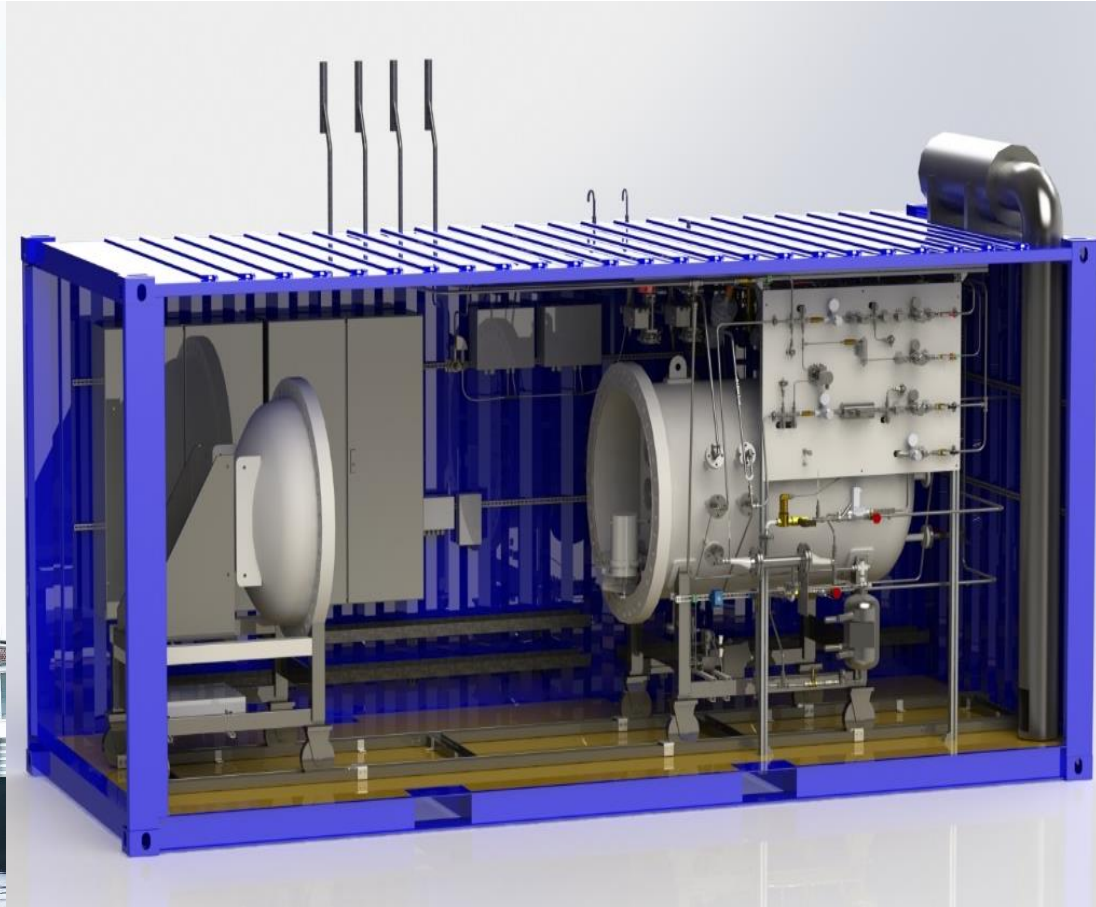


+ Development of High-Temperature Electrolysers for Renewable Electricity Storage



Hydrogen Days Prague 2015
Oliver Posdziech, Manager BU-SYSTEMS



Company



Company facts

Team

>70 employees (90% engineers & technicians)

Partnership

Strategic partnerships with Bilfinger, Total & EDF

Funding

~ 24.000 kEUR equity invest and subsidies since 2010

Patents

> 30 patent families

Customers

4.200 kEUR revenues with global customers (2013)



VAILLANT GROUP



+

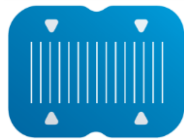
SOC stack – One design

20 – 40 W

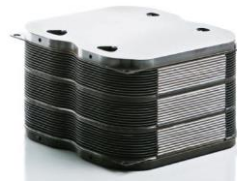
650 – 1,000 W

1.5 kW - 25 kW

Fuel Cell
(SOFC)



Repeating
SOFC Unit



SOFC
Stack



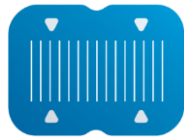
SOFC System

70 W

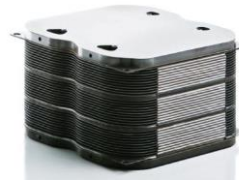
2,200 W

10 kW - 500 kW

Electrolysis
(SOEC)



Repeating
SOEC Unit



SOEC
Stack



SOEC System

One device for multiple purposes

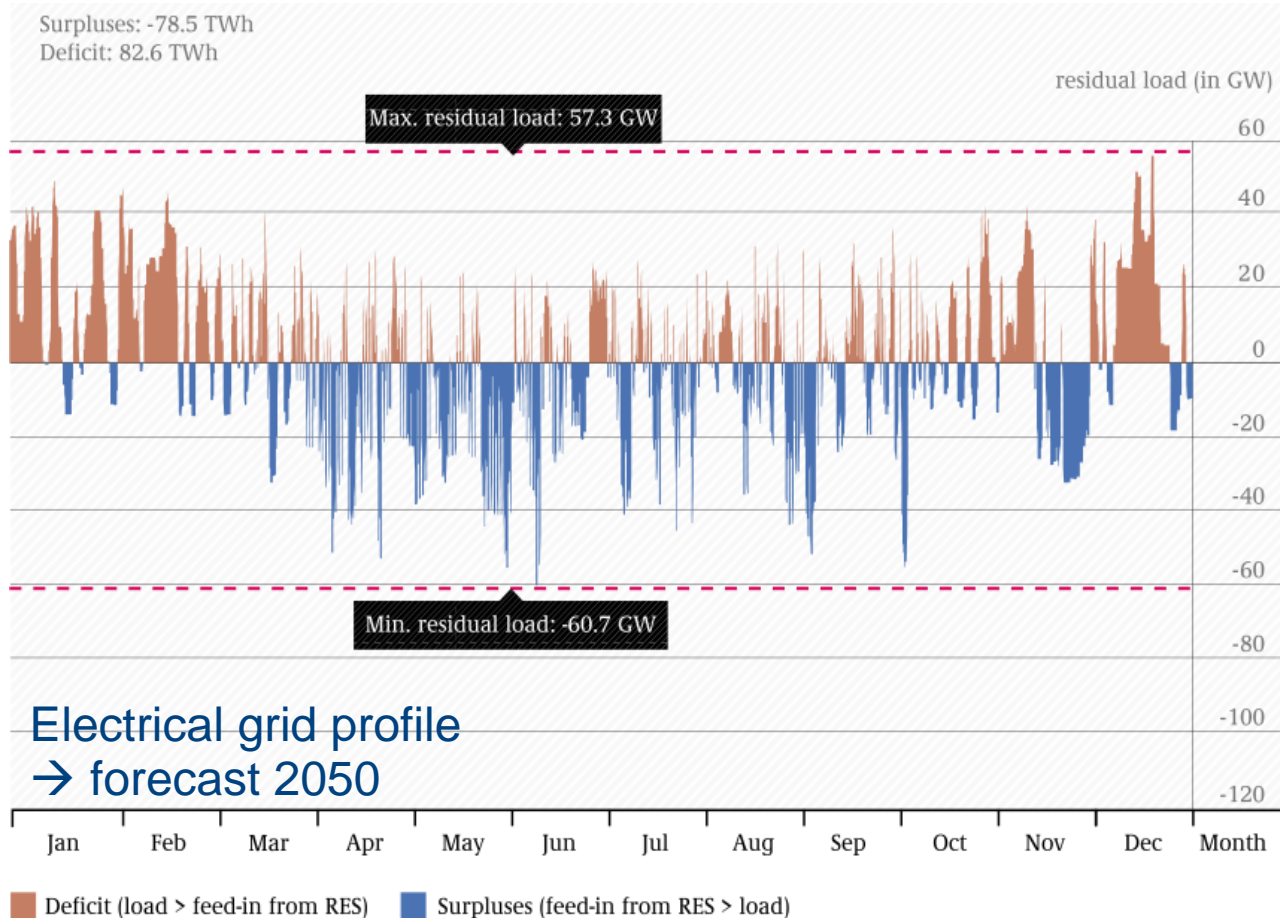
	<u>Application</u>	<u>Power Range</u>	<u>Partner</u>	<u>End-customer</u>
SOFC	Combined Heat and Power (private)	1 kW _{el}	VAILLANT GROUP	Single and multi family households
	Offgrid electricity production (oil & gas)	3-5 kW _{el}	ОАО «КОНЦЕРН ЭНЕРГОМЕРА» ЭНЕРГОМЕРА	Pipeline operators, oil and gas extraction, telemetry
	Efficient electricity production (marine)	20-500 kW _{el}	ThyssenKrupp 	Marine applications, biogas plants, turbine operators
SOEC	Reversible hydrogen storage	100 kW _{el}		Oil and gas companies, refineries, utilities, grid operators, etc.
	Hydrogen refuelling station	10 kW _{el}	 	Fueling stations
	Power-to-Liquids	200 kW _{el}	 	Oil and gas companies, refineries, utilities, grid operators, etc.



SOEC applications and technology

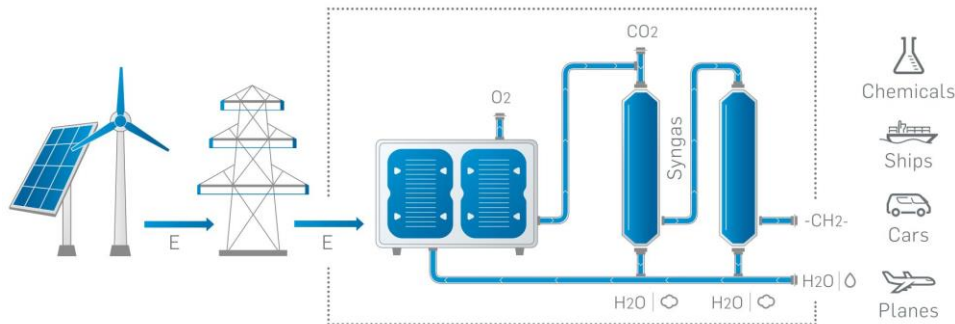


Challenges of renewable electricity

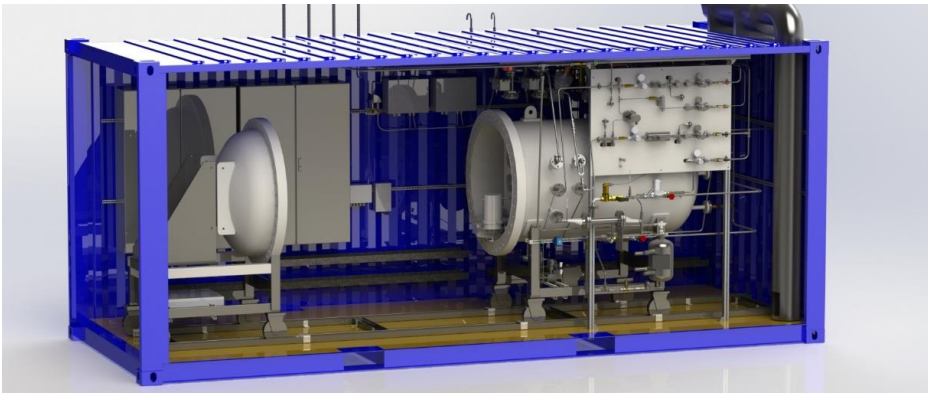


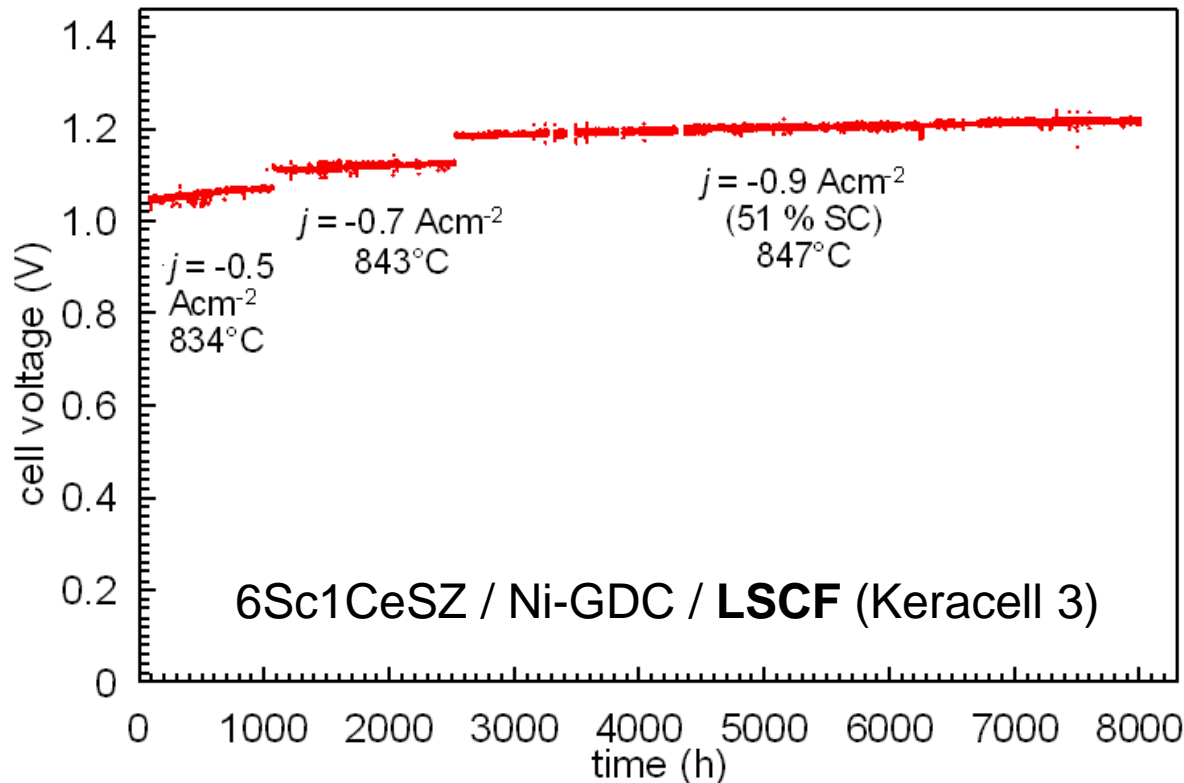
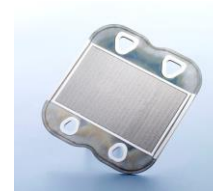
© FhG IWES

- Strongly fluctuating loads vs. fluctuating demands
 - Grid balancing
 - Economics of power generation
 - Electricity costs
- **Storage of surplus electricity**



- Conversion in chemical products or gaseous fuels
→ Power-to-Liquids
→ Power-to-Gas
- Hydrogen as feed material for chemical and metallurgical industries
- Hydrogen car fuelling
- Hydrogen storage and power generation

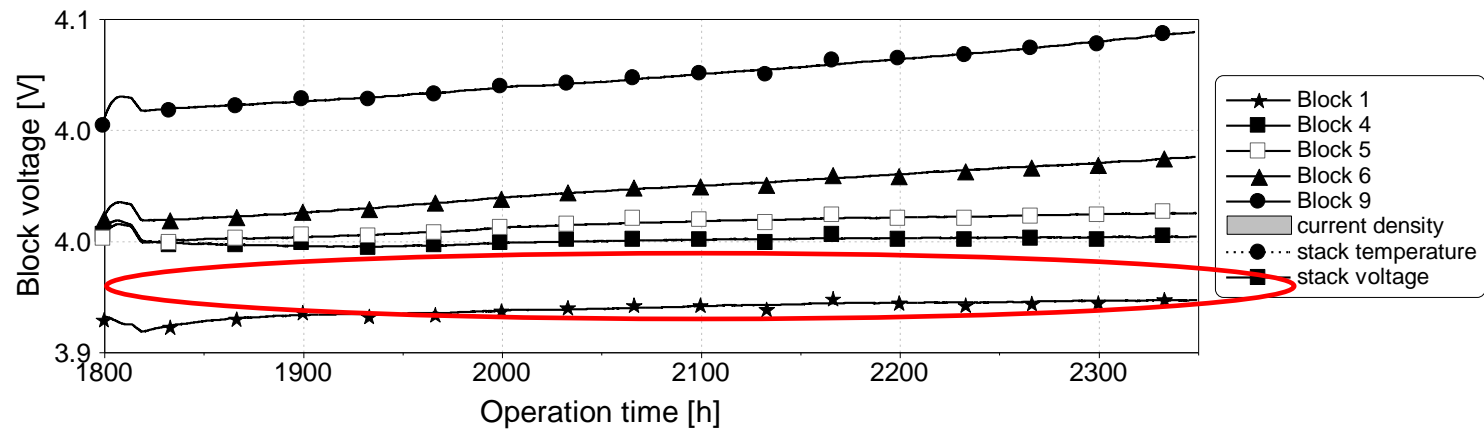
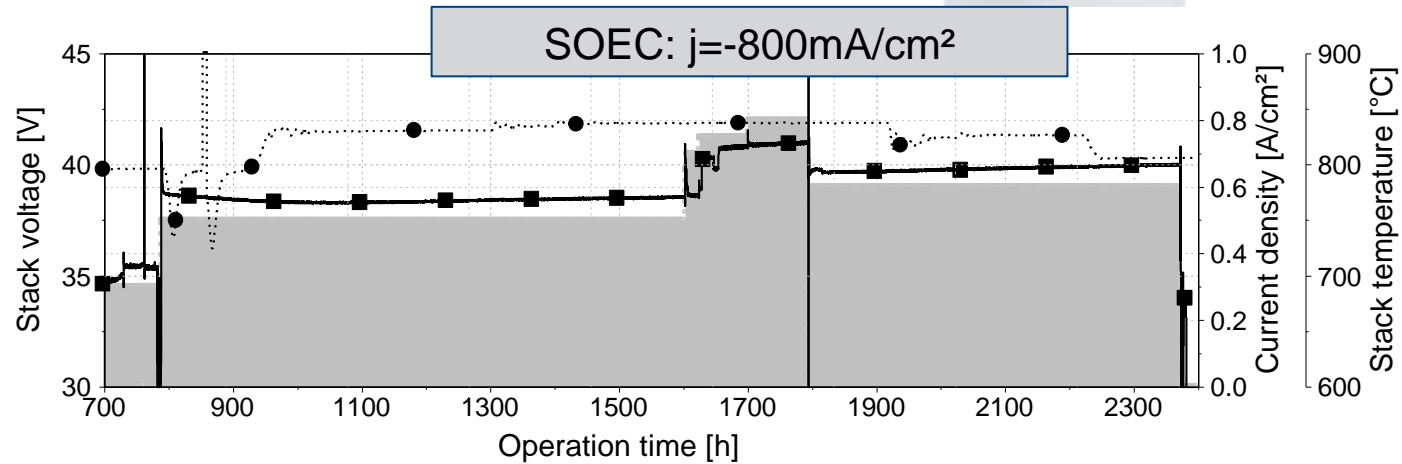




- Constant voltage degradation at -0.9 A/cm^{-2} : **8 mV/kh (0.6 %/kh)**
- Overall cell operation $>> 8000 \text{ h}$
- Steam conversion up to 80 % successfully tested

+

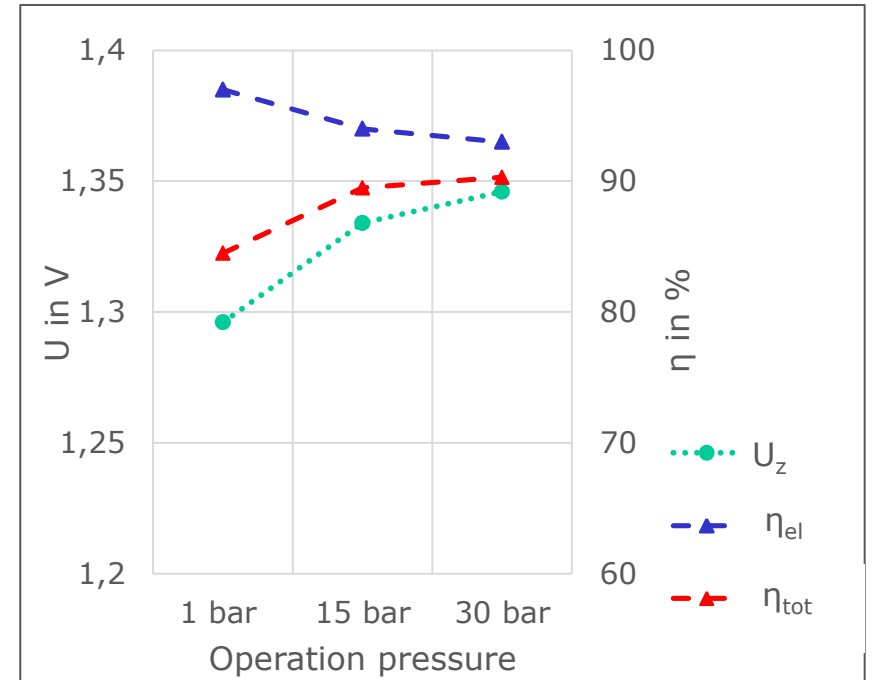
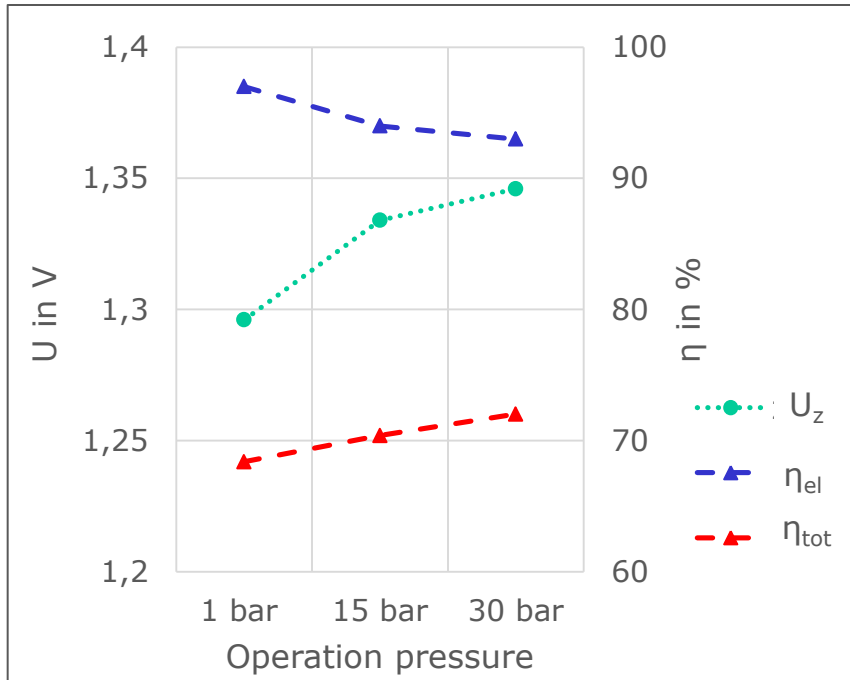
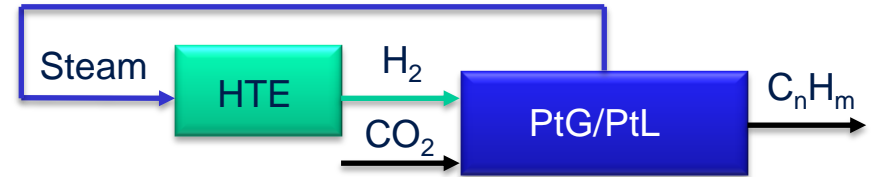
SOEC development – stack technology



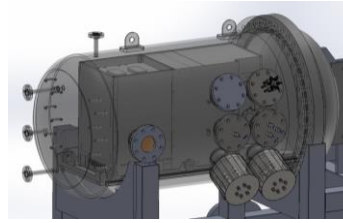
Best material combination: 0.7%/1000h voltage degradation

+

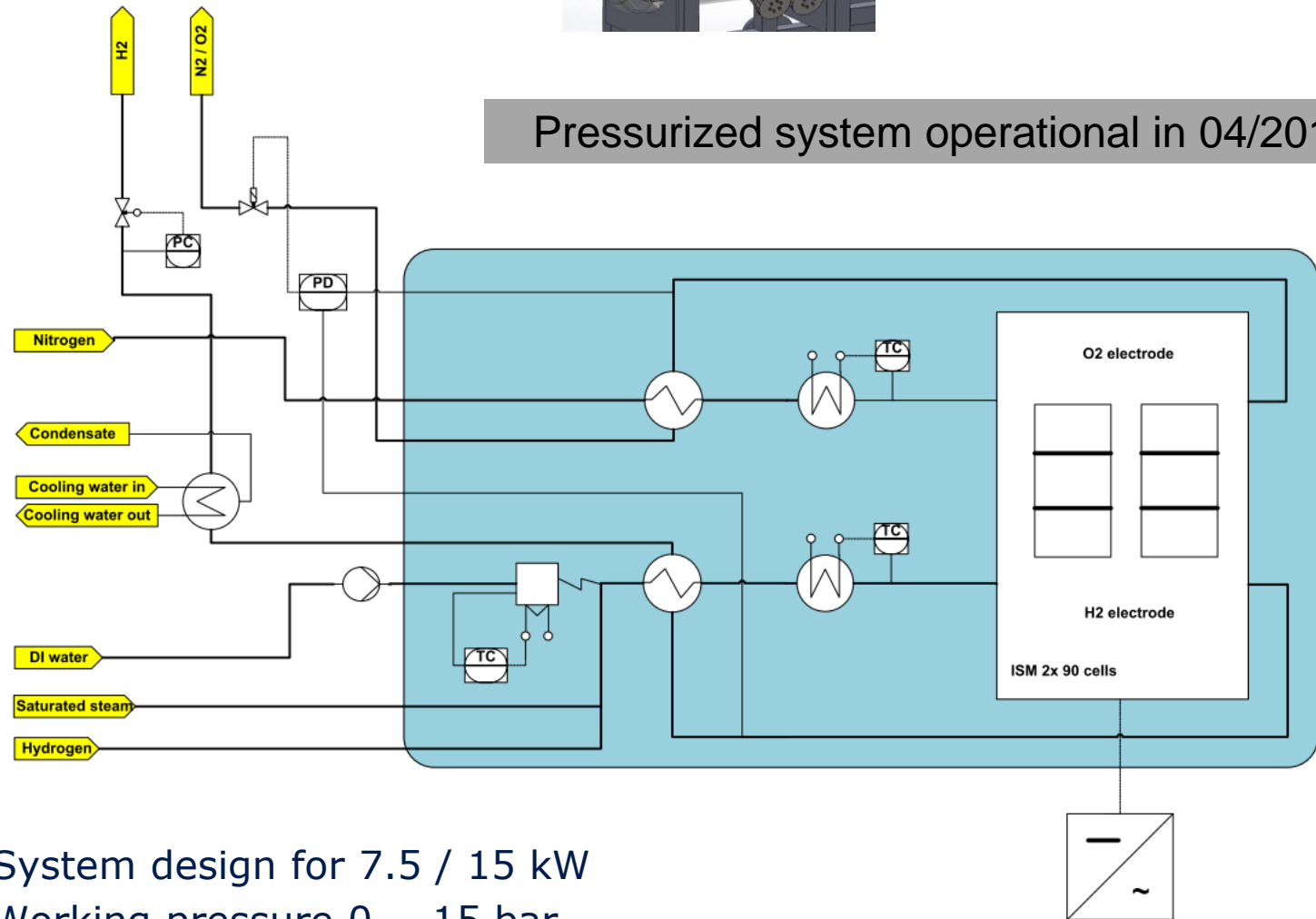
Pressurized SOEC



Power density 0.6 A/cm², final pressure of H₂ 30 bar



Pressurized system operational in 04/2015



- System design for 7.5 / 15 kW
- Working pressure 0 ... 15 bar



Reversible Solid Oxid Cells and applications



Sketch of the rSOC system

rSOC connection to natural gas grid: unlimited energy storage capacity

The reversible Solid Oxide Cell improves the quality and reliability of the distribution system:

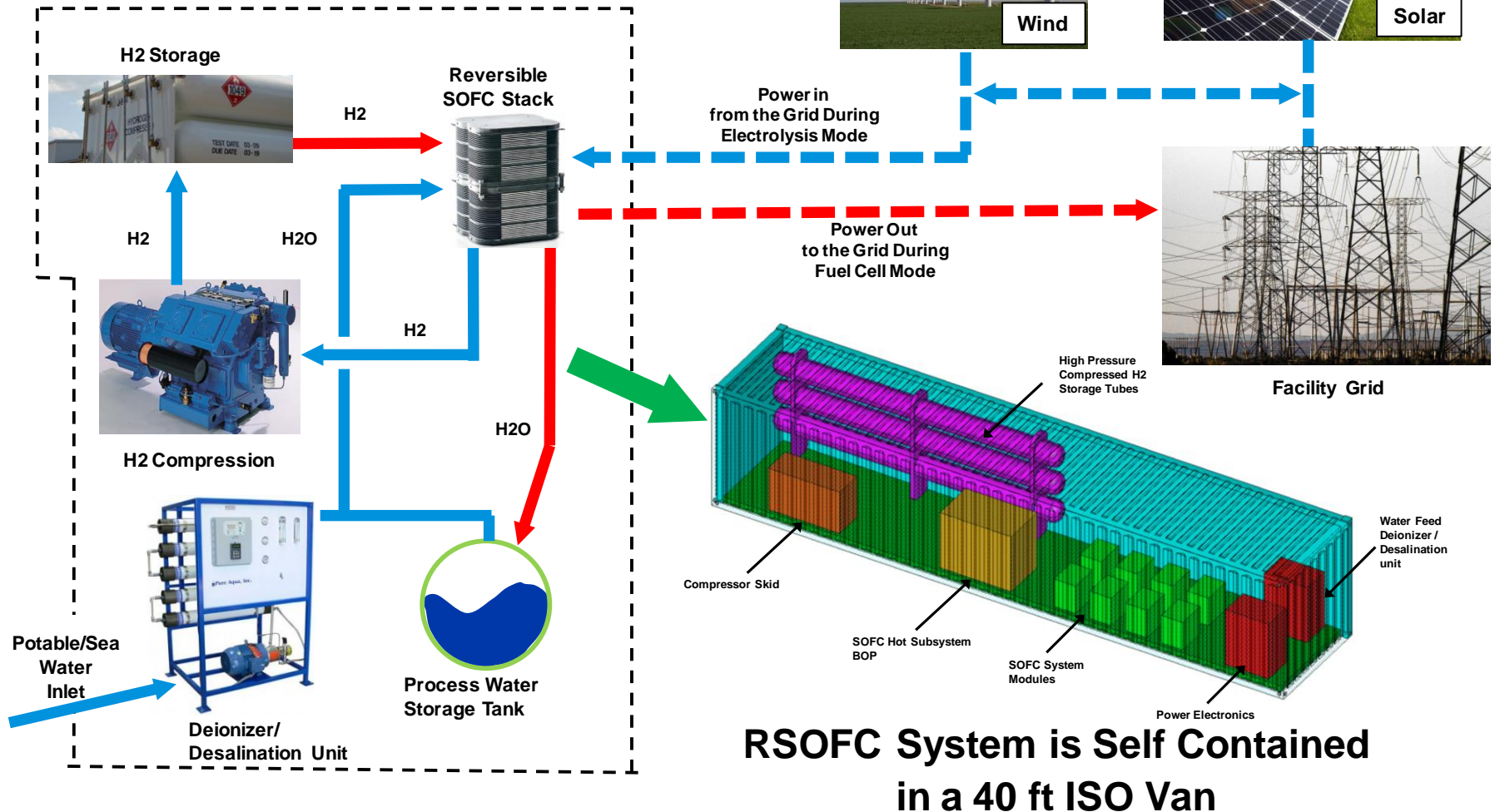
- By allowing load and peak leveling,
- flexible capacity share between storage & supply,
- whilst providing high-quality hydrogen and producing valuable electricity.
- Roundtrip efficiencies up to 60 % possible with sophisticated H₂ and heat storage strategies
- Operation time extension due to high flexibility – faster amortization

+

Reversible SOC (50/120 kW_{el})

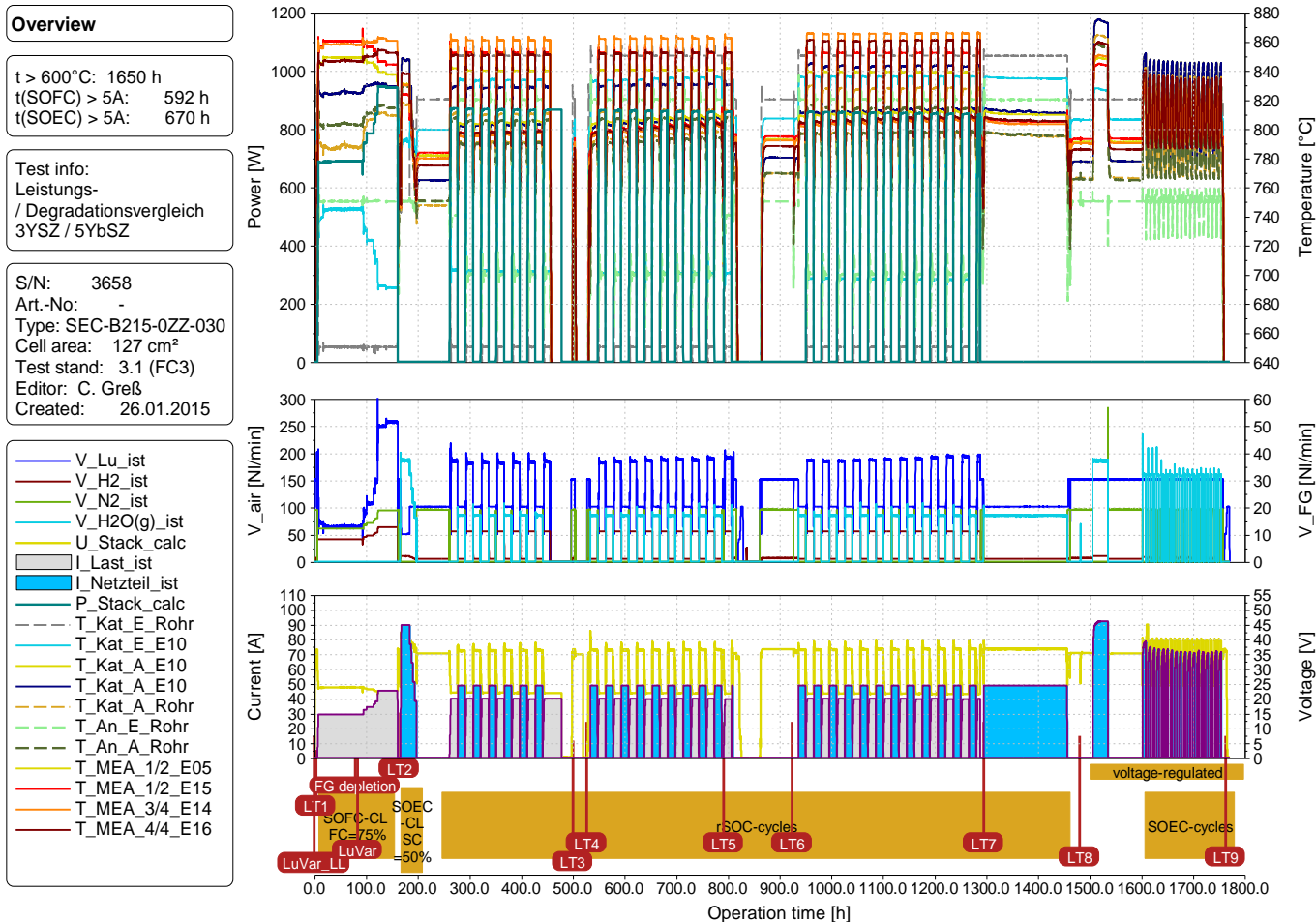


- **Electrolysis Mode** – $\text{H}_2\text{O} \rightarrow \text{H}_2 + \text{O}_2 \rightarrow \text{Produce and Store H}_2$
- **Fuel Cell Mode** – $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O} \rightarrow \text{Use H}_2 \text{ to Produce Power}$



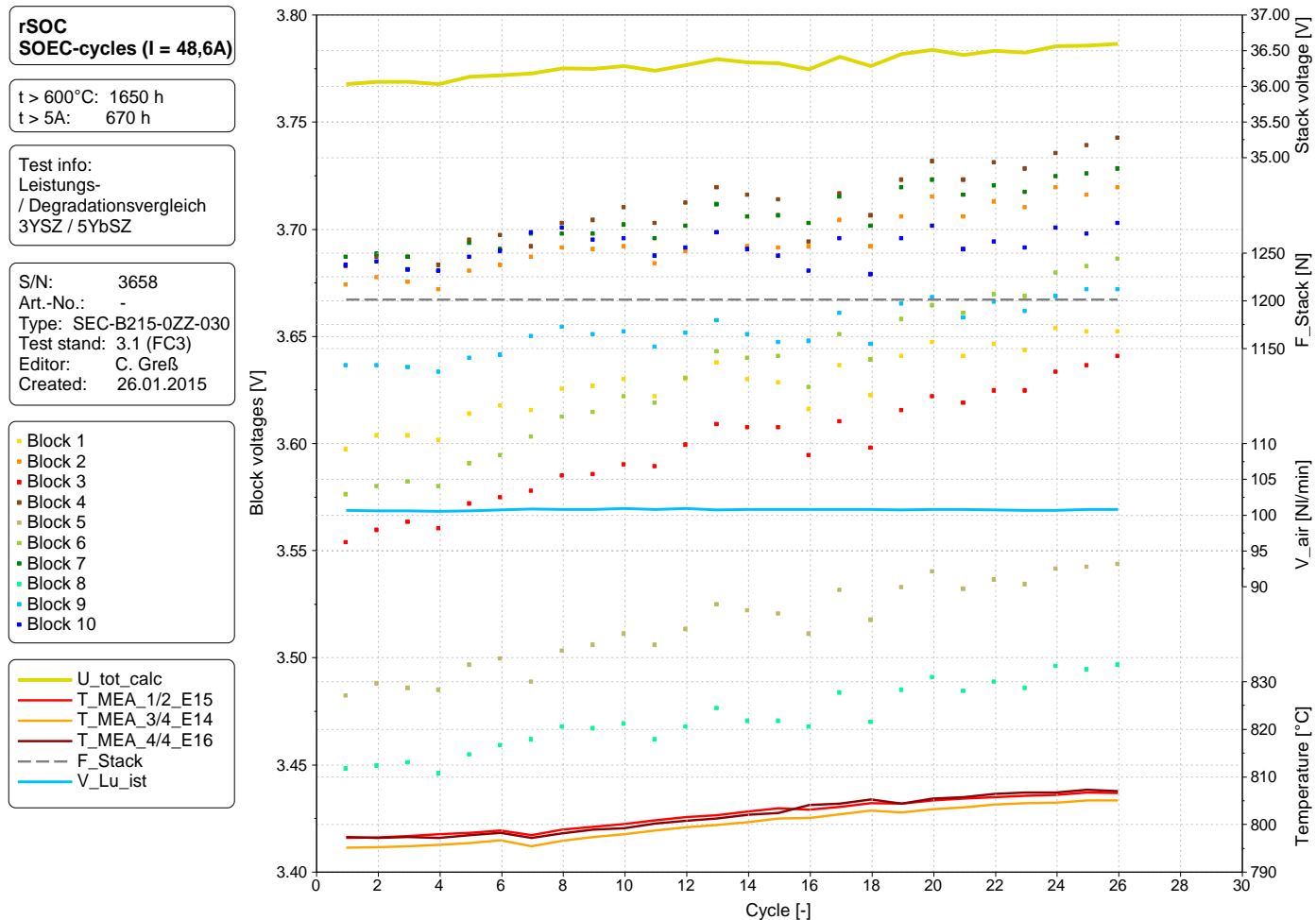
Reversible cycling tests

- 12h SOFC: current density 310mA/cm² @ fuel utilization 75%
- 12h SOEC: current density -380mA/cm² @ steam conversion 60%



Reversible cycling tests

- Voltage degradation ca. 0.06 % / cycle



- Sunfire product portfolio bundles a variety of different SOC application
- SOEC technology has progressed considerably within the last 3 years
- Low degradation rates where proven at cell and stack level
- Operation of the world-wide first pSOEC module will be started in the coming days
- Reversible SOC technology shows promising prospects for grid balancing with superior economics



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