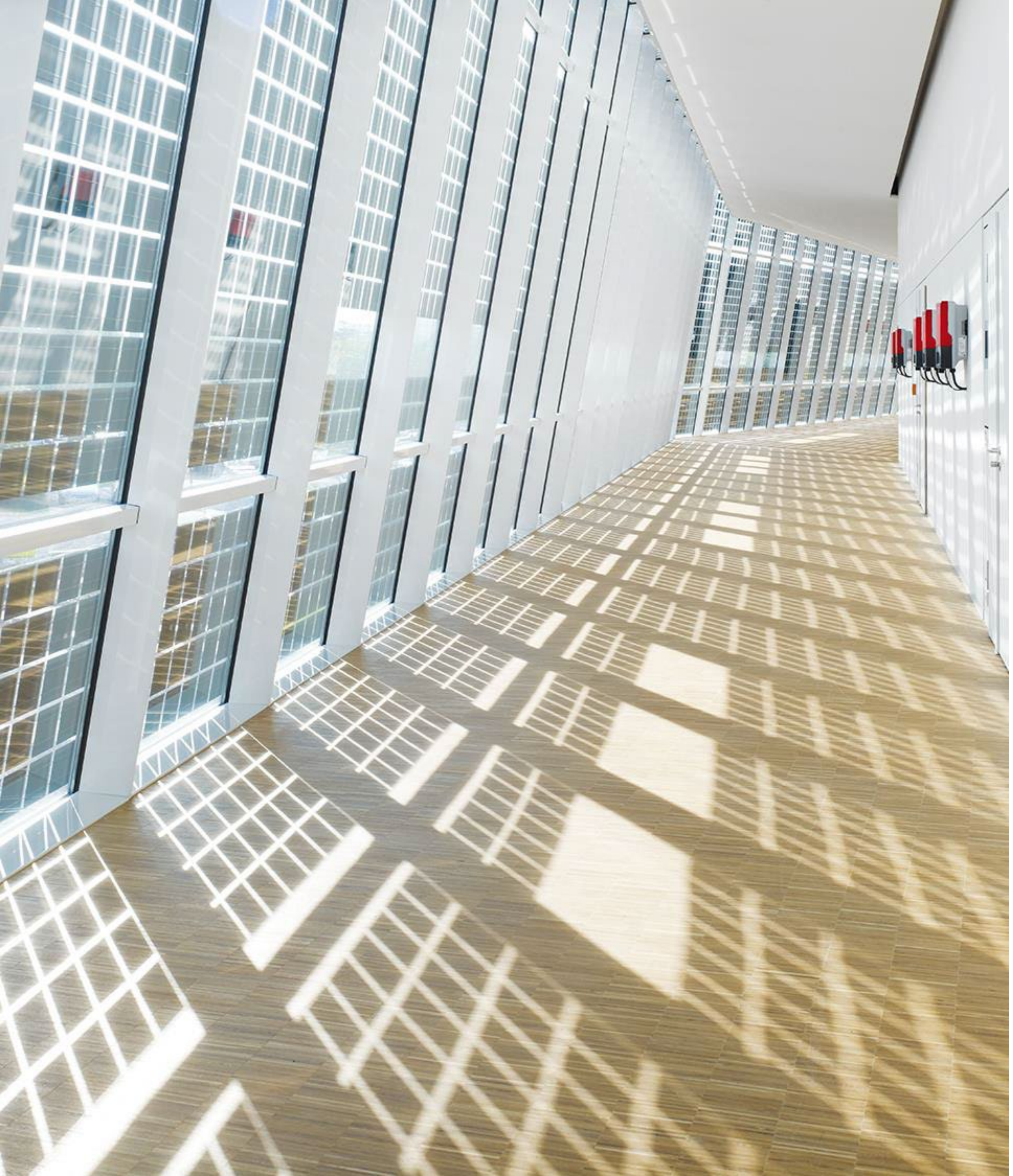


AGENDA

1 SMA and SMA Altenso

2 Quick market update

3 Commercial Aspects – Reliability & Efficiency

4 Technology Development

5 Grid Services – increasingly important

6 Summary

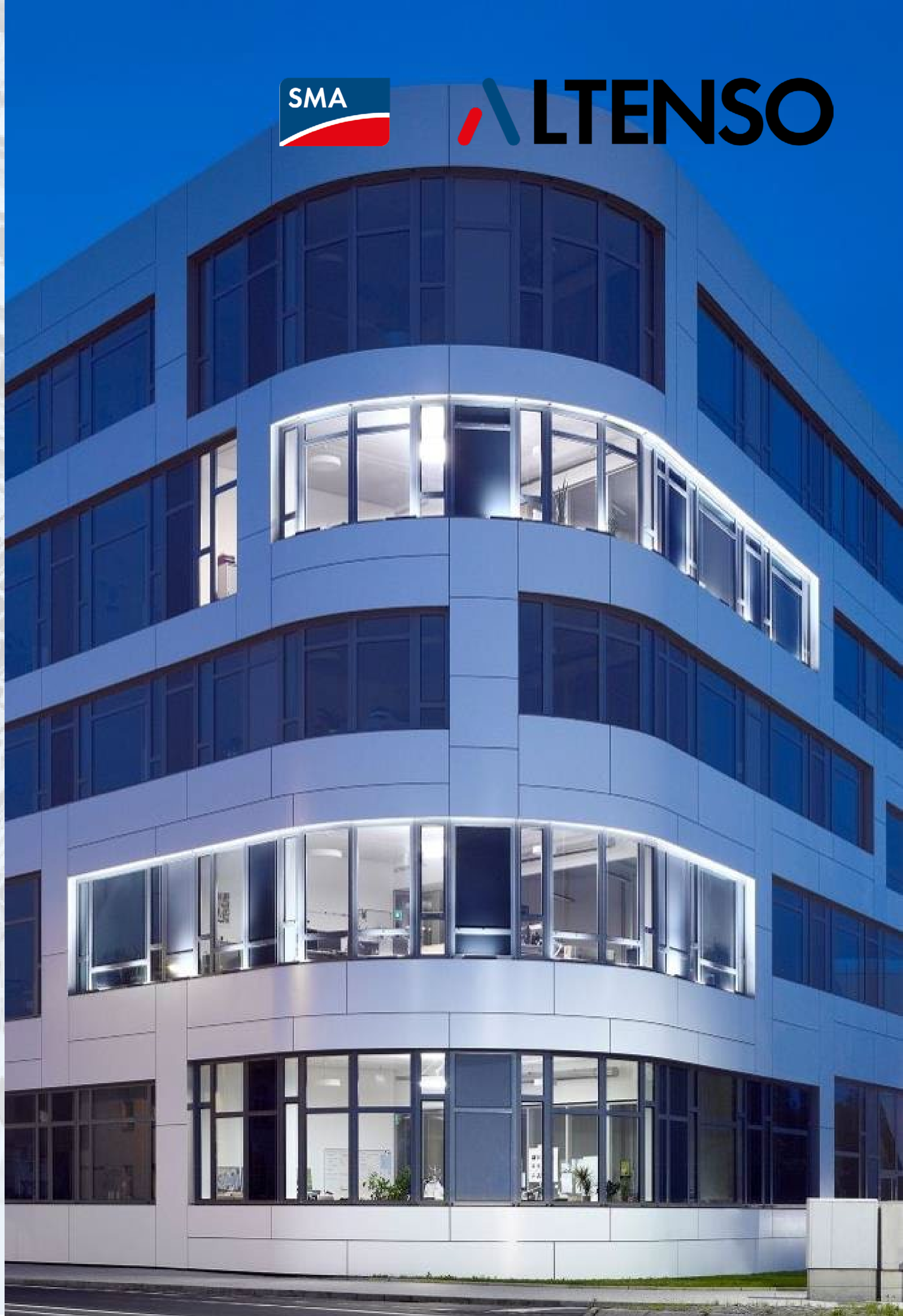
SMA GROUP

SMA is the leading specialist for PV and storage technology

- Founded in 1981 in Niestetal, Germany
- **>130 GW** installed base in **> 190 countries**
- Complete portfolio from 1.5 kW to 4,600 kW power converters
- **20 subsidiaries** with strong service capabilities
- Own Test lab in Niestetal, Germany
- **> 600 R&D** engineers with over **1,500 patents**
- **21 GW production** capacity per year (**40 GW/a from 2025**)
- **3,945 employees**
- > 50 staff in Australia
- Annual turnover **1.1 bn EURO**

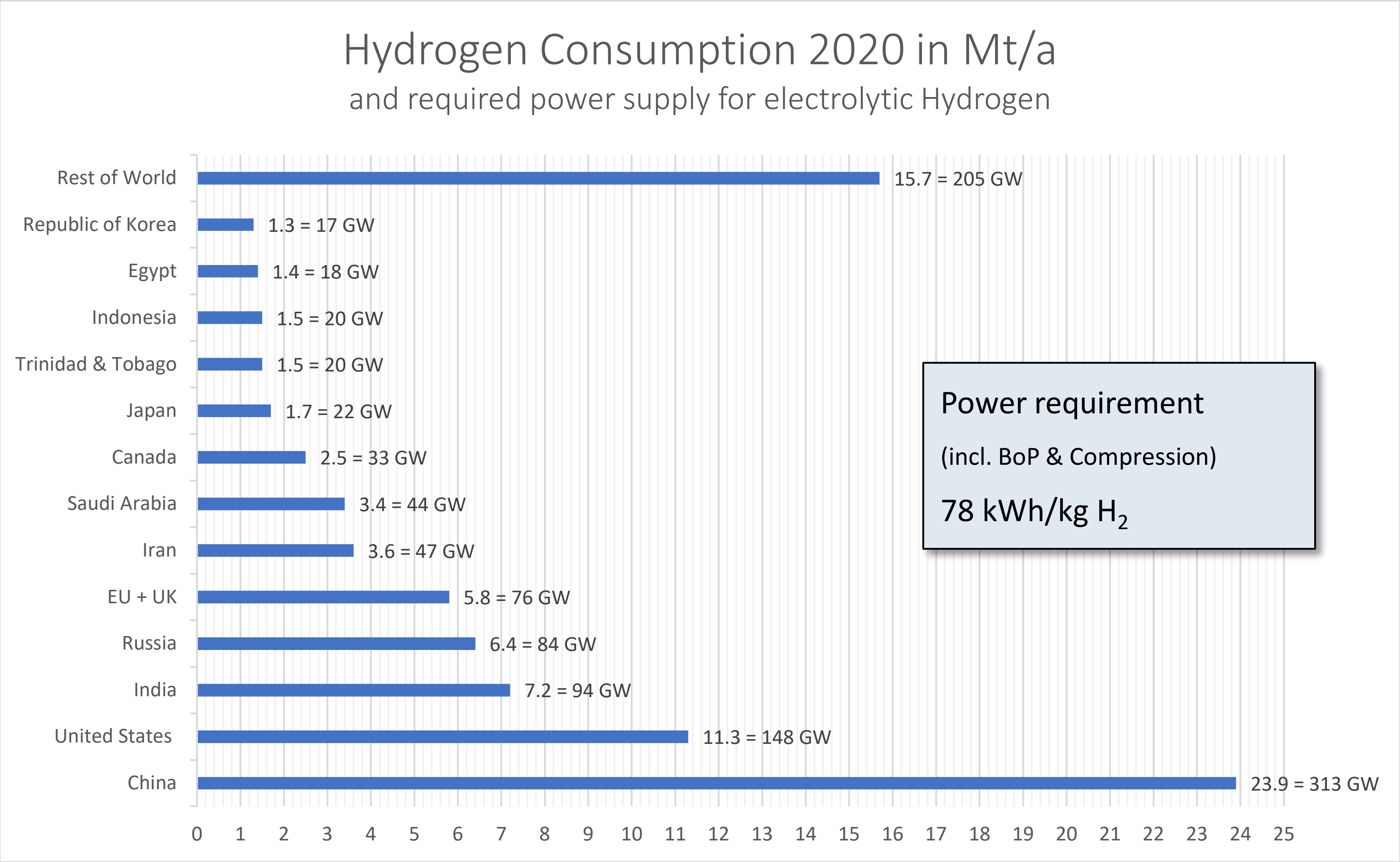
SMA Altenso is the specialist @ SMA for advanced power solutions

- Founded in 2014 in Niestetal, Germany
- Since 2018 active in the **Hydrogen Market**
- **65 staff**
- 100% subsidiary of SMA Solar Technology AG
- Focus on **complex Battery and Power to Gas Systems**
- Tailored **Power Conversion Systems for Electrolysers**
- **> 70 active electrolysis projects** in production, construction or operation
- Production Capacity of **60 x 20’ container stations per week**



Source: Bloomberg

Electrolysis – a substantial load



To produce all hydrogen (87 Mt/a) with electrolysis, a minimum power of > 1,100 GW would be required

1. Source: STATISTA 2023

All calculations based on 6,000 FLH/a

Market Update

Headquarters
Local subsidiaries
Projects

SMA Altenso works on over 70 projects with > 500 MW in production, under construction or operational.

TREND: market is splitting between large number of small projects (< 10 MW) and an increasing number of large projects (> 100 MW) with some projects even > 1,000 MW

SMA Altenso GmbH

Kraftwerk Kubel, St. Gallen, Switzerland

Let’s talk money…

Example: 5 MW Electrolyzer

- **Production: 1,000 Nm^3/h = 1,800 kg/day = 20,000 USD/day @ 11 USD/kg**
- **Consumption: 99,000 kWh/day[1)] = 15,000 USD/day @ 0.15 USD/kWh**

1 day more maintenance costs 20,000 USD or in a 500 MW Plant 2 MUSD!

1% better efficiency saves 55 kUSD/year or in a 500 MW Plant 5.5 MUSD!

Efficiency and reliability are the most important drivers for economical success

1. Based on 55 kWh/kg H_2

Technical Developments

Today

- Design for Project
- Monolithic Systems
- No standards
- “Artisan” build process

Substantial long and expensive on-site construction

Future

- Modular industrialized systems
- Design for Manufacturing
- Standardization

On-site assembly of pre-manufactured and pre-commissioned modules

Puertollano, Spain

SMA ALTENSO

Challenges in large H2-Plants

Traditionally achieved with Thyristor Rectifiers (SCR) as power electronics are comparatively cheap.

- ☹ High harmonics ➞ large tuned filters necessary
- ☹ High DC-Ripple ➞ fast ageing of electrolyser and low Power 2 Gas efficiency
- ☹ Very low power factor ➞ large capacitor banks required
- ☹ No grid services possible ➞ critical for large loads
- ☹ No FRT capabilities ➞ plant goes off-line during faults

THE SOLUTION: modern power electronics on IGBT basis

1. IGBT = Insulated Gate Bipolar Transistor

Trend from on- to off-grid

Several Projects in Australia and other countries announced with > 1 GW.

Not possible to connect such large loads to the grid

- Wind and Solar will be connected directly to generate hydrogen
- Combination of grid forming converters, batteries, super capacitors, electrolyzers, solar and wind is essential.
- No grid connection results in substantial challenges for system stability
- Electrolyzers must be able to follow fast load changes – difficult for atmospheric alkaline systems

Trend:

Increasing penetration of PEM Systems as they are better suited for fast load changes


Tehachapi Wind Farm, CA, US

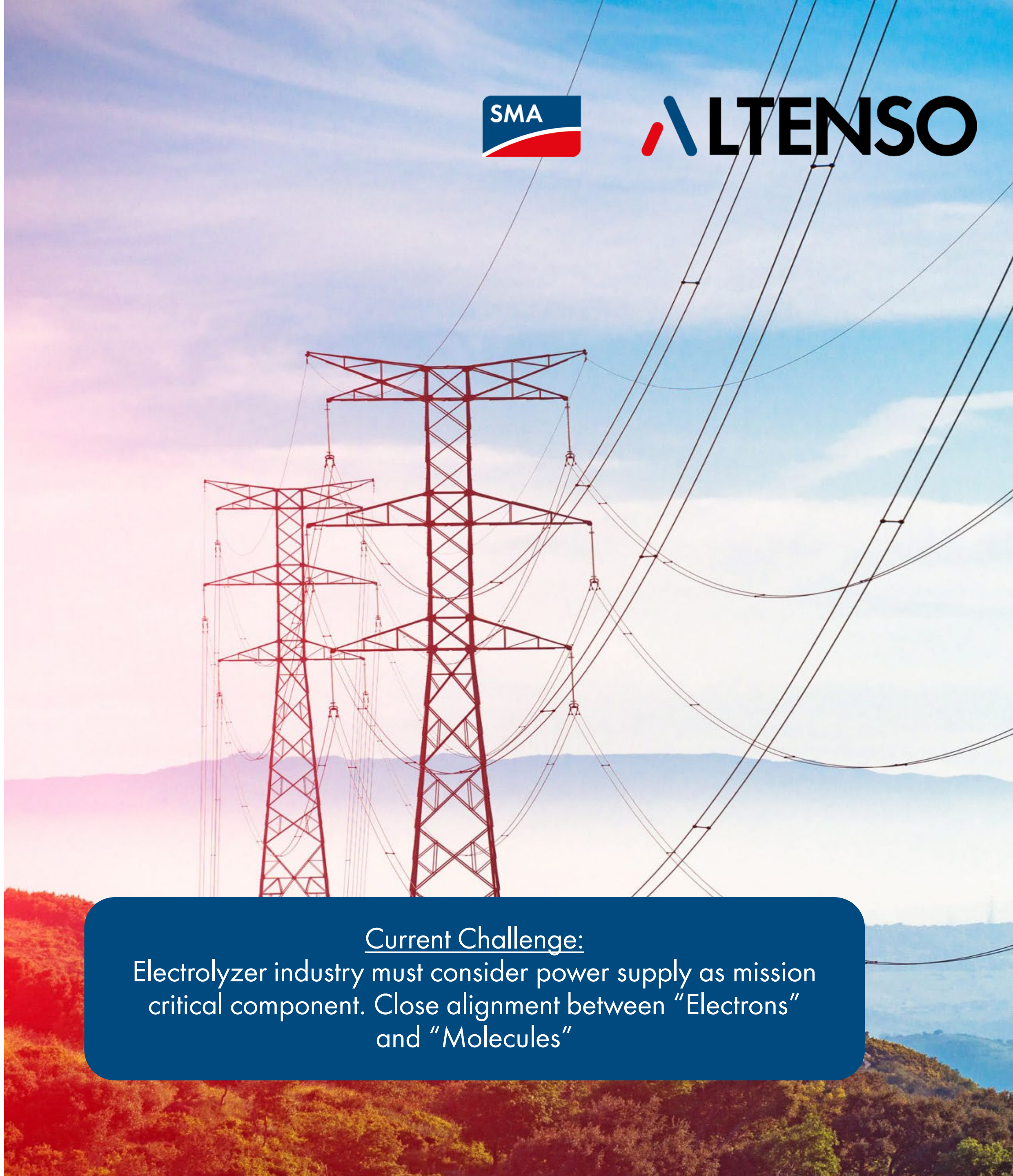
Challenge for the grid

Electrolysers

- Very large loads to be expected in already stressed load centers
- Substantial reactive power consumption
- Electrolyzers require stable grid

Consequences

- Frequency management – active load control
- Voltage stability – power factor management
- Grid Faults – Fault Ride Through
- Grid pollution – increasing pressure to minimize harmonics
- Grid services – additional revenue streams



Current Challenge:
Electrolyzer industry must consider power supply as mission critical component. Close alignment between "Electrons" and "Molecules"

Another Trend – for tomorrow

- Electrolysis Plants become larger
- Electrolysis Plants are very complex technical structures operated by experienced personnel
- Modular systems require high power density

First discussions about higher DC Voltages have commenced (> 1500 V_{DC})

Challenges:

- World of Standards cannot keep up with fast market development
- Completely new technology required for semiconductors, cables, switches, other electrical components

SUMMARY

- **Electrolysers are very large loads**
- **Trend from „design for project“ to „design for manufacture“**
- **Large loads represent substantial challenges to the grid**
  - Reactive power
  - Frequency stability
  - Voltage stability
  - Load control
  - Fault Ride Through

ONLY **ADVANCED POWER ELECTRONICS** CAN SOLVE THE GRID CHALLENGE FOR LARGE SCALE ELECTROLYSIS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THANK YOU FROM ALL OF US