



# JOIN THE JOURNEY TO NET ZERO

Power Generation Symposium | Europe



A Rolls-Royce  
solution



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# Hydrogen Ecosystem

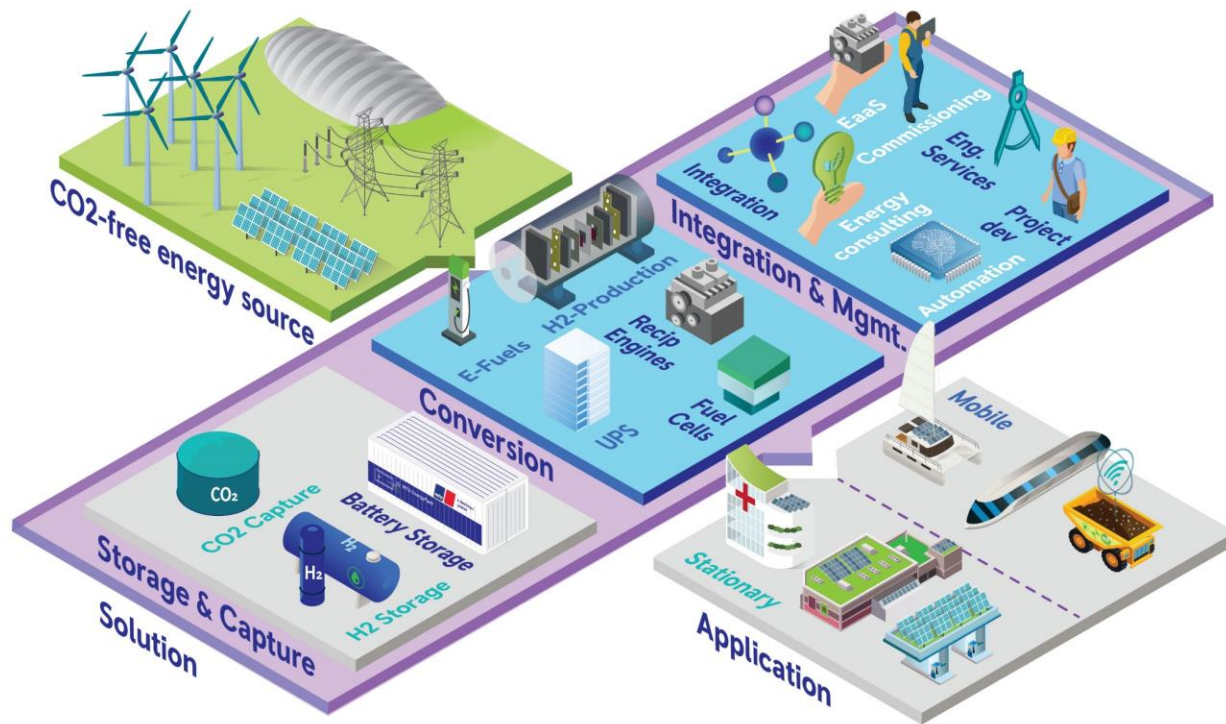
Armin Fürderer, Director Sustainable Customer Solutions

June 29<sup>th</sup> 2022



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## Our vision of the future energy value chain



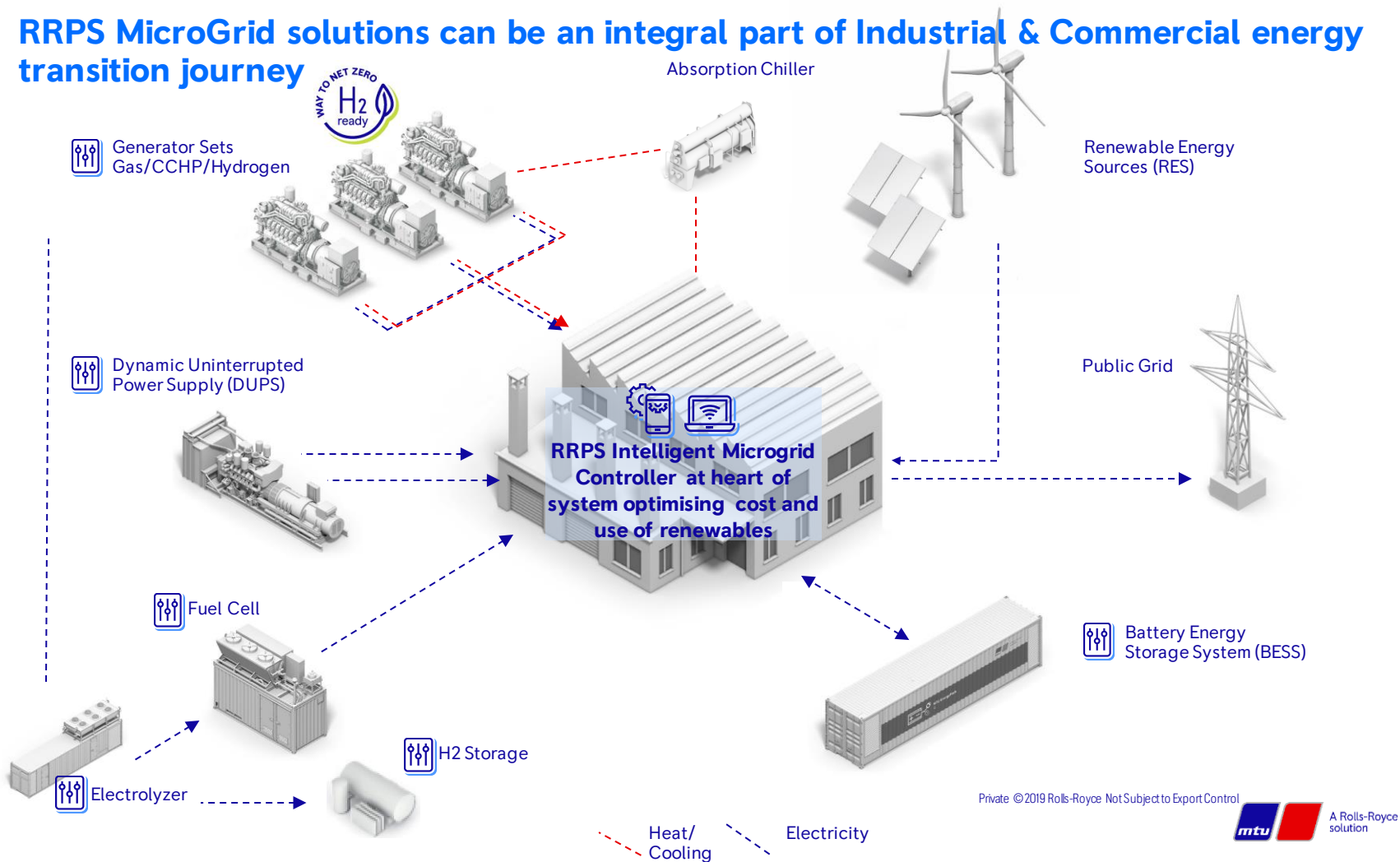
"We see ourselves as the centerpiece in the future energy value chain, providing zero-carbon solutions as a one-stop-shop to our mobile & stationary customers"

# 01

## *mtu* Hydrogen Ecosystem



# RRPS MicroGrid solutions can be an integral part of Industrial & Commercial energy transition journey



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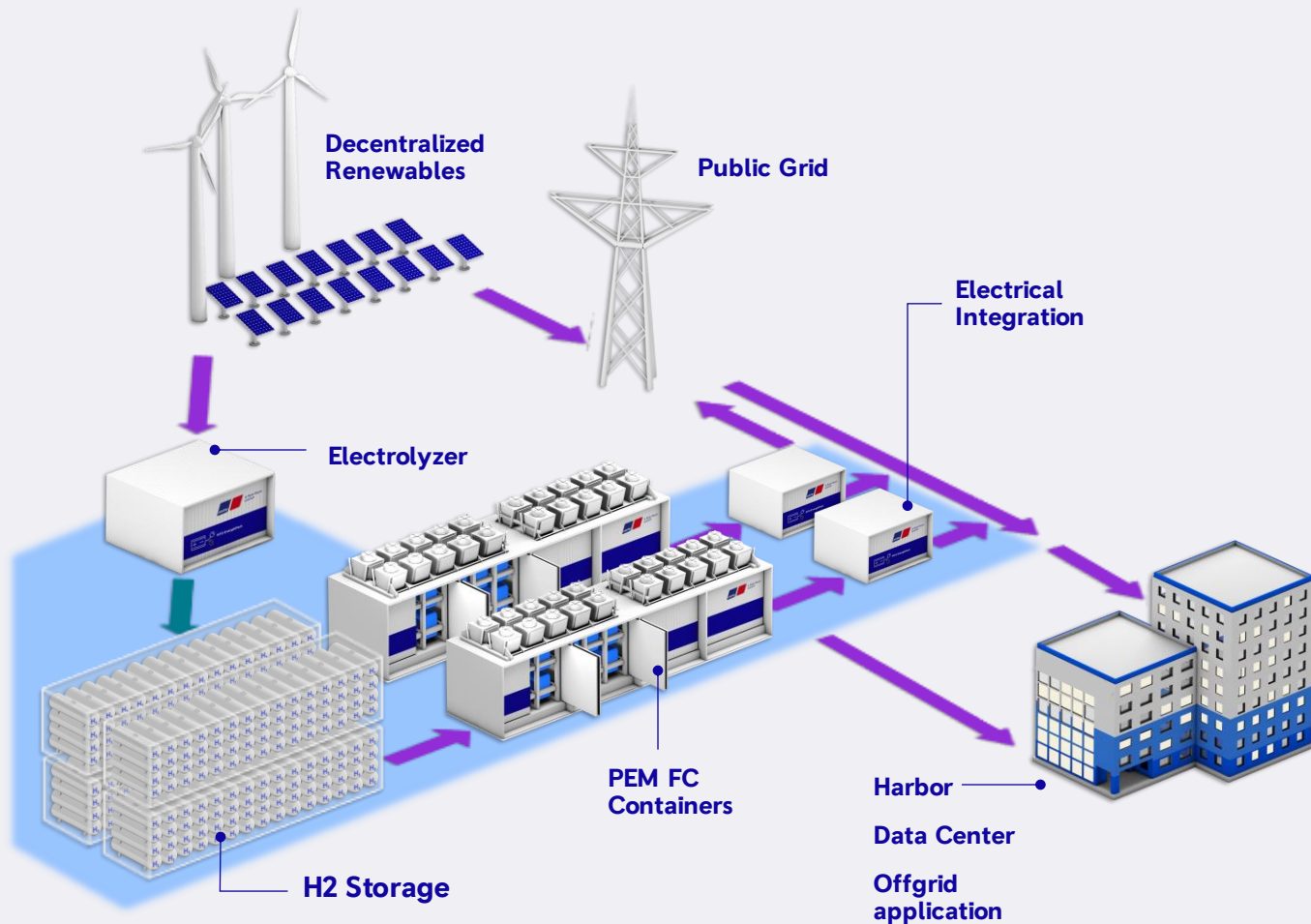


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# mtu hydrogen Ecosystem

Triple-use energy system to provide **CARBON FREE** uninterruptible backup power and grid services

- 100% carbon free
- high flexibility
- local production of H<sub>2</sub>
- enables CO<sub>2</sub> free enhanced Grid services
- provides backup and peaking capabilities

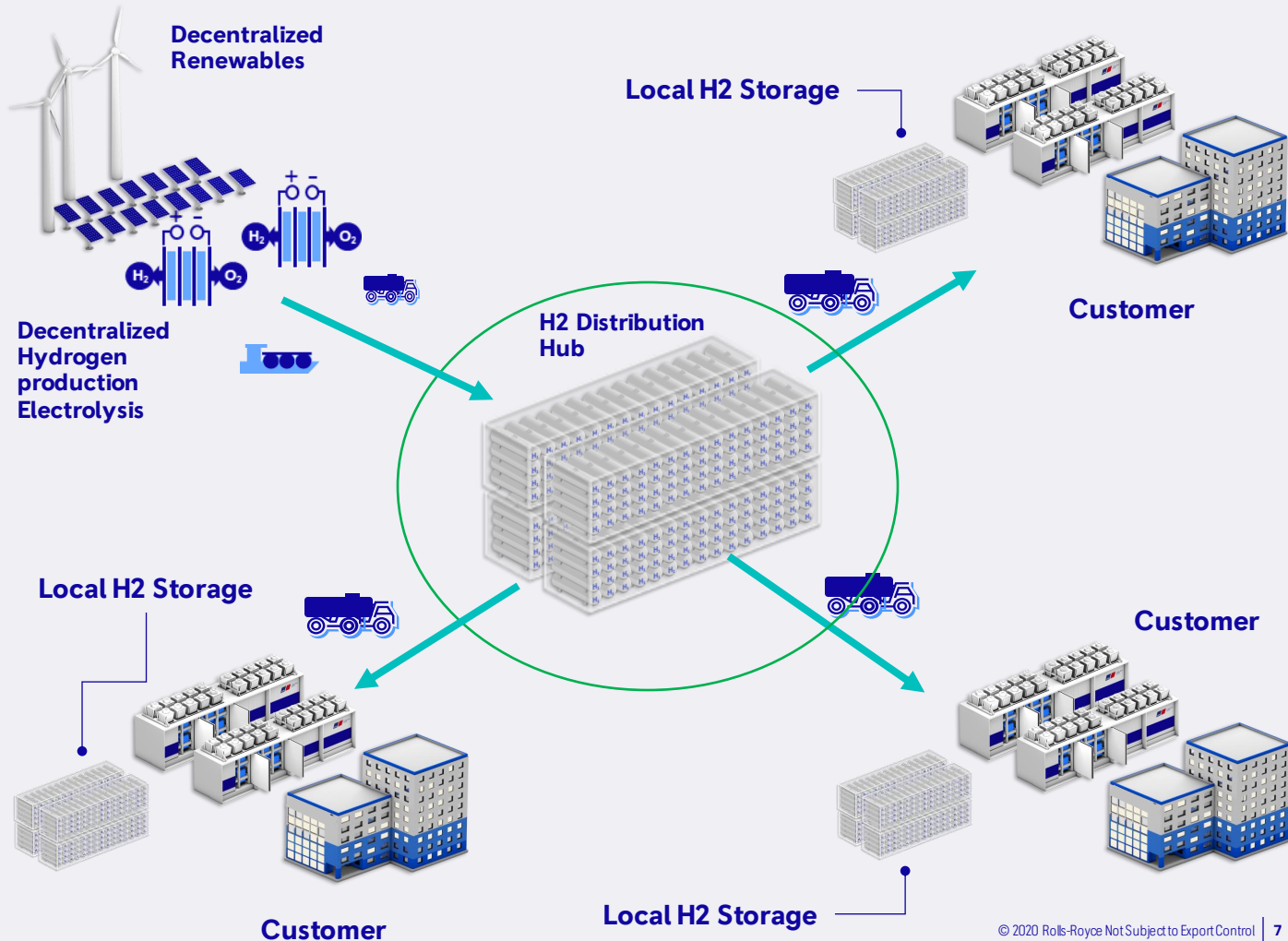




# mtu hydrogen supply concept

1. Decentralized Hydrogen production,
2. Decentralized storage
3. Local storage

- Decentralized hydrogen production @ Wind/PV Park
- Decentralized Storage with integrated Storage facility
- Local hydrogen storage up to 12h





Friedrichshafen, Germany

# Microgrid Validation Center

The Microgrid Validation Center in Friedrichshafen combines different energy generation assets with storage and load to enable validation of different stationary energy solutions.

In off grid mode, the assets and control algorithms' ability to maintain grid stability can be validated. In on grid mode, grid-forming functionality and the offering of grid services such as frequency response can be validated and further developed. The control system optimizes the energy management according to optimization goals such as cost or CO<sub>2</sub> emissions. An integrated emulator acts as a programmable load to enable simulation of a wide variety of scenarios.

## Configuration



Off grid + On grid



Solar PV



BESS



Diesel



Gas



Emulator



Fuel Cell  
(2021)



H2 Engine

## Main Benefits

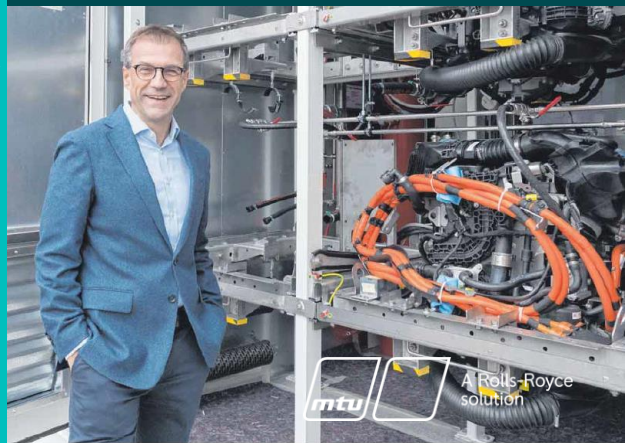
- Development and validation of new control algorithms & technologies
- Realistic show case for customers
- CO<sub>2</sub> and cost savings for factory

## Applications

- Integration of PV
- Regulation of Frequency and Voltage
- Load sharing
- Black start
- Island & Grid-parallel operation
- Peak Shaving / Energy Shifting
- Uninterruptible power supply (2021)

## Solution

- 12V4000 Diesel 1300kW
- 12V4000L64 Gas 1300kW
- EnergyPack 2000kVA / 1000kWh
- PV 80kW
- Fuel Cell 250kW
- Emulator (SMA) 2500kW
- MTU Plant Manager





# Groundplan

Hydrogen Trailers

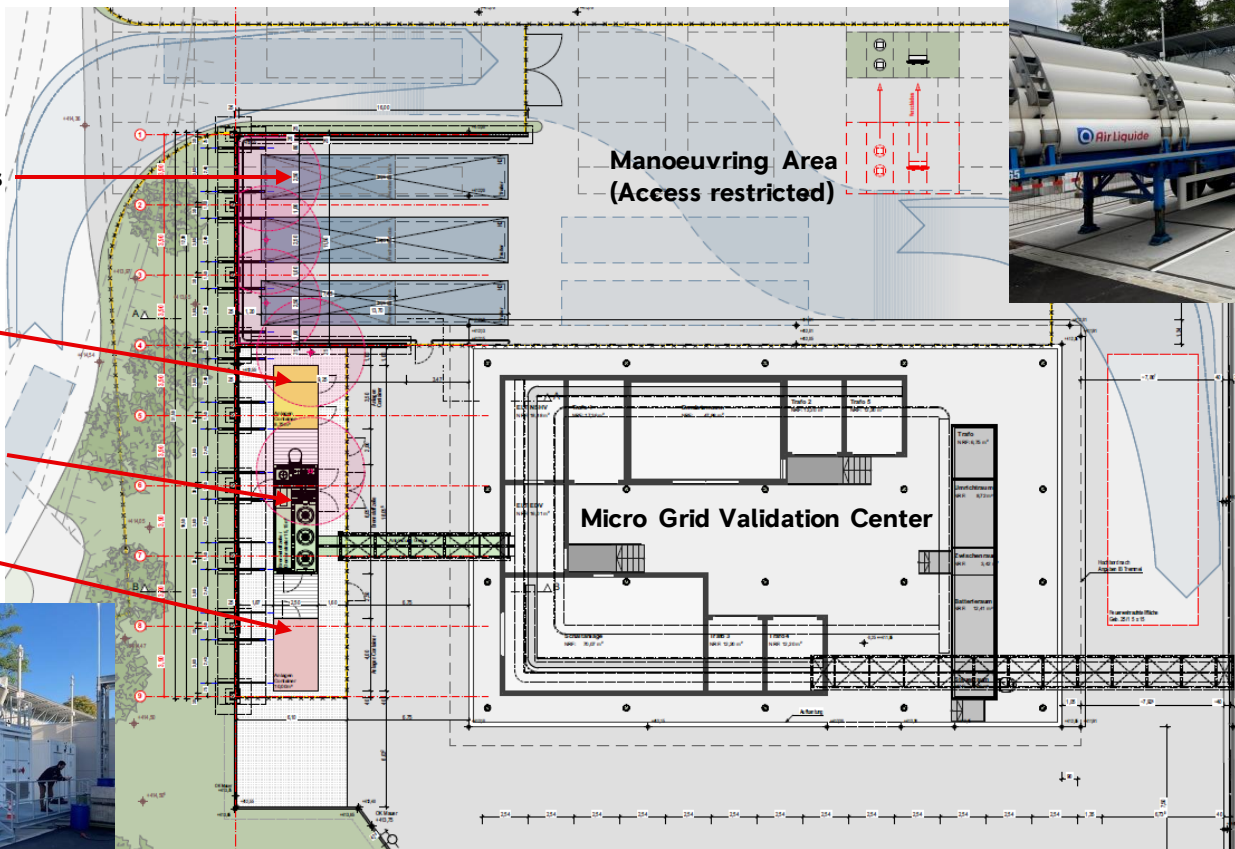
H<sub>2</sub>-Processing

FC-Demonstrator

Control Room

Manoeuvring Area  
(Access restricted)

Micro Grid Validation Center



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01

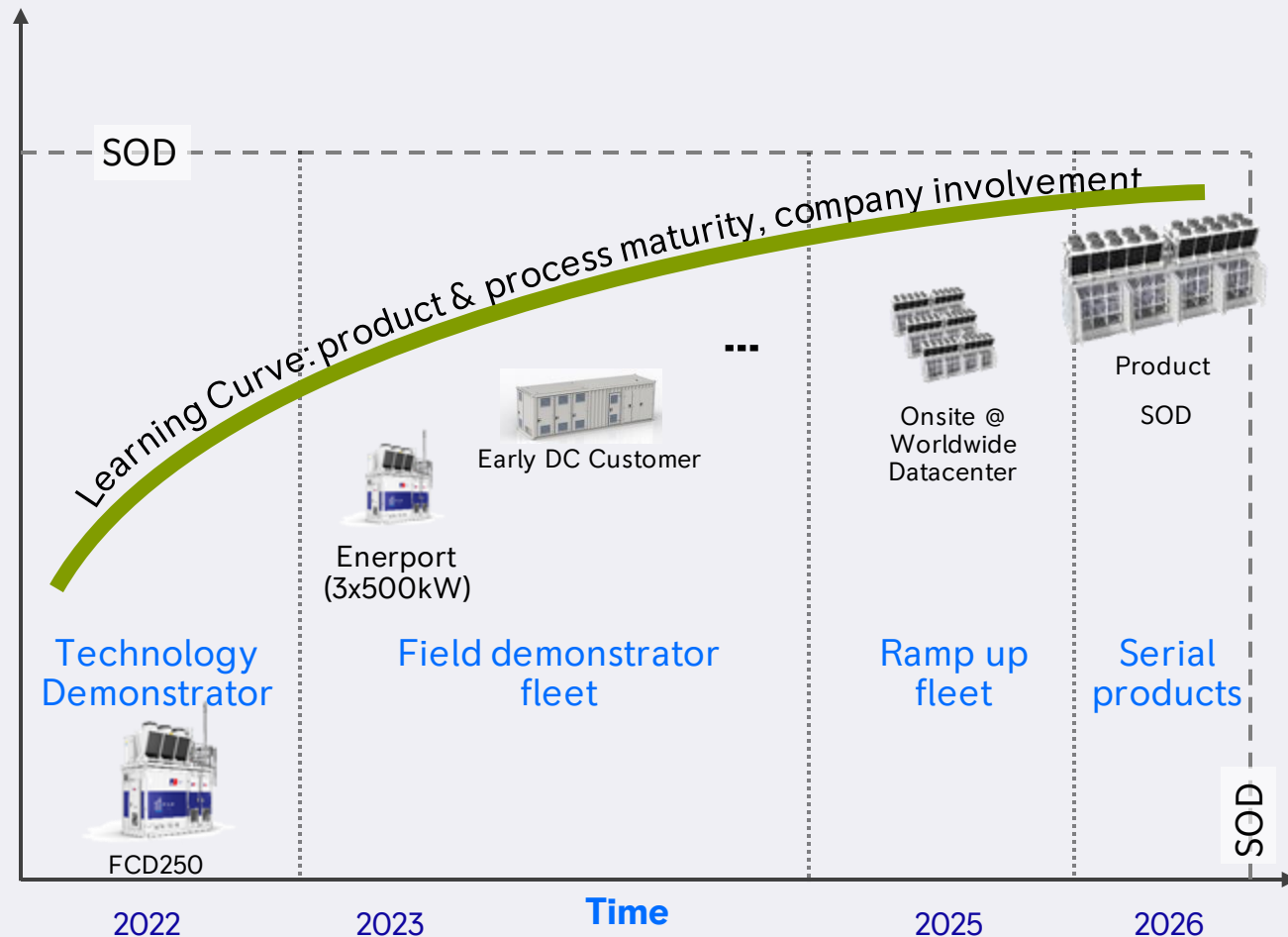
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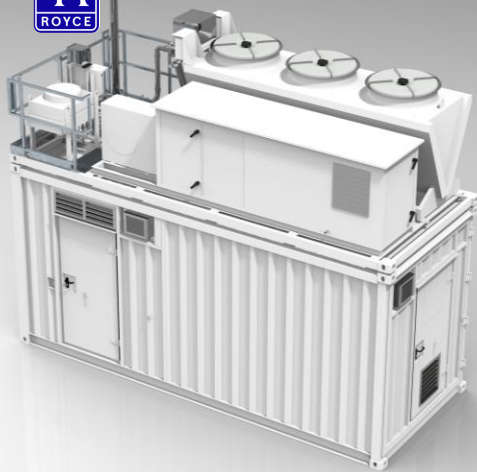
# *mtu* Fuel Cells

## Fuel Cell product roadmap

- **Technology Demonstrators** as learning objects for RRS as step 1
- **Field demonstrators** as proof of concept for Customers and RRS
- **Fleet ramp-up** to initiate technology change
- **Serial products** in order to deliver volume

Product Maturity



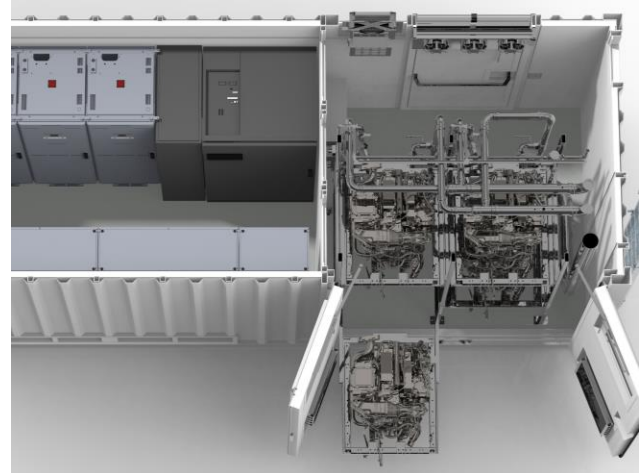
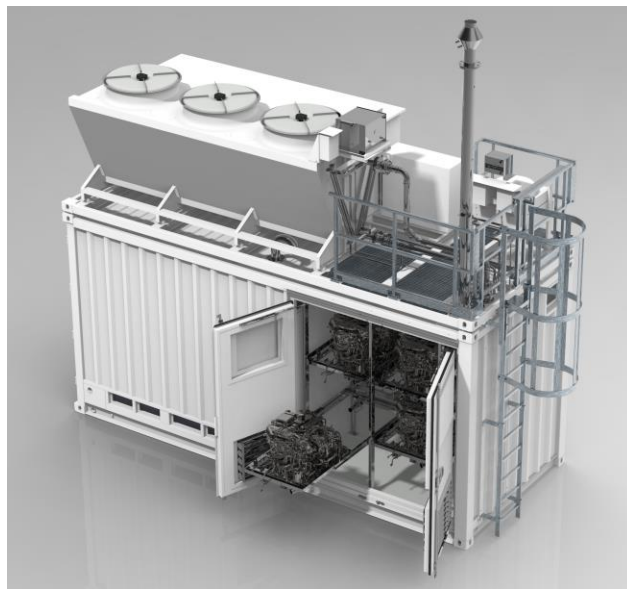


## Integrated.

By being operable under the open sky without any infrastructure apart from hydrogen, the standalone Fuel-Cell Demonstrator is much more than a test bench.

## Versatile.

Equipped with a cutting-edge static online-UPS system and Li-Ion batteries, the demonstrator can be adapted for various different customer use cases.

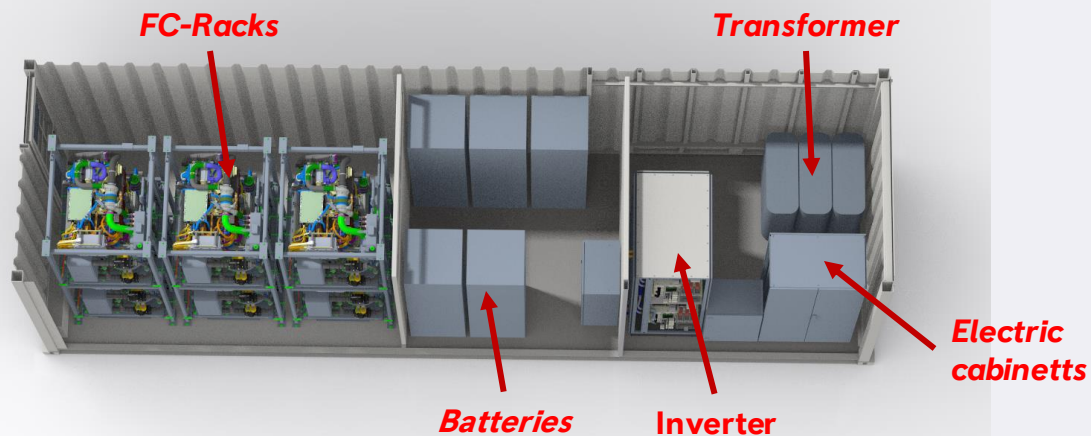


## Pioneering.

Demonstration of new concepts for modular FC system integration will set the foundation for large scale power generation from PEM fuel cell technology.



## Enerport Design 600kW VAC 30ft







## mtu Fuel Cell Solution

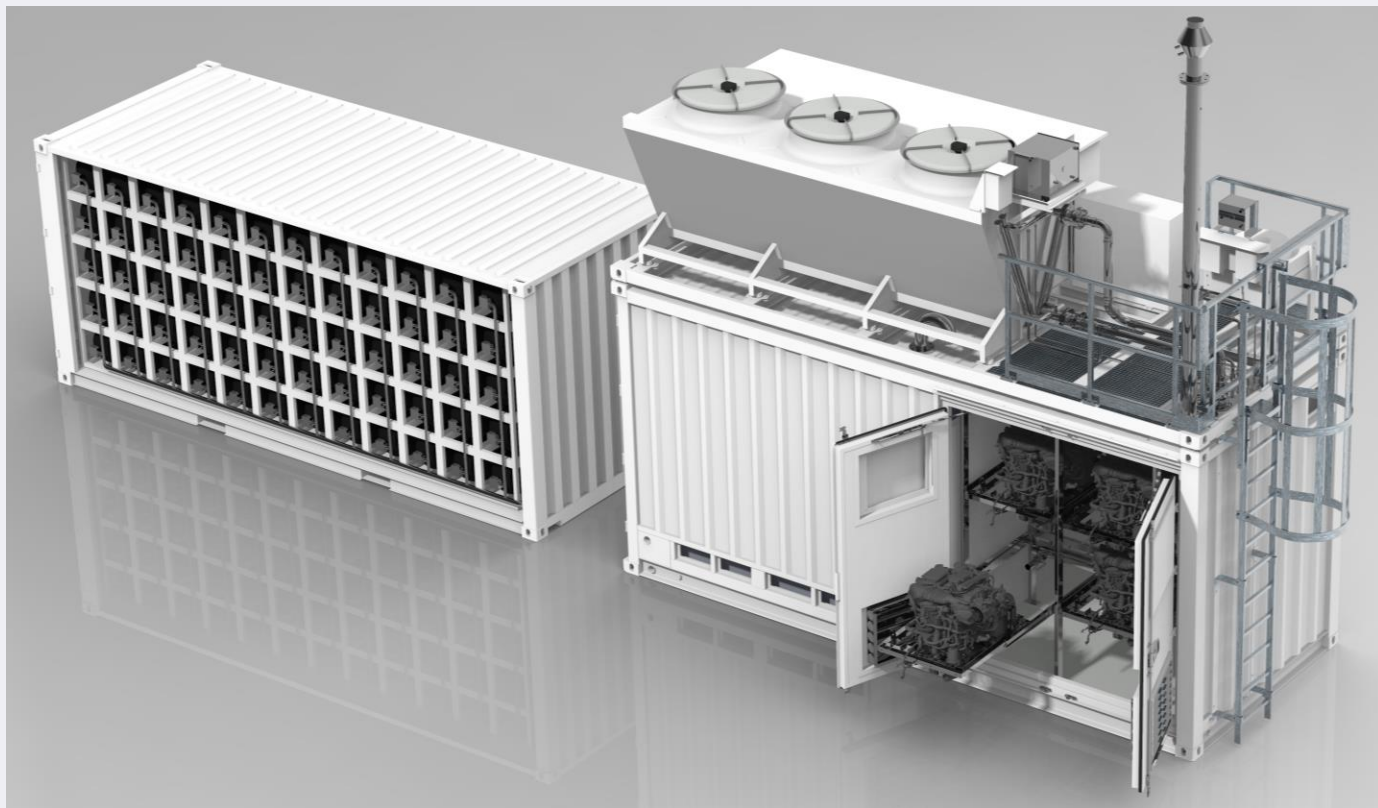
Examples for H<sub>2</sub>-Storage  
@250KW power:

### 20" Container

- 289 kg usable H<sub>2</sub> at 350 bar,  
15,8 h operation at 100% load
- 458 kg usable H<sub>2</sub> at 700 bar,  
25 h operation at 100% load

### 40" Container

- 578 kg usable H<sub>2</sub> at 350 bar,  
31,6 h operation at 100% load
- 915 kg usable H<sub>2</sub> at 700 bar,  
50,1 h operation at 100% load



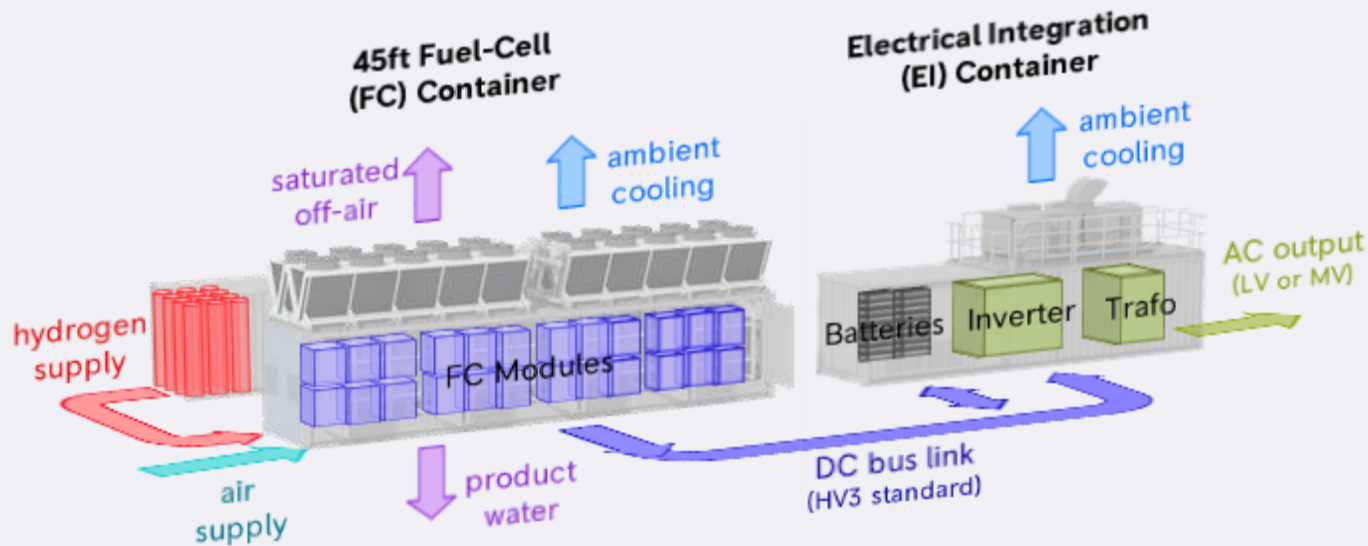
20ft Container  
H<sub>2</sub>-Storage

20ft Container  
Fuel Cell with UPS

## Energy System Concept: PEM Fuel Cell Generator Prime & Backup Power

Options:

1. Inverter solution with an AC power output for decentralized power generation.
2. Integrated solution for datacenter with a FuelCell System and an UPS (s. next slide).



### Fuel Cell Container:

Fully integrated standalone solution for outdoor usage at customer-defined power scale.



### Electrical Integration:

Multitude of different customer-specific integration solutions conceivable.

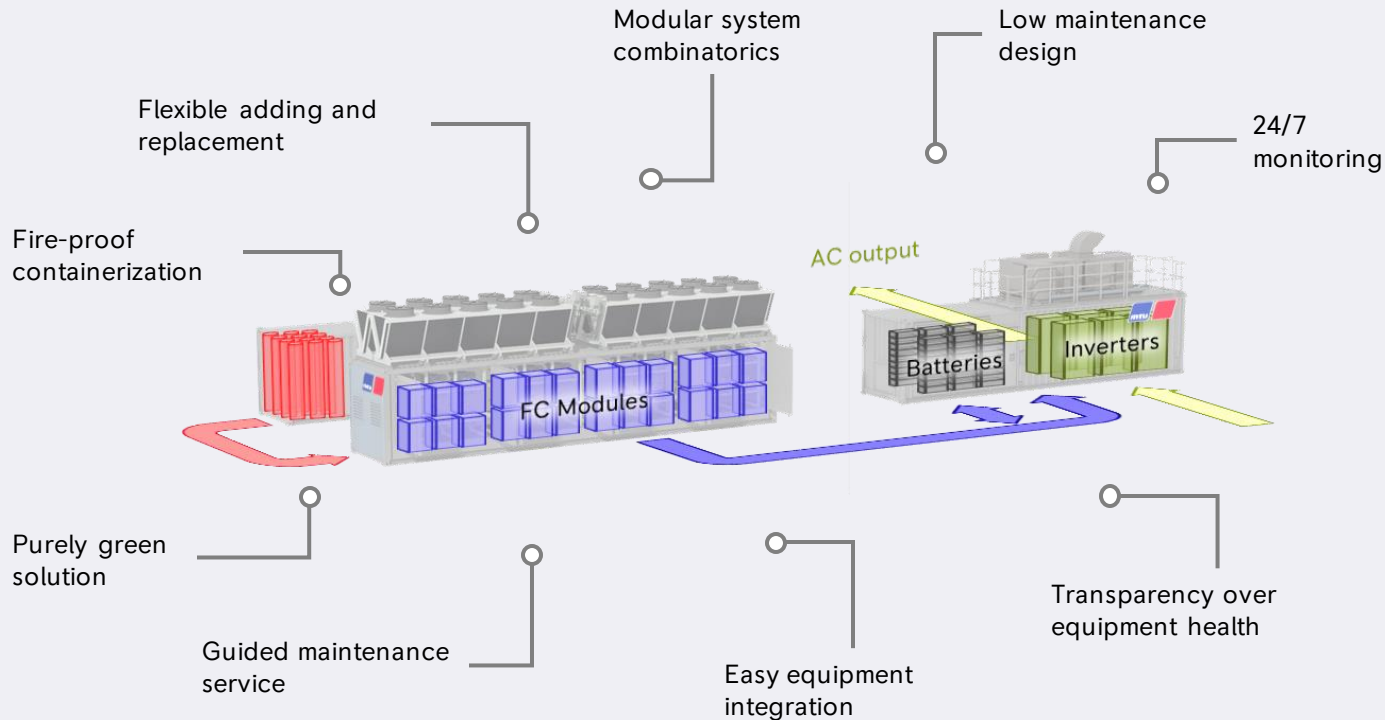


## Integrated FC & UPS Backup System

Customers value our solution as a scalable, low maintenance and green solution



## Key product features of fuel-cell powered green solutions



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02

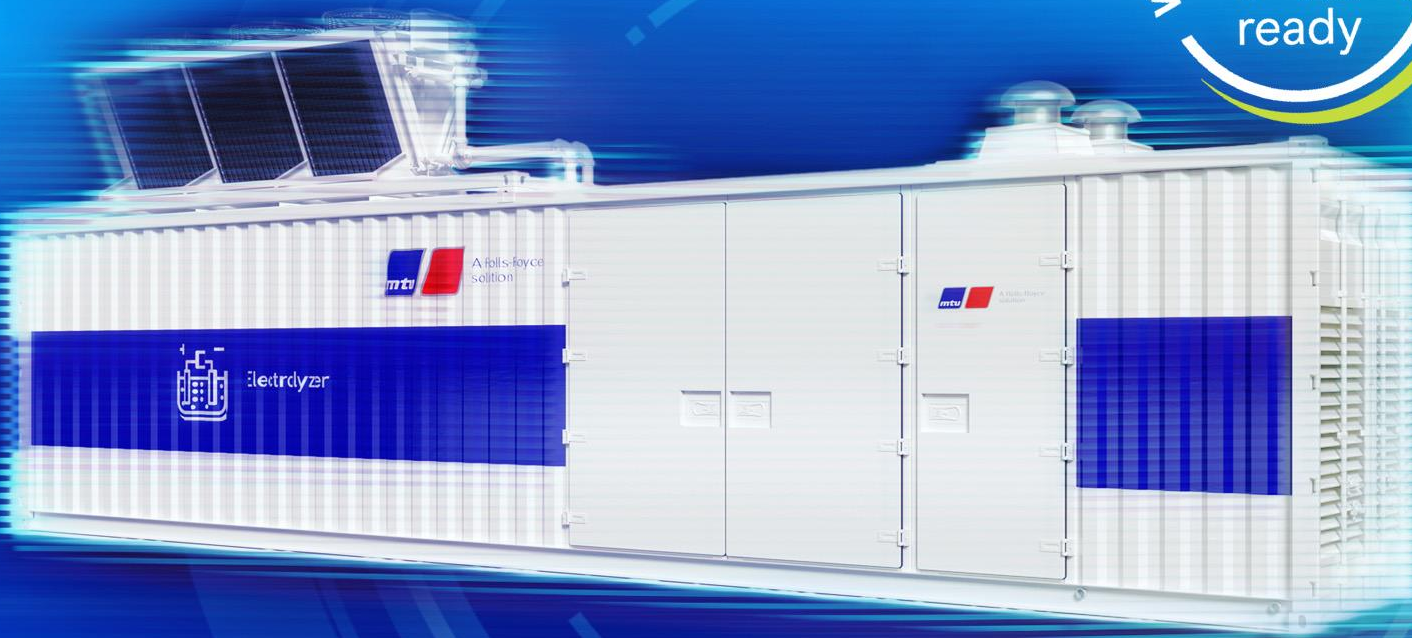
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# *mtu* Electrolyzer



## Solution Offerings | Electrolyser

WAY TO NET ZERO  
 $H_2$   
ready

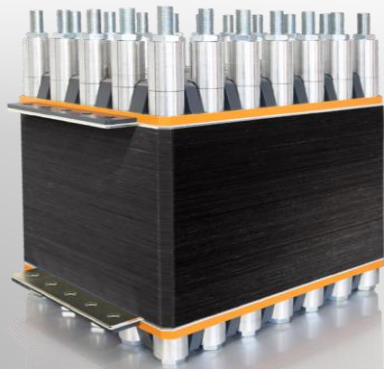


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## Solution Offerings | Electrolyser



### Key Improvements

#### MEMBRANE ELECTRODE ASSEMBLY

Better connectivity to reduce catalyst need

#### END PLATE

Advanced design to optimize installation space

#### POROUS TRANSPORT LAYER

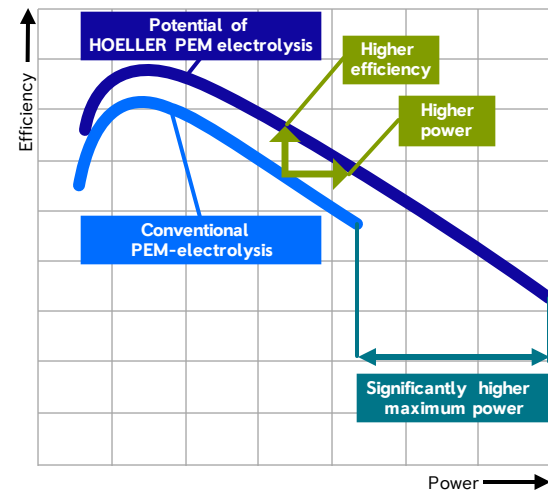
Lower resistance to increase power and efficiency

#### BIPOLAR PLATE

Optimization of the flow field to maximize power

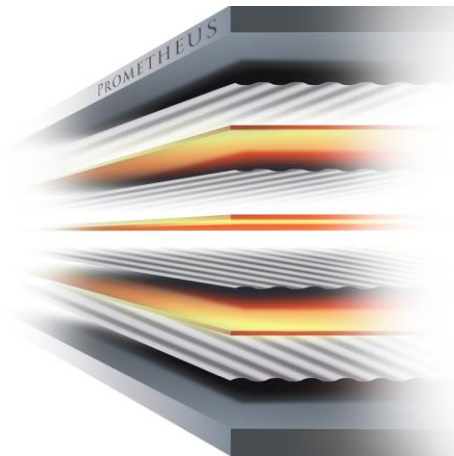
#### HIGHER OUTPUT PRESSURE

Simplification of the system



### PEM Electrolyzer Stack

High Performance PEM Stack technology. Higher Efficiency due to advanced design. Compact design min 1.5MW per Stack.



### Pioneering

Next Generation of PEM Stack technology. Enables cost effective production of green hydrogen.





## mtu Electrolyzer

### Prometheus L Stack

#### Second Generation

Higher Hydrogen Output  
Pressure (target 75-80  
bar)

Increased temperature  
(target 120 degrees C)

#### Technical information

Power consumption	up to 1.5 MW with approx. 312 cells
Active surface	Approx. 1.180 cm <sup>2</sup> / cell
Voltage and current	up to DC 750 Volt, 2.500 Ampere
AC power consumption at full capacity	Approx. 4,5 kWh / Nm <sup>3</sup> (stack)
Degradation	Stacks are designed to last a minimum of 80.000 hours of operation
Dimensions (length * width * height)	1030 * 830 * 2260 mm
Stack Weight	approx. 1600kg
Nitrogen purge	Stack will feature nitrogen purge.
Water consumption	Less than 1 liter per Nm <sup>3</sup> H <sub>2</sub>
Response time	Less than 10 seconds in both directions
Hydrogen production	Up to 680 KG / day Operating pressure 40 bar
Stack operating temperature	80 degrees Celsius max.
Start of production	Q4 2023

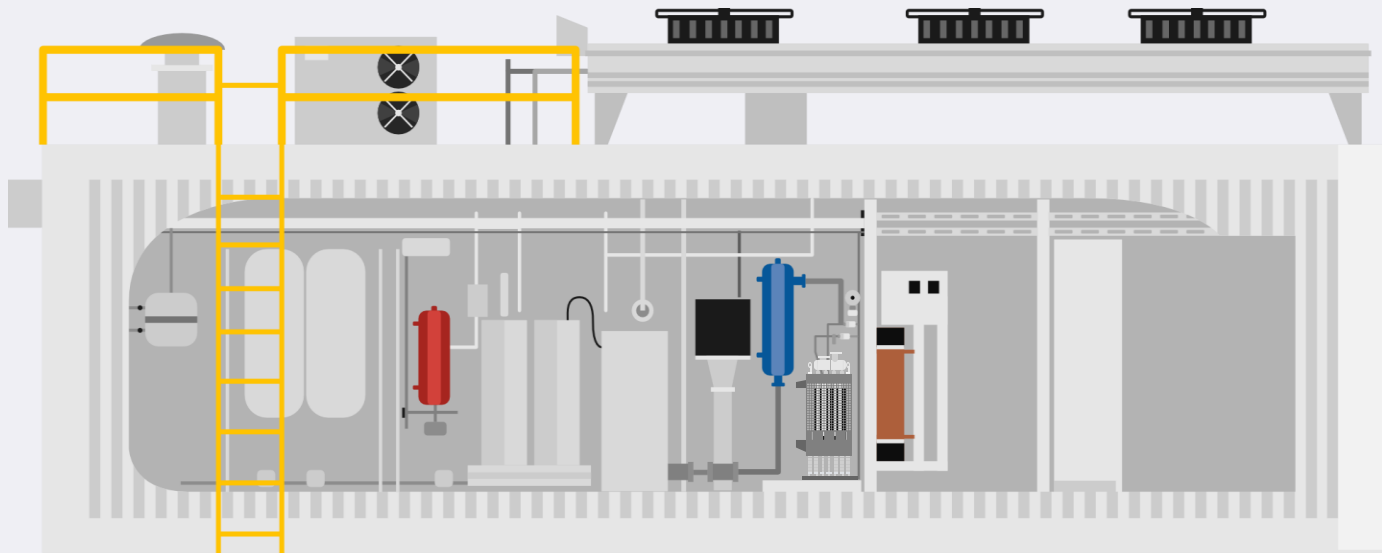




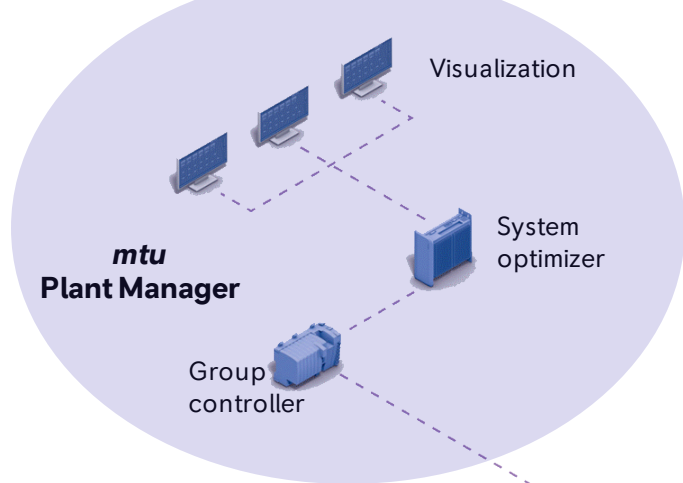
**mtu** Electrolyzer

**up to 2MW  
containerized**

# THE STACK IS THE HEART OF THE ELECTROLYZER

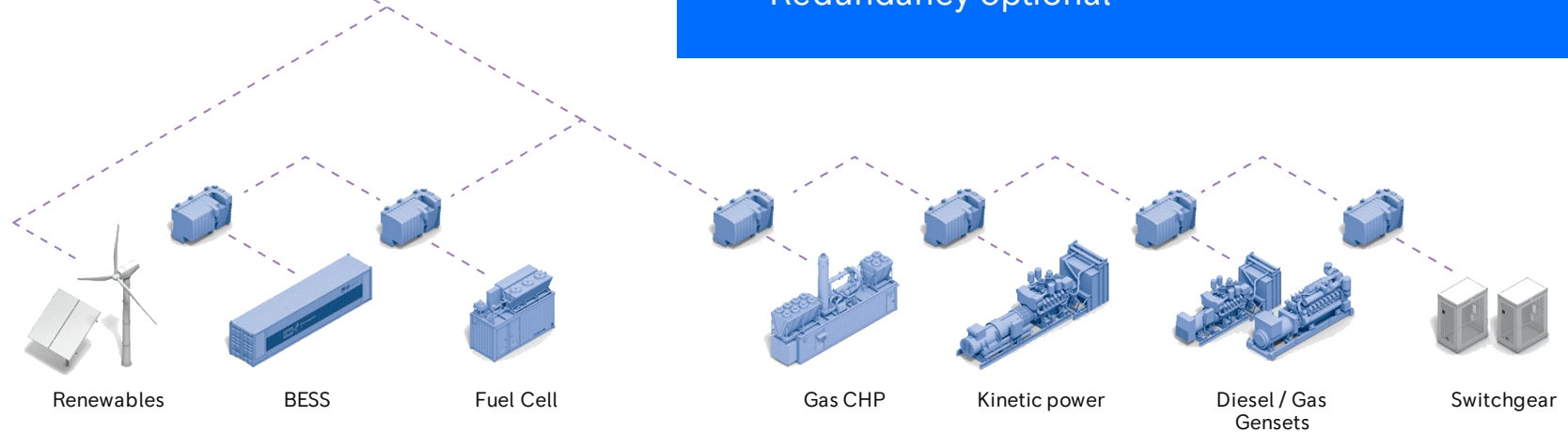


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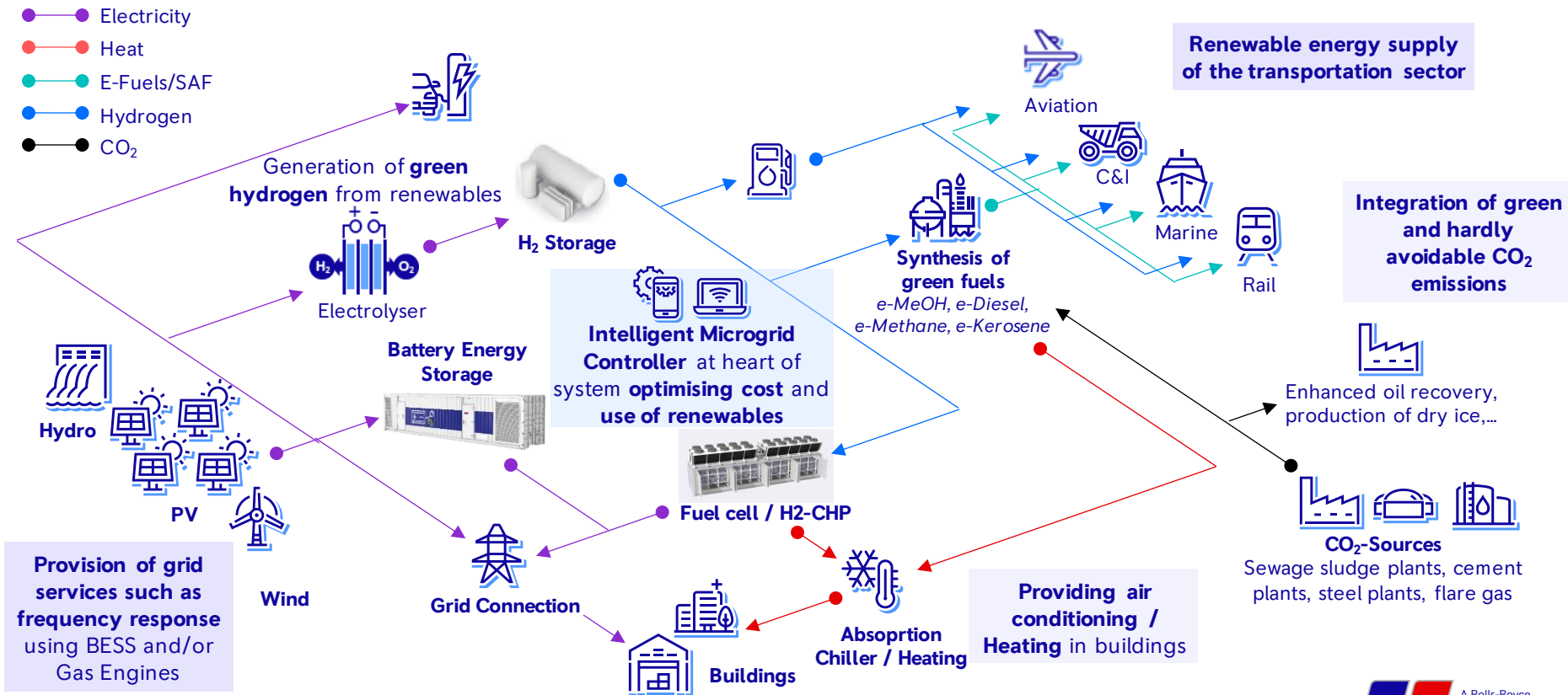
## **mtu Plant Manager**

- Control of power generation, storage and load
- Mathematical optimization algorithms
- Grid Stability
- Power distribution
- On grid / Off grid / Emergency Power / Peaking
- Scalable / Flexible
- Redundancy optional





# The Future of Green Transport and Energy: Renewable Cross-Sectoral Energy System







**Thank You!**