

# Portable 100W power generator based on efficient planar SOFC technology

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10th CMCEE

CMCee

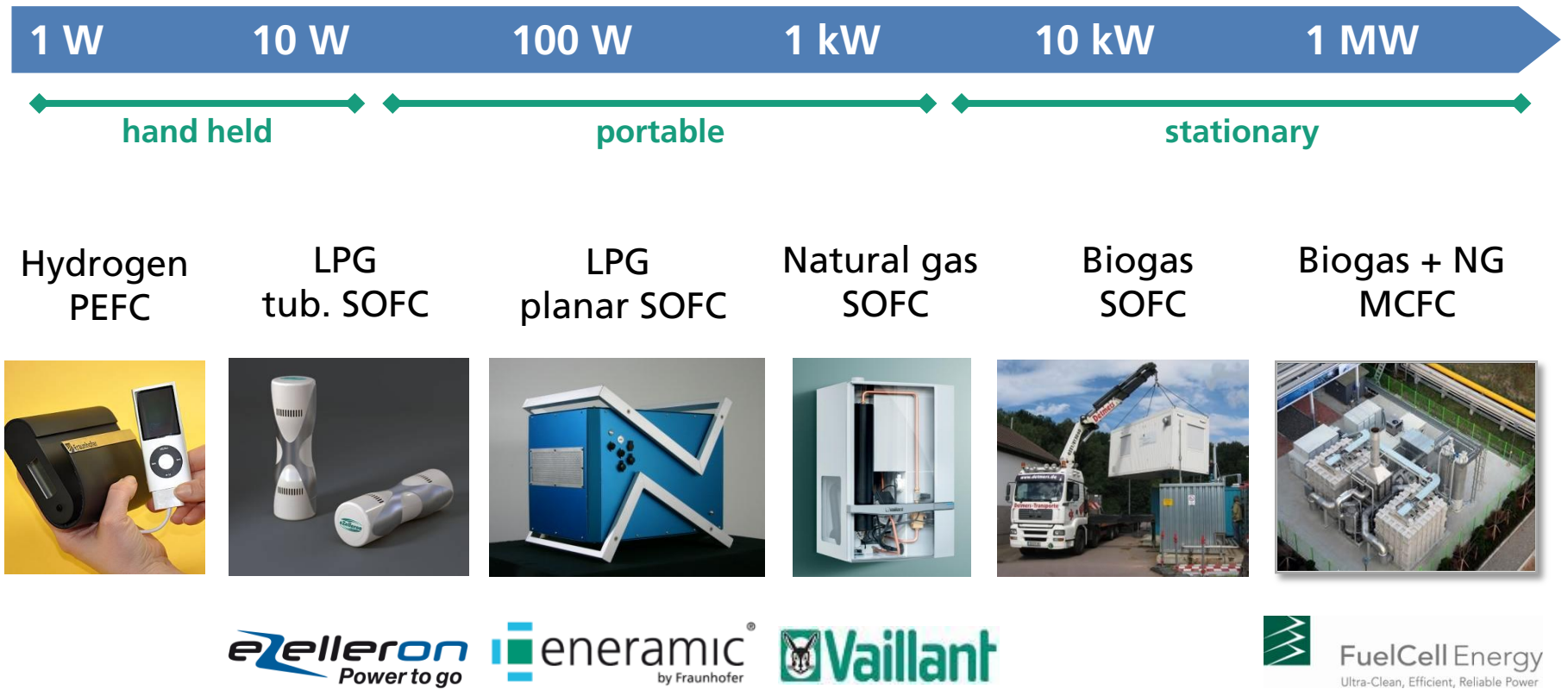
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# Fuel cell development

## Fraunhofer IKTS



# Outline

- Eneramic® specification
- Concept, design and testing
  - Stack
  - HotBox - core
  - Stand-alone system
- Progress / outlook



# Eneramic<sup>®</sup> – system

## Applications and requirements

Description	Design specification
Range of use	Industry, remote power supply, leisure
Technology	Fuel cell-battery-hybrid system
Operation	Fully automatic, immediately available
Nominal power	100 W <sub>net</sub> / 130 W <sub>gross</sub> @ 12V
Fuel	Propane, LPG, ethanol
Durability	10 years (approx. 3000 hrs & 300 cycles)
Weight / volume	< 10 kg / < 20 Litre
Costs	Competitive price (4500 – 7000 €)



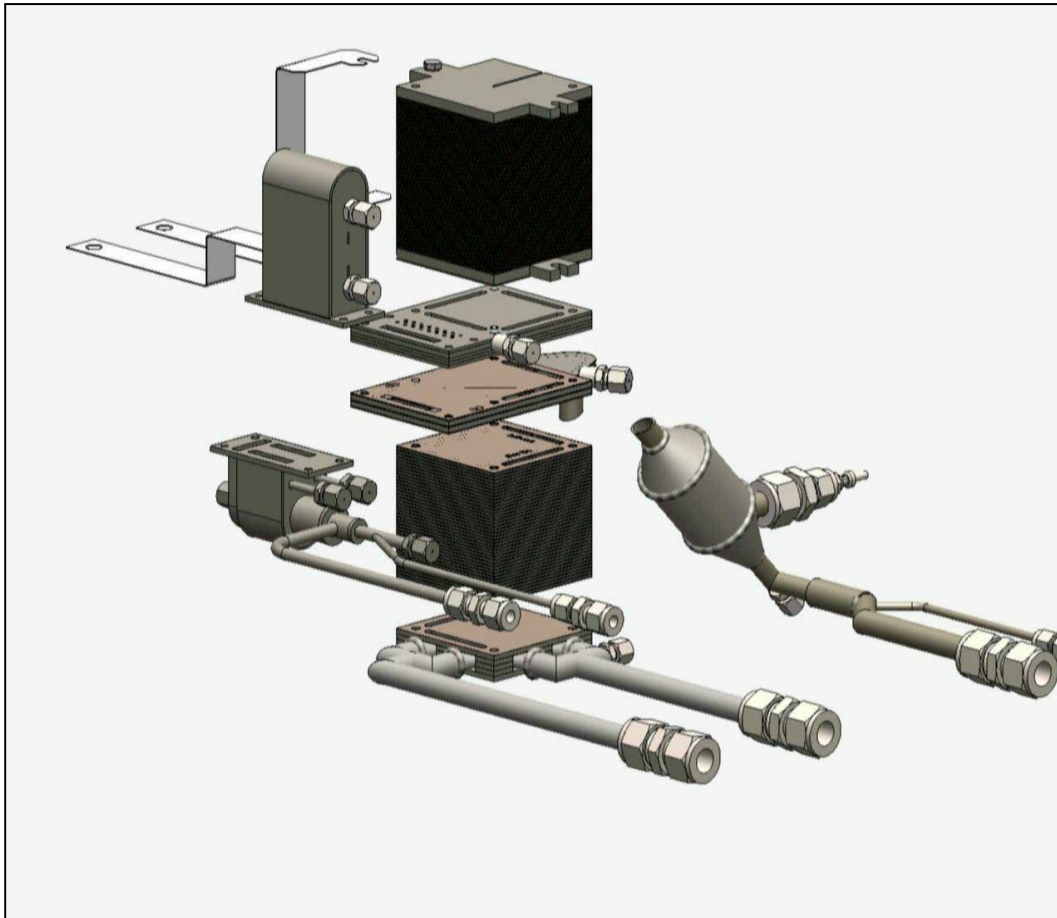
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# Eneramic<sup>®</sup> by Fraunhofer

## A) Stack design

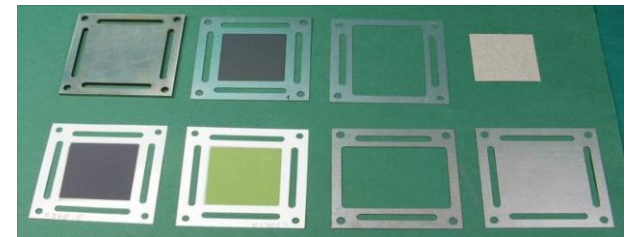


### Planar stack technology

- Crofer22APU interconnect
- 3YSZ based electrolyte supported cell
- $\text{SiO}_2\text{-Al}_2\text{O}_3\text{-BaO}$  sealing glass

### Cost effective fabrication

- Laser cutting
- Screen printing, dispensing



# Long-term stability at stack level

## Insulated 40-cell stack

40-cell stack | Ni/8YSZ  
 $H_2/N_2/H_2O = 48/48/4$ ,  
 $T_{stack} = 859^\circ C$ ,  $FU = 70\%$

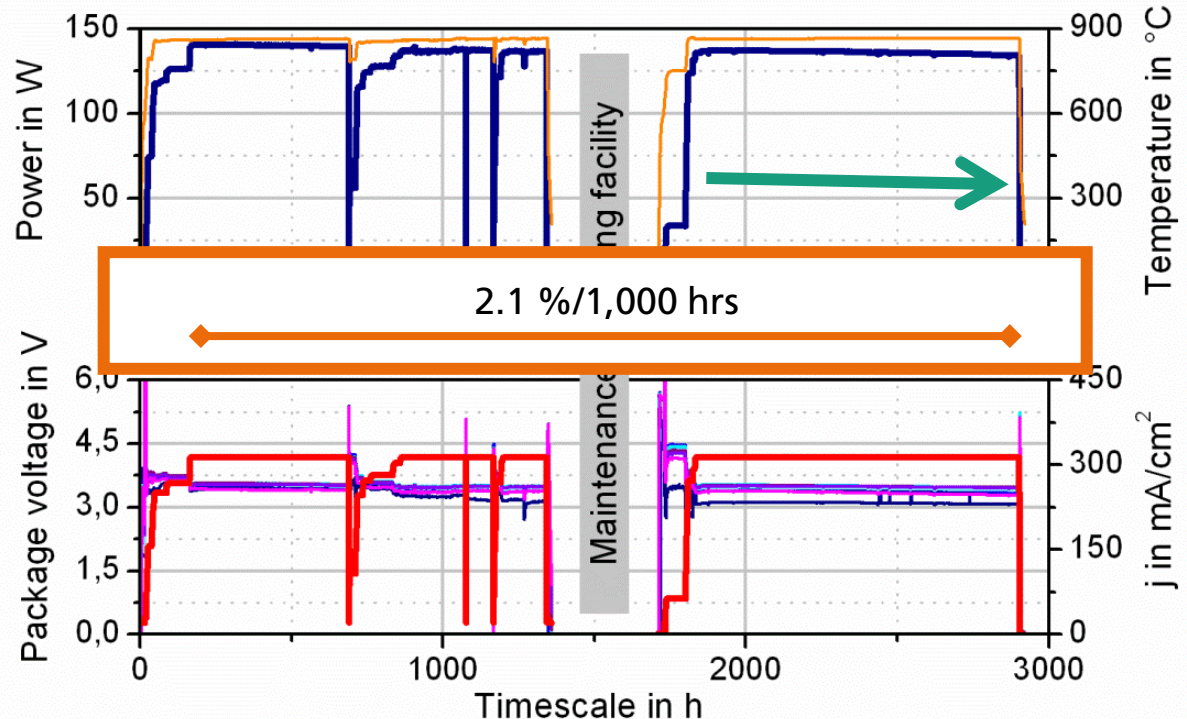
$$P_{max} = 140.2 \text{ W}$$

$$j = 312 \text{ mA cm}^{-2}$$

$$p_{grav.} = 100 \text{ W kg}^{-1}$$

$$p_{vol.} = 375 \text{ W litre}^{-1}$$

- After 2,200 hours and 4 cycles:  
 $P_{end} = 133.8 \text{ W}$
- Calculated overall power degradation  
 $\rightarrow 2.1\% / 1,000 \text{ h}$



Power output  $> 130 \text{ W}_{DC}$  is still enough to supply 100W for the user and the parasitic BoP components of the eneramic<sup>®</sup> system!

# Cyclability at stack level #1

## Thermal cycling of 40-cell stack

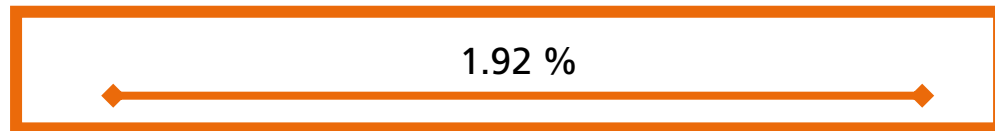
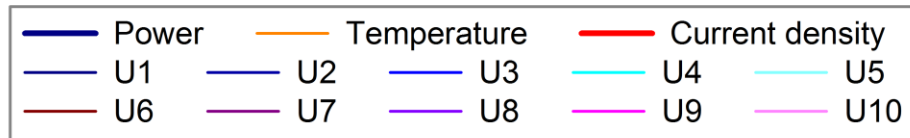
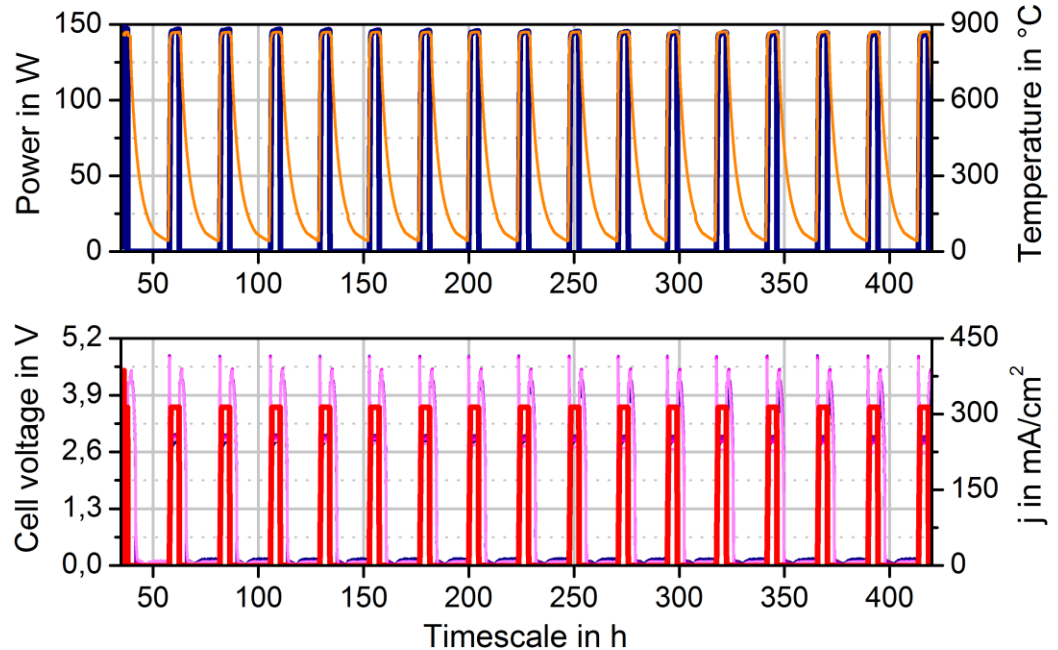
### Thermal cycles in furnace

$H_2/N_2/H_2O = 48/48/4$ ,

$T_{stack} = 840 - 859^\circ C$ ,  $FU = 70 \%$ ,

Stack heating rate 20 K/min

- $P_{start} = 147 \text{ W}$
- After 17 cycles:  
 $P_{end} = 143.9 \text{ W}$
- Cal. degradation  
< 0.11 % / cycle





# Cyclability at stack level #2

## System cycle of 40-cell stack

### System cycles in furnace

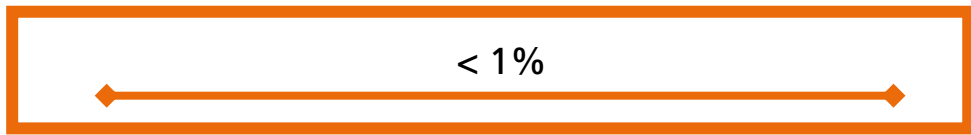
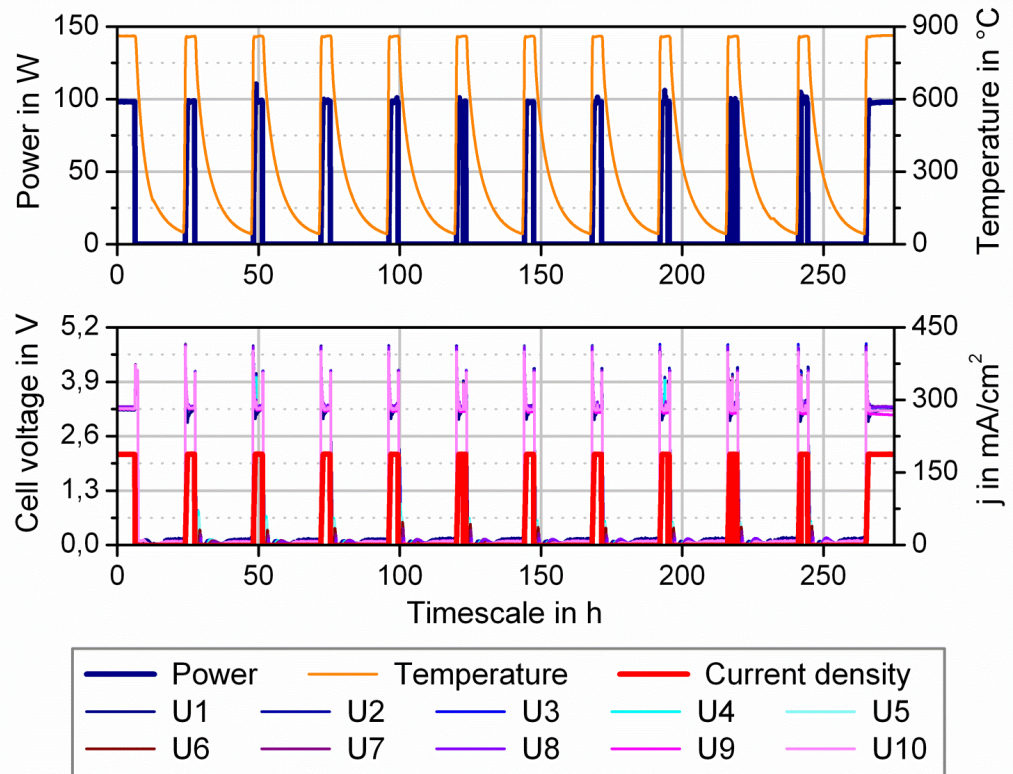
$H_2/N_2/H_2O = 48/48/4,$

$T_{stack} = 840 - 859^\circ C, FU = 70 \%,$

Stack heating rate 20 K/min

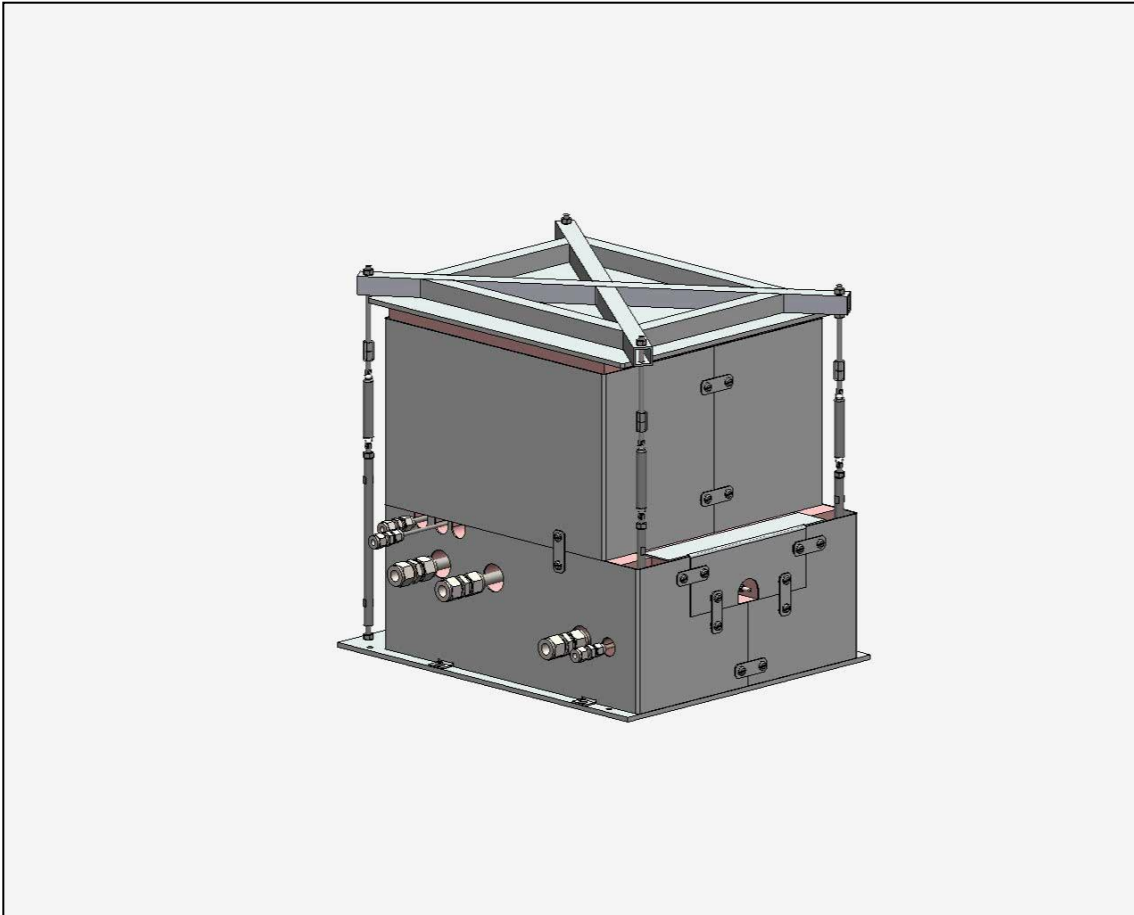
No inert gas on anode

- $P_{start} = 98.4 W$
- After 12 cycles:  
 $P_{end} = 97.7 W$
- Cal. degradation  
< 0.06 % / cycle
- Stacks ready for system integration and field testing
- Degradation due to cathode contact losses



# Eneramic® by Fraunhofer

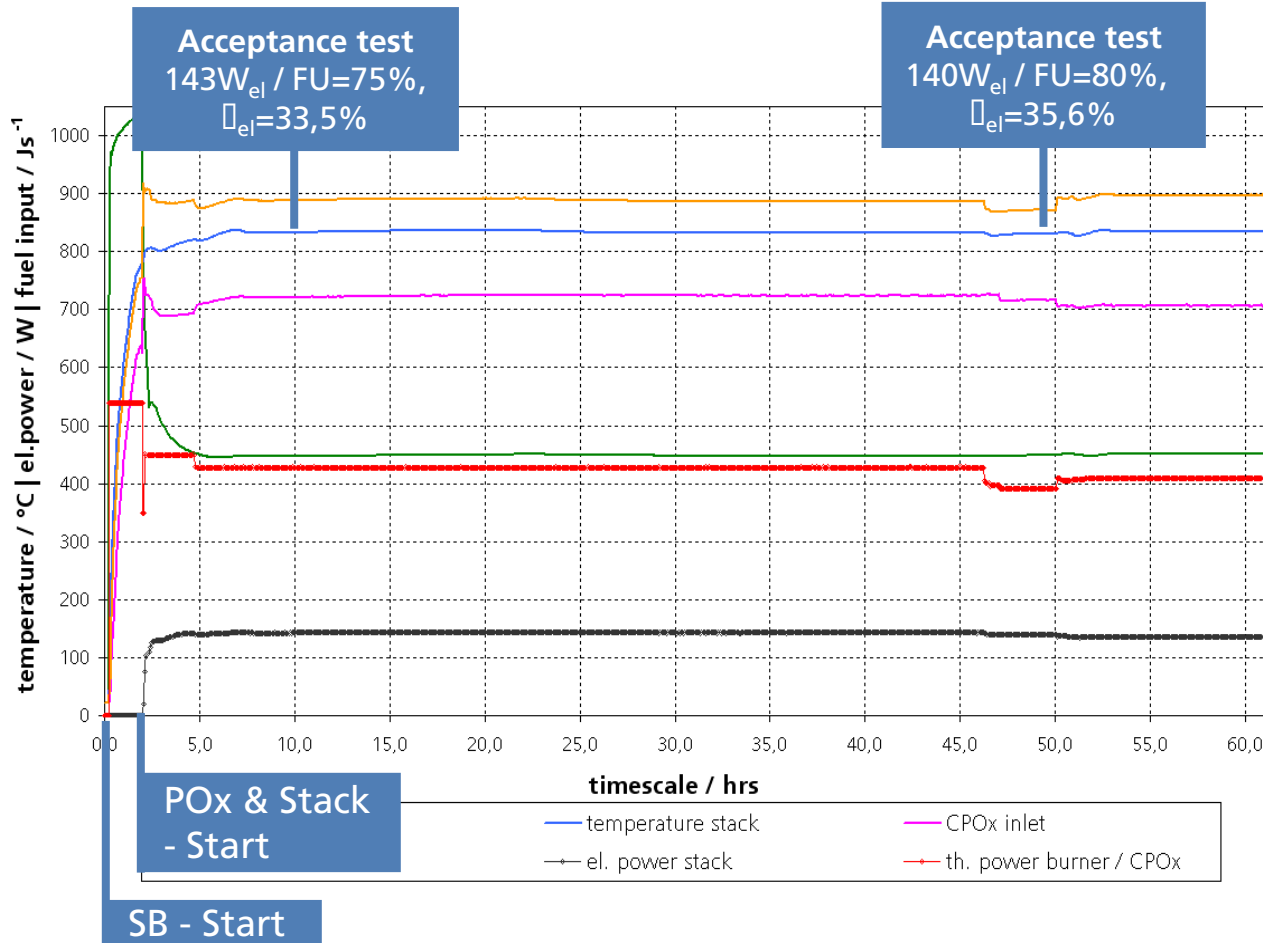
## B) HotBox-core and multilayer concept



- Compact system design
  - High thermal integration for maximum efficiency
- Robust system configuration
- Multilayer technology based design
- Integrated manifolds
- Reduction of piping and pressure losses
- Ease of fabrication

# Short term testing

## HotBox performance test



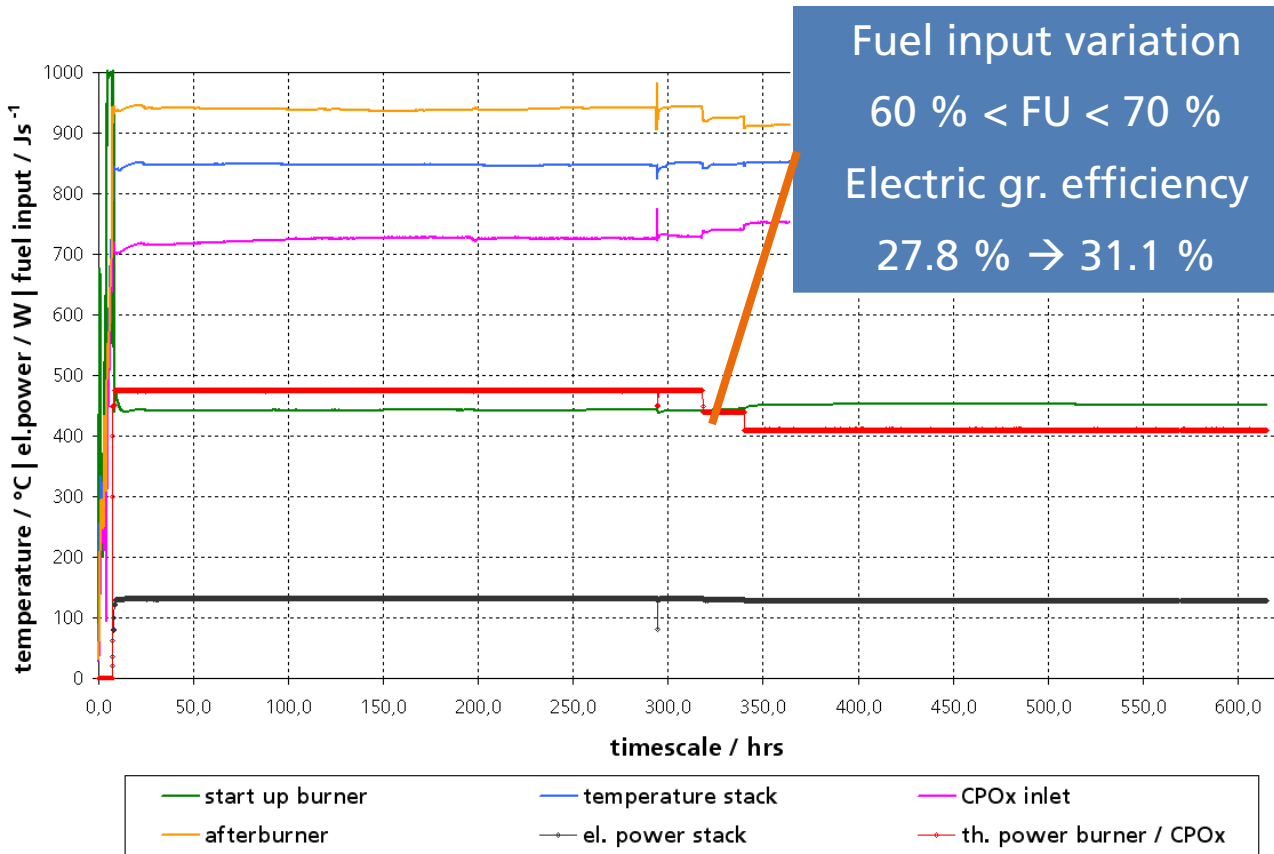
### Technical progress - 2<sup>nd</sup> HotBox prototype



- Improved gross efficiency (+3%)
- Reduced start-up time (-1 hr)
- Size reduction (-31%)

# Stationary testing

## 2<sup>nd</sup> HotBox generation



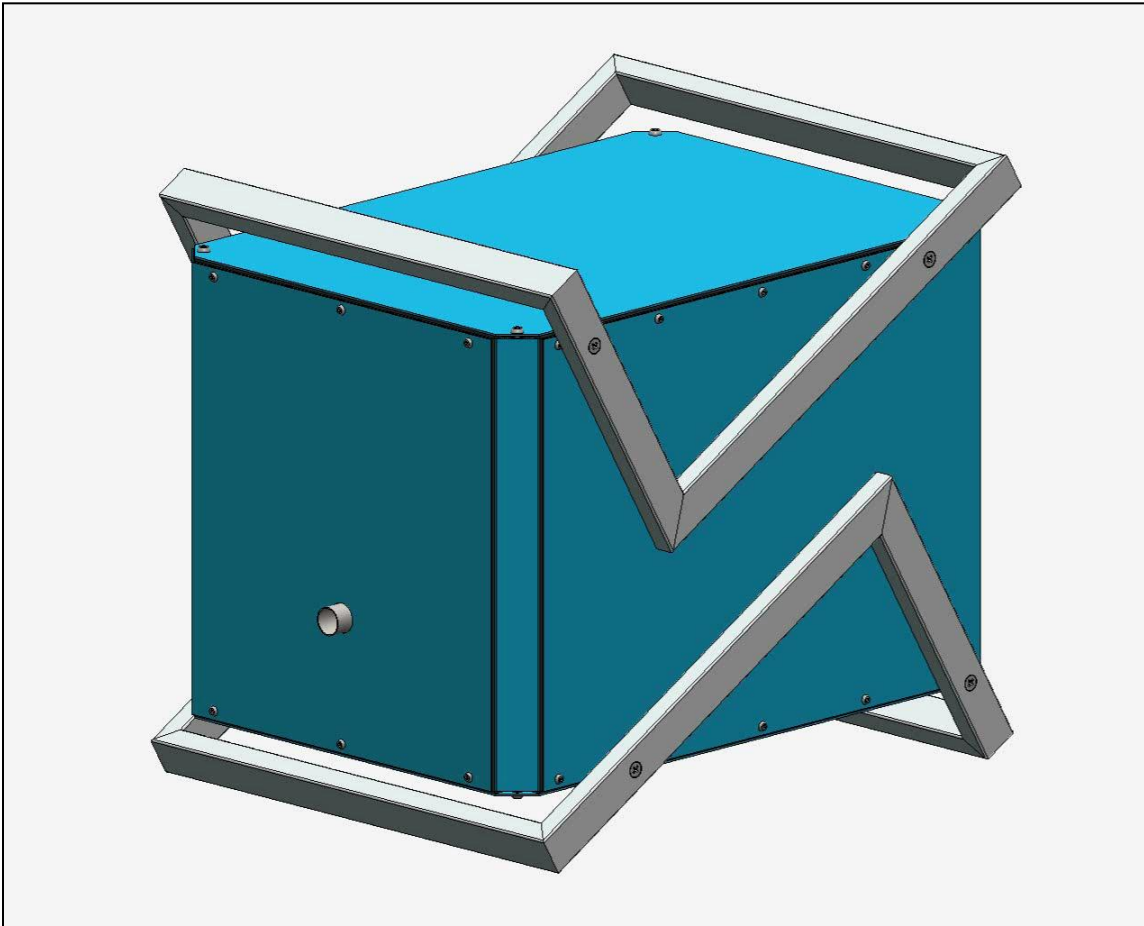
### Technical highlights

- Improved long term performance (<1% / 1000hrs)
- base case
- 1<sup>st</sup> HotBox (< 4% / 1000 hrs)



# eneramic® by Fraunhofer

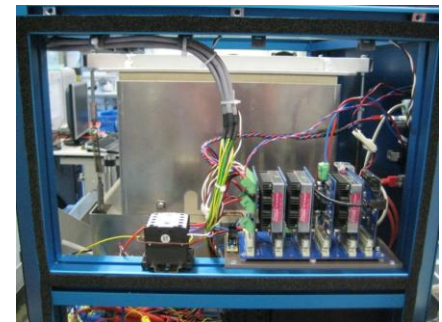
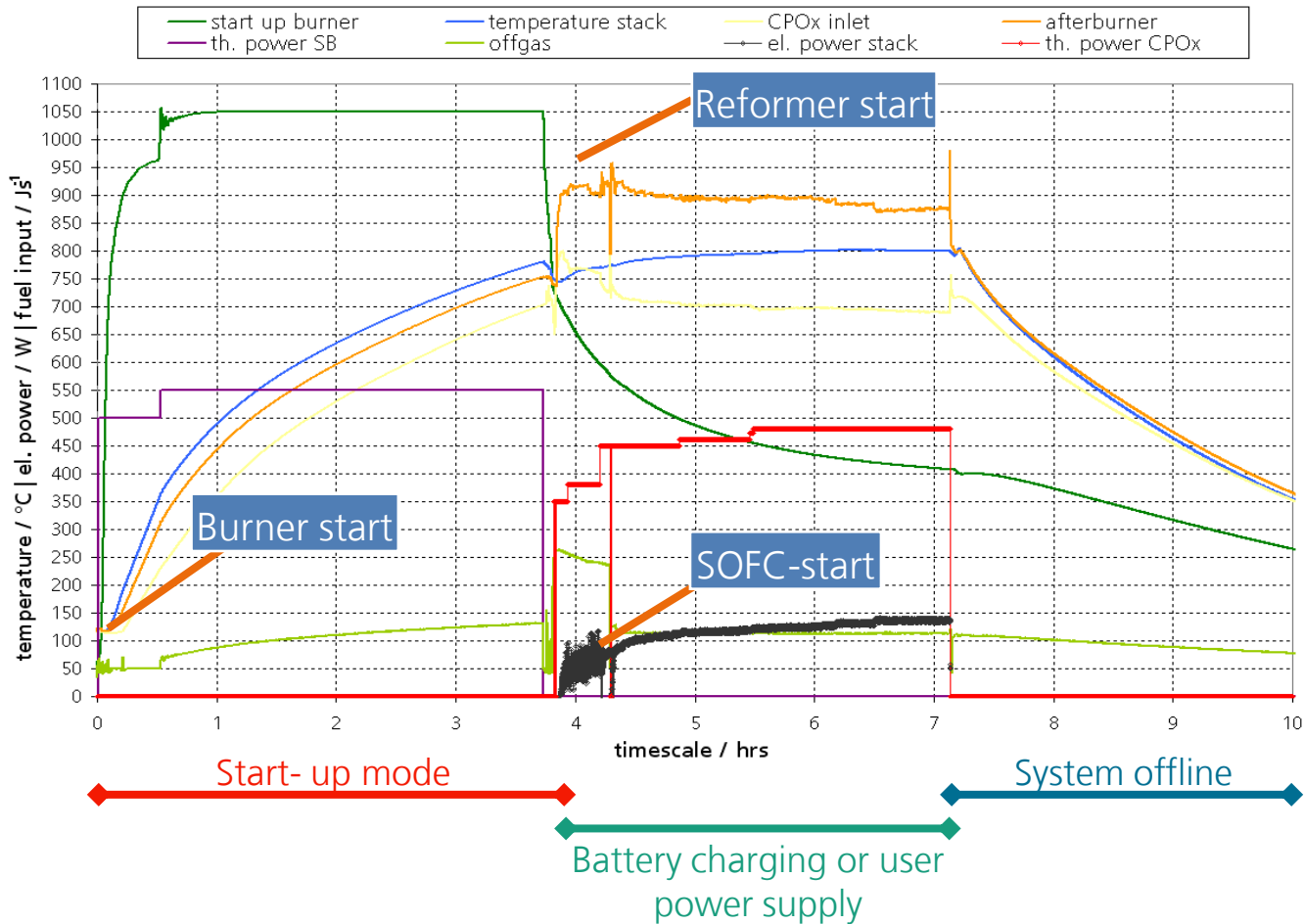
## C) Stand alone prototype



- Extremely simple process layout and component design
- External fuel supply
- Sulphur adsorber
- Exhaust gas cooling for safety reasons
- Commercially available blowers and valves
- In-house development of electronic system

# Eneramic<sup>®</sup> - stand alone prototype

## Operating cycle



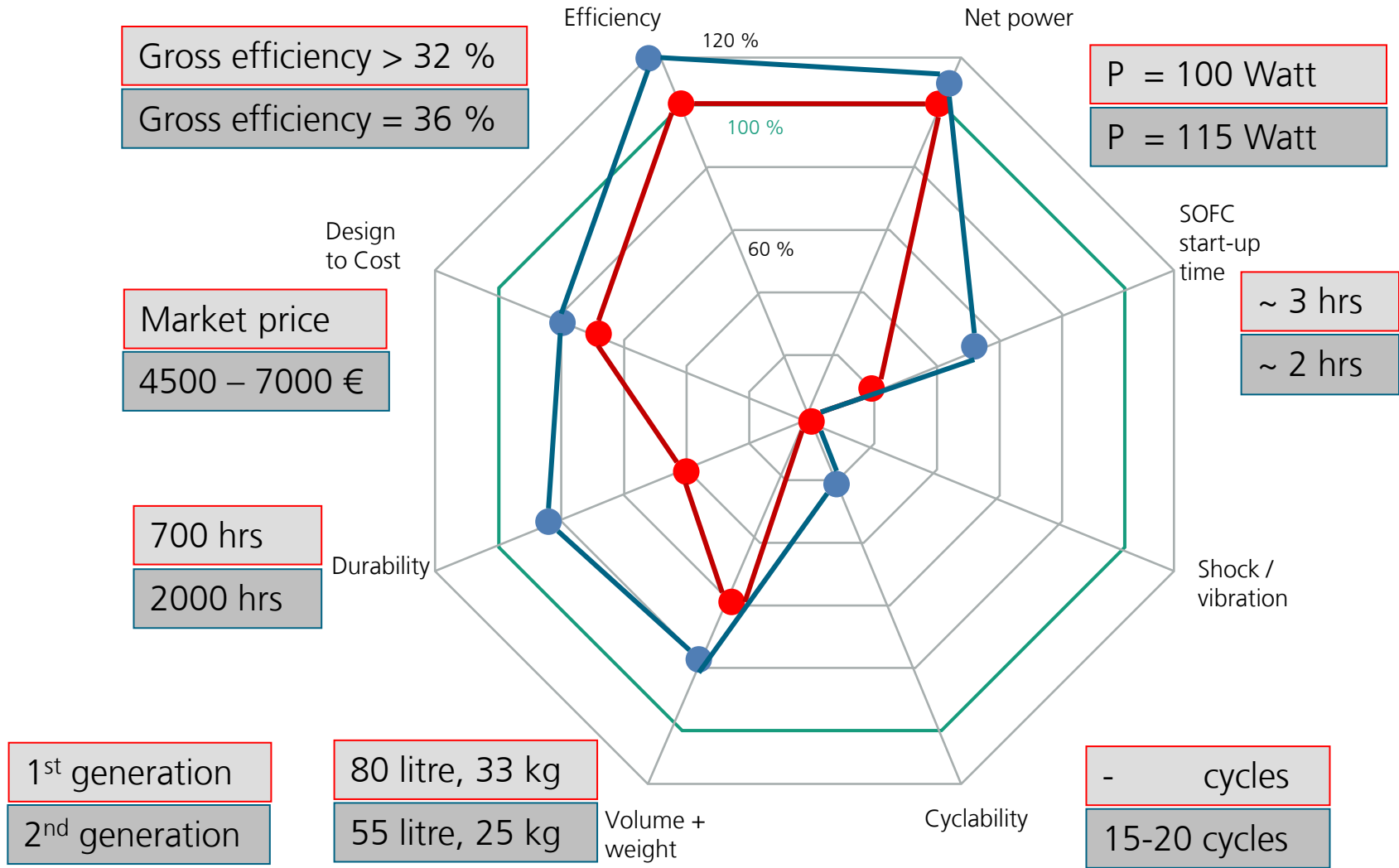
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# Progress and challenges

## From 1<sup>st</sup> to 2<sup>nd</sup> HotBox - generation





# eneramic<sup>®</sup> by Fraunhofer

## Next Steps

- Development of next prototype → remote power supply
- Field testing
- Optimization of start up time
- Further testing (cycling, long term stability, shock and vibration)

Fraunhofer currently investigates several options for commercialization (Spin-off, licensing, ...)

Thanks for financial support of *Fraunhofer future foundation*  
Stay tuned @ [www.eneramic.de](http://www.eneramic.de)

