Keramische Technologien und Systeme für die effiziente Energiewandlung und -speicherung

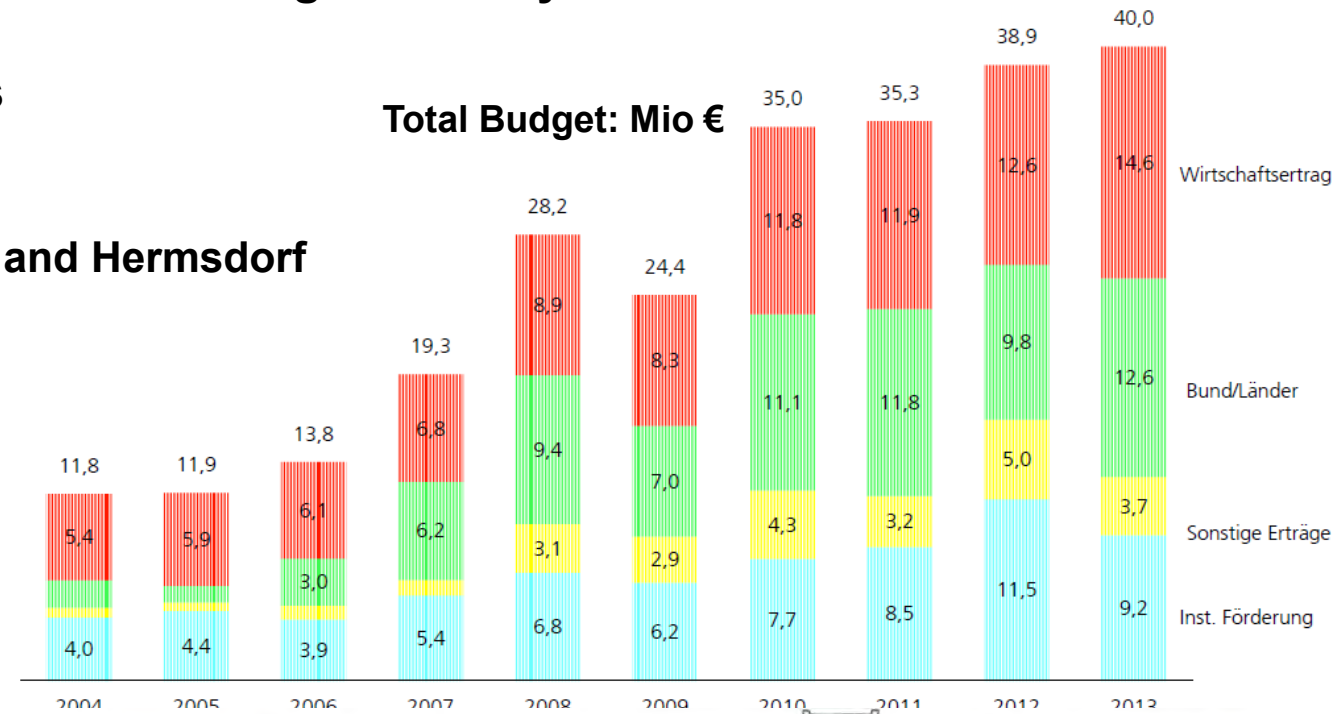
Institut für Keramische Technologien und Systems: IKTS

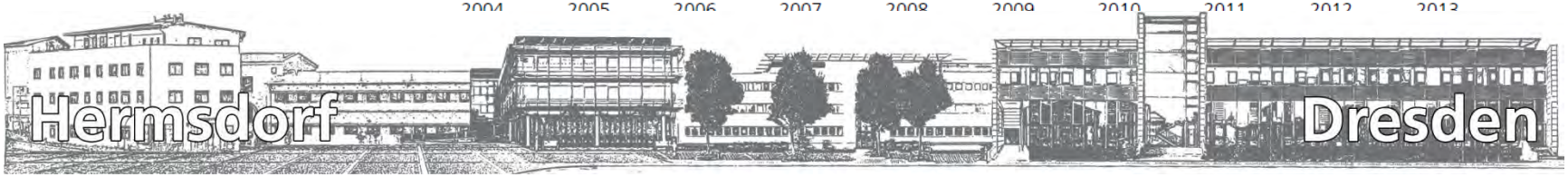
Alexander Michaelis

Main sites : **Dresden and Hermsdorf**

staff: **450**

Total Budget: Mio €



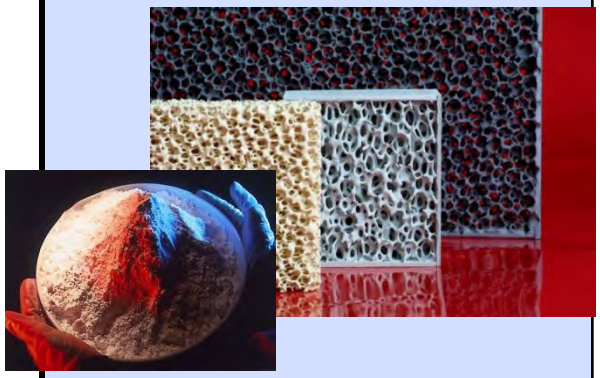


Fraunhofer IKTS

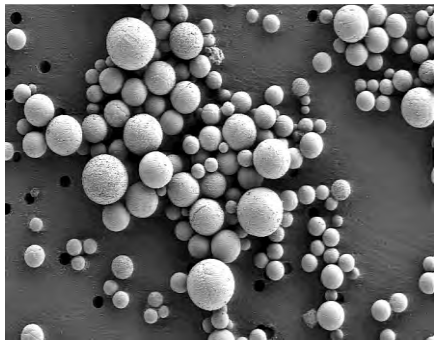
Core Competencies of IKTS

structural ceramics *functional ceramics*

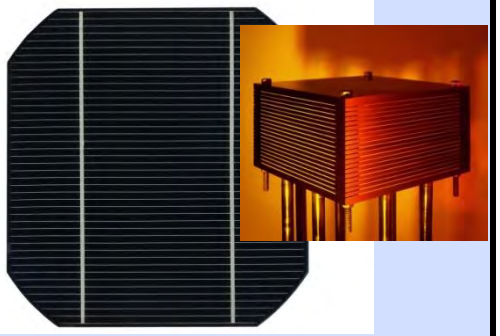
Ceramic Materials



Sintering / Characterization



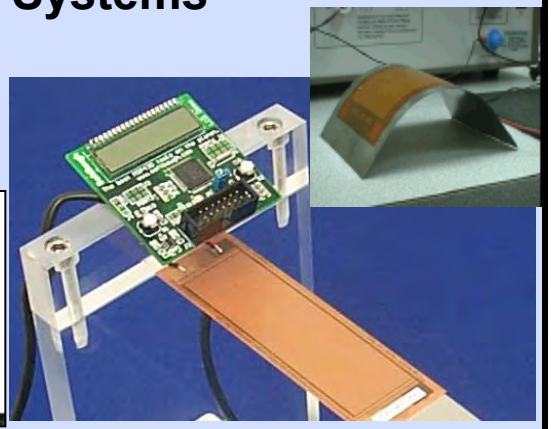
Micro- and Energy Systems



Processes / Components

Environmental Technologies

Smart Materials and Systems



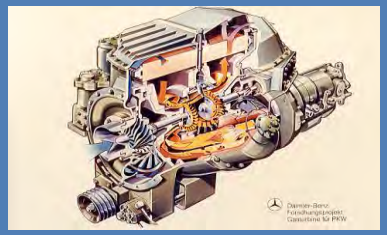
Fraunhofer IKTS

Smart Ceramic Materials for Energy and Environmental Technologies and Systems

LEHMANN Maschinenbau GmbH

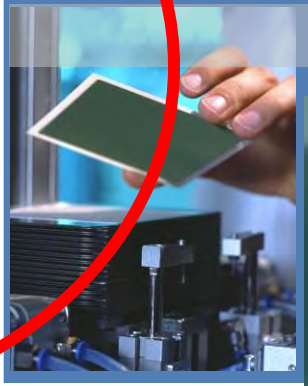
Bioenergie-Anwendungszentrum / Pöhl

Ceramics for combustion engines

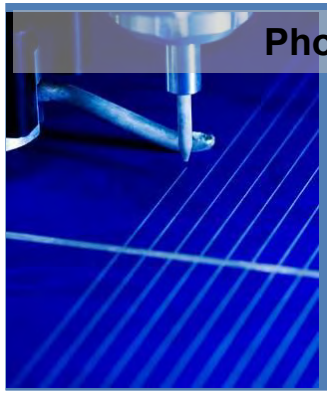


Membranes for Filtration / Bioenergy

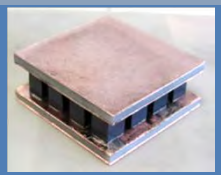
Fuel Cells

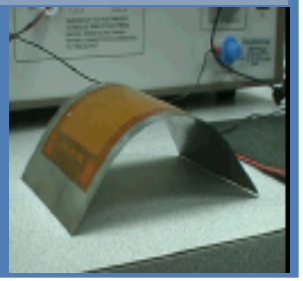


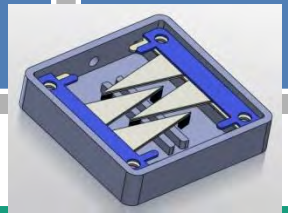
Photovoltaics



Energy Harvesting (Piezoceramics, TEG)







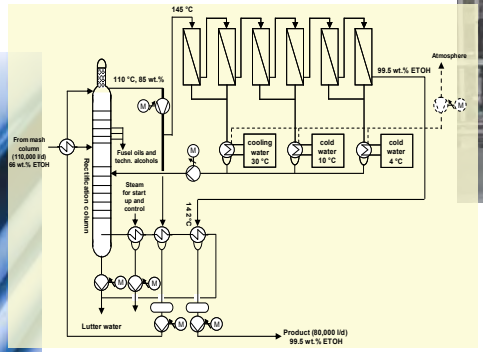
Storage Technology

- Li-Battery
- SuperCap
- Na-NiCl
- SOEC - (Electrolysis)

Fraunhofer IKTS

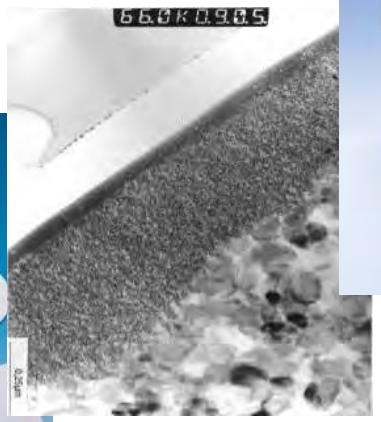
Ceramic Membrane Systems for liquid and gas filtration

system / plant

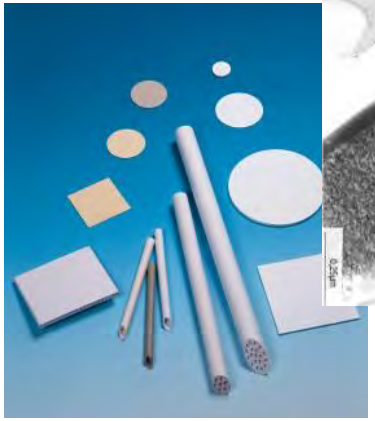


process

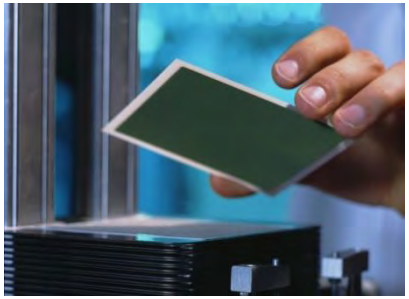
module



membrane



support



Formation of structural pores < 1 nm

Crystallographic cages/channels

GFT Membrane Systems GmbH

Lattice plane distances

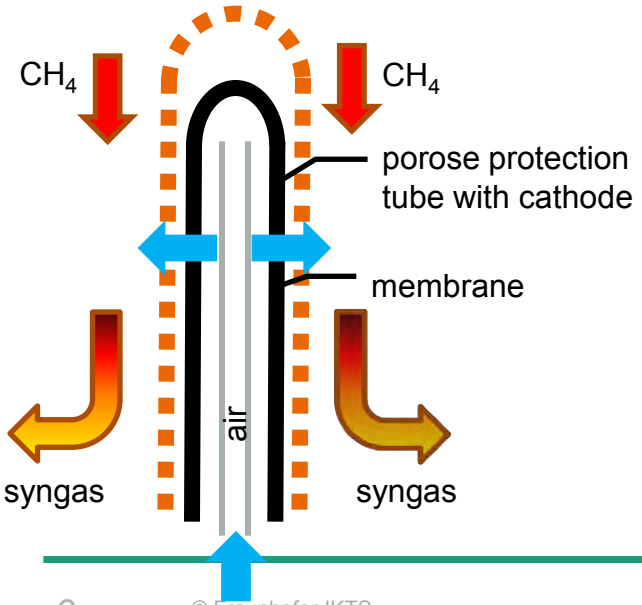
DBI GUT
Gas- und Umwelttechnik GmbH

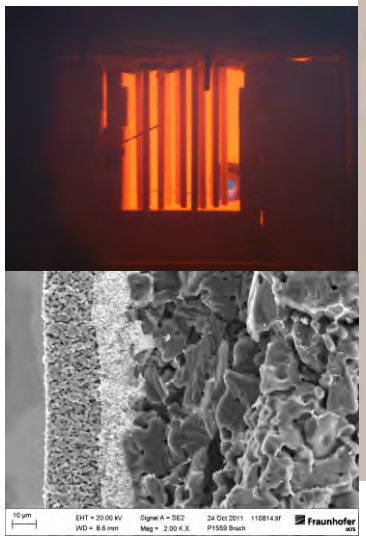
Crystallographic defects (vacancies)

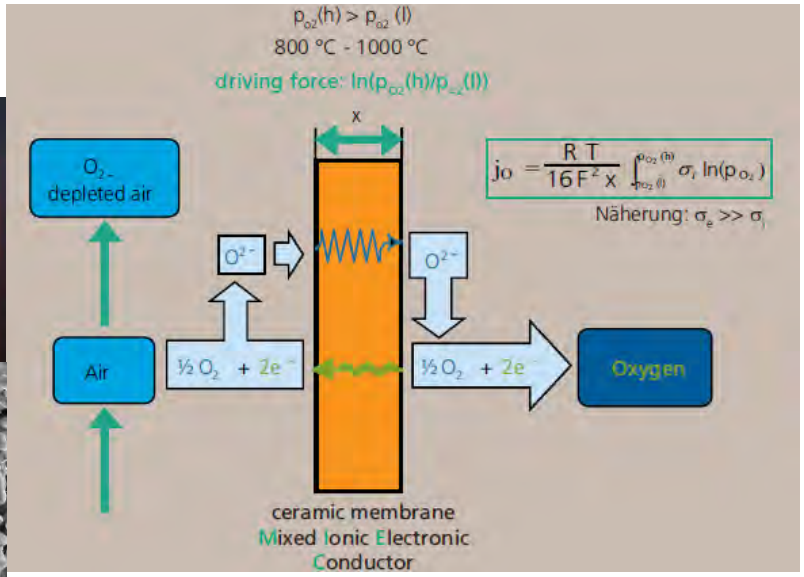
SVT
BFI VDEh-Betriebsforschungsinstitut GmbH
Institute for applied research

O_2 permeable membranes for combustion processes

- new long term stable materials
- high flux by the use of asymmetrical membranes







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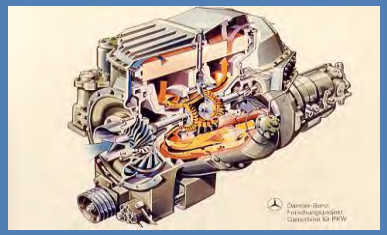
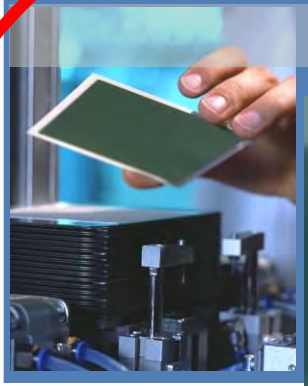


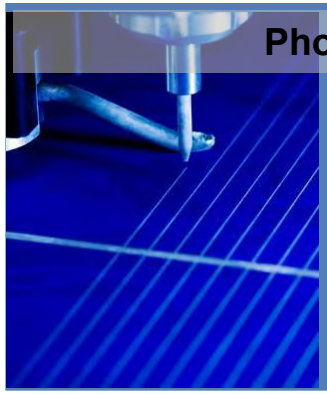
Membranes for Filtration / Bioenergy

Fuel Cells



Vaillant

Photovoltaics



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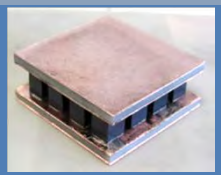
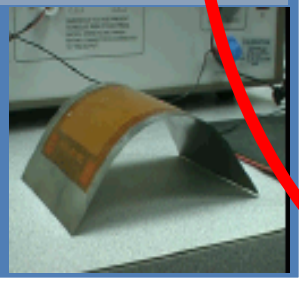
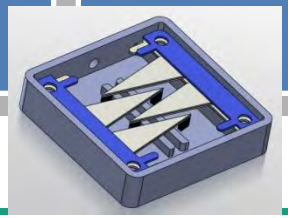




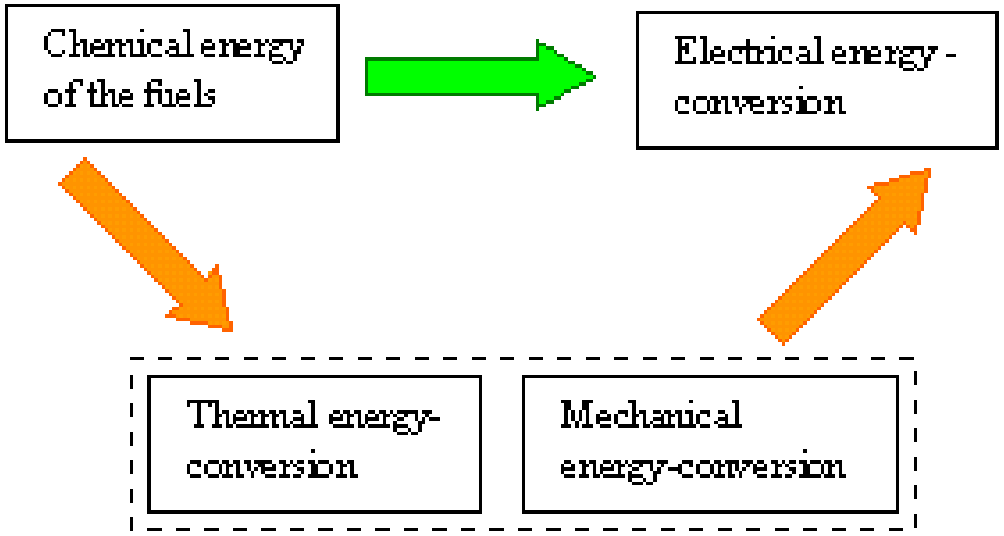


Storage Technology

- Li-Battery
- SuperCap
- Na-NiCl
- SOEC - (Electrolysis)

Fraunhofer IKTS

Brennstoffzellen

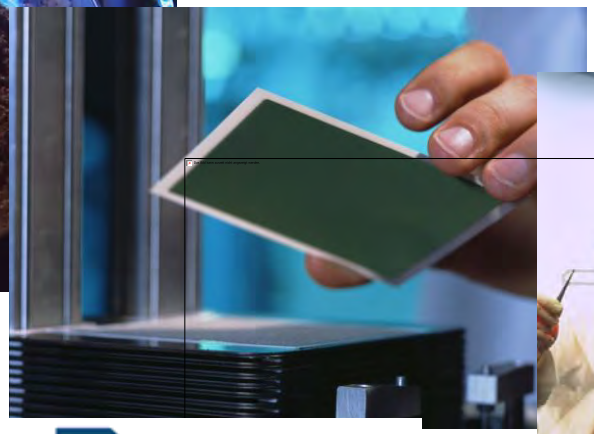


- → hocheffiziente Energiewandlung: elektrisch > 45 – 55%, KWK > 90 %
- → geringste Emmisionen
- → Grundlastfähig
- → Dezentral
- → Wartungsarm, hohe Verfügbarkeit

Solid Oxide Fuel Cell (SOFC) value chain

Material

MEA

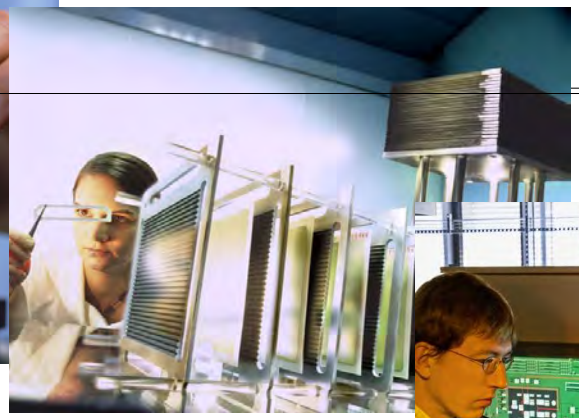


ENrG Inc.

www. enrg-inc.com

Stack

PLANSEE



System

- **Take over of Siemens AG planar SOFC Technology including IP and some assets in 1998**

Fraunhofer IKTS

Fuel Cell Systems developed at IKTS

1 W	10 W	100 W	1 kW	10 kW	1MW
Hand held		portable		stationary	

eZelleron Power to go

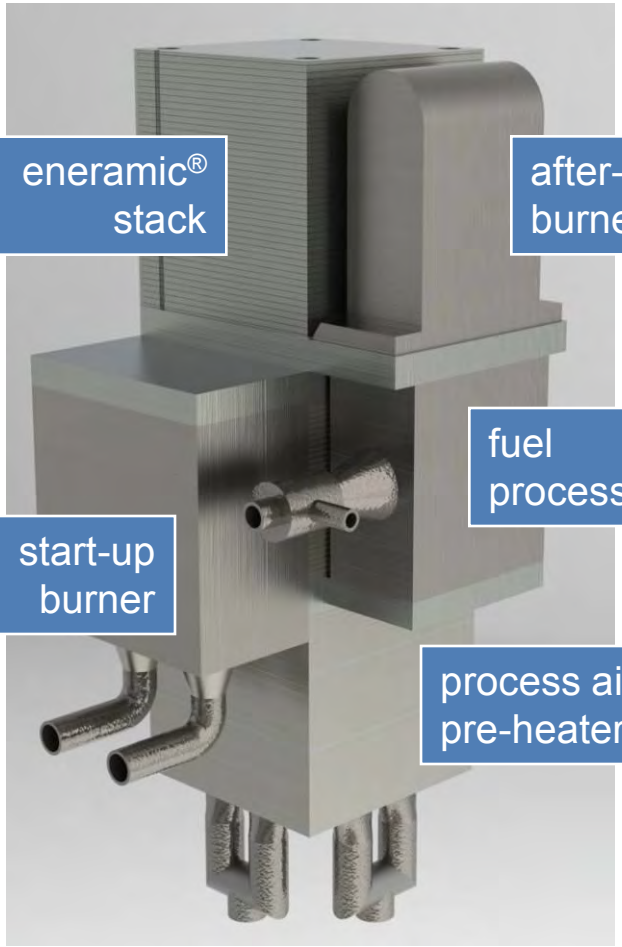
eneramic by Fraunhofer

Vaillant

FuelCell Energy
Ultra-Clean, Efficient, Reliable Power

Hydrogen PEFC	Tubular SOFC	LPG SOFC	Natural gas SOFC	Biogas SOFC	Biogas + NG MCFC

eneramic® DESIGN OPTIONS AND ADVANCED SYSTEM CONCEPTS



→ Portable SOFC system based on ceramic components and multilayer technologies

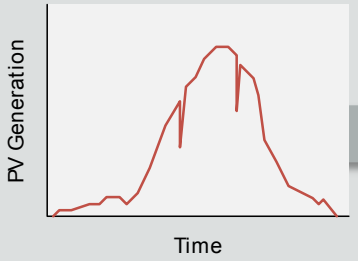
eneramic® by Fraunhofer

Fraunhofer IKTS

Advanced System Concepts → „Range Extender“ for stationary (and mobile) systems

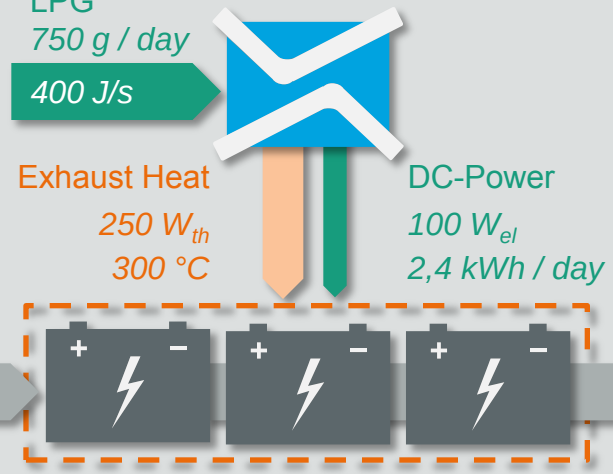
PV Module / Wind Turbine

P_{Peak} = 7,5 kW [1]
Capacity Factor: 25 %[1]
≈ 45 kWh / day



High-Temperature Battery Storage

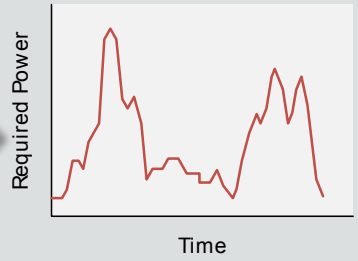
557 V / 64 Ah / 35,7 kWh [2]



Na/NiCl-Battery maintained at 270 °C

Application

$P_{Average}$ ≈ 2 kW [3]
≈ 48 kWh / day



- Application Examples:
  Remote Surveillance Systems, Telecom Sites, Weather Stations, Irrigation Systems

[1] indicative values for small PV systems in Europe; [2] example data of a ZEBRA Z12 Telecom Battery
[3] indicative values for typical cell site power consumption

Fraunhofer IKTS

Fuel Cell Systems developed at IKTS

1 W	10 W	100 W	1 kW	10 kW	1MW
Hand held			portable		stationary

eZelleron Power to go

eneramic by Fraunhofer

Vaillant

FuelCell Energy
Ultra-Clean, Efficient, Reliable Power

Hydrogen PEFC	Tubular SOFC	LPG SOFC	Natural gas SOFC	Biogas SOFC	Biogas + NG MCFC

IKTS has put systems in the field

Vaillant mCHP system
Complete system design of the world‘s first wall-hanging fuel cell based micro co-generator (Europe‘s largest heating applicance manufacturer)

Bio-Gas fuel cell

Complete design and assembly of a kW-class fuel cell running on biogas.

The IKTS fuel cell was put in a container and tested on-site at a biogas plant for one complete summer.

→ **SOEC** Tests ongoin g

Fuel Cell Systems developed at IKTS

1 W	10 W	100 W	1 kW	10 kW	1MW
Hand held			portable		stationary

eZelleron Power to go

eneramic by Fraunhofer

Vaillant

FuelCell Energy Ultra-Clean, Efficient, Reliable Power

Hydrogen PEFC	Tubular SOFC	LPG SOFC	Natural gas SOFC	Biogas SOFC	Biogas + NG MCFC

FCES GmbH

- Joint Venture (Operativer Betrieb seit 05/2012):

Fraunhofer IKTS

- Lizenzen für Patente und Anlagevermögen der MTU Onsite GmbH
- Je ca. 150 ExpertInnen für Brennstoffzellen-Technologie und keramische Werkstoffe, Pulver, Pasten
- 25% Anteile

FuelCell Energy
Ultra-Clean, Efficient, Reliable Power

- Lizenzen für Patente und 20 Jahre Produktions-Know-how
- MCF-Zellen
- Ca. 250 ExpertInnen für Brennstoffzellen-Technologie
- 75% Anteile

FuelCell Energy Solutions
Saubere, effiziente, zuverlässige Energie

Nutzpotential

Preiswerte Materialien
und Fertigungsprozesse

20 Jahre Betrieb

Erdgas

Nutzung bestehender
Infrastruktur
und von
Abfallstoffen

Biogas
aus:

- Kläranlagen
- Lebensmittelerzeugung
- Deponien
- Biomasse

Strom

- > 47 % Wirkungsgrad
- > 95 % Verfügbarkeit

Wärme

- Hochtemperatur-wärme: Zweistufige Auskopplung möglich
- Ca. 400 °C und 85-90 °c

Kälte

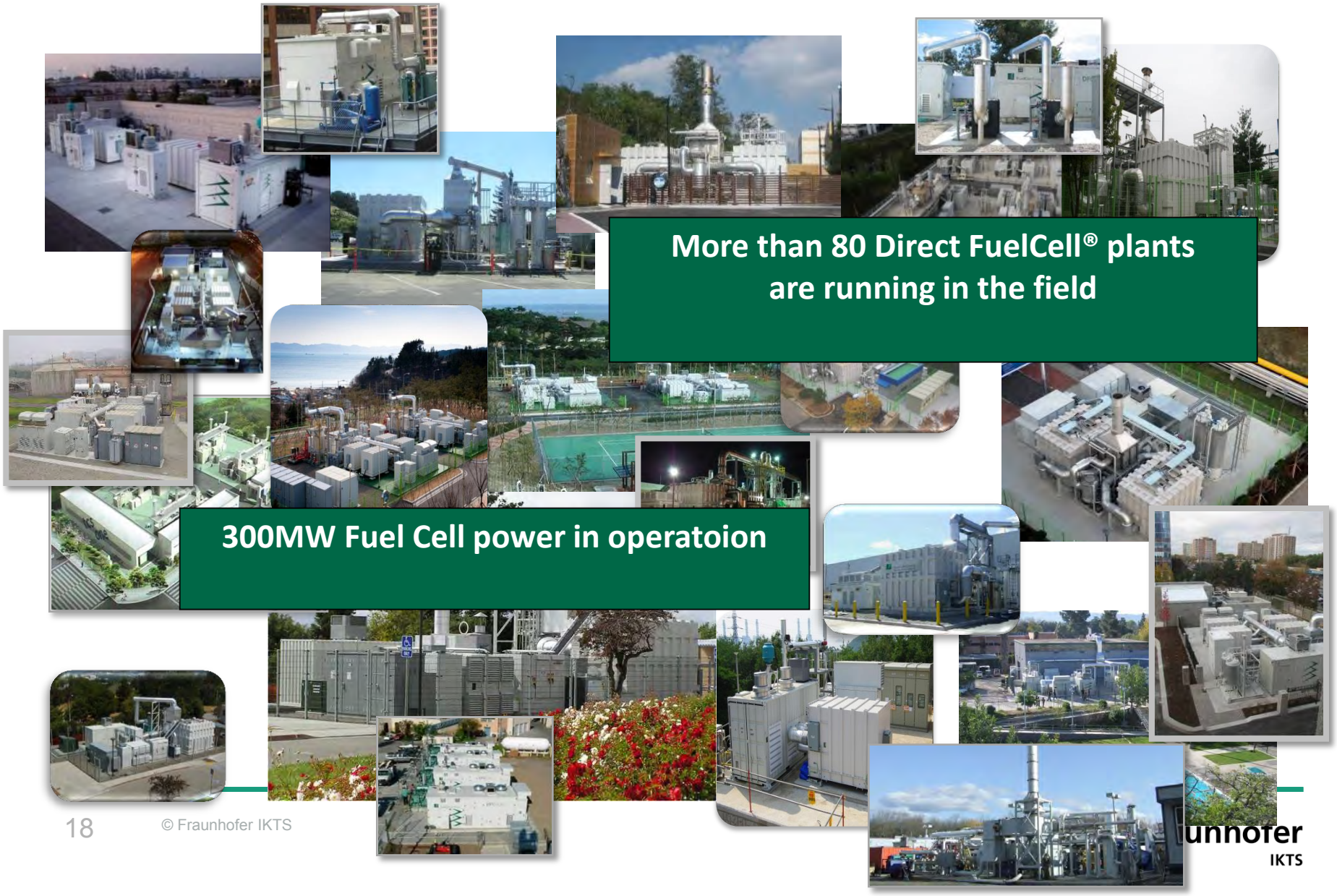
- Ab- oder Adsorbtionskälte-maschinen
- Klassische Wärmetauscher

H2

- Wasserstofftankstelle

+ Geräuscharm
+ Vibrationsfrei
+ Emissionsarm
(low CO2, nahezu no SOx, no NOx)

MCFC: Market proven!



Anwendungsbeispiele

Erdgas

1.4 MW Kraftwerk einer Universität

2.8 MW Kraftwerk einer med. Einrichtung

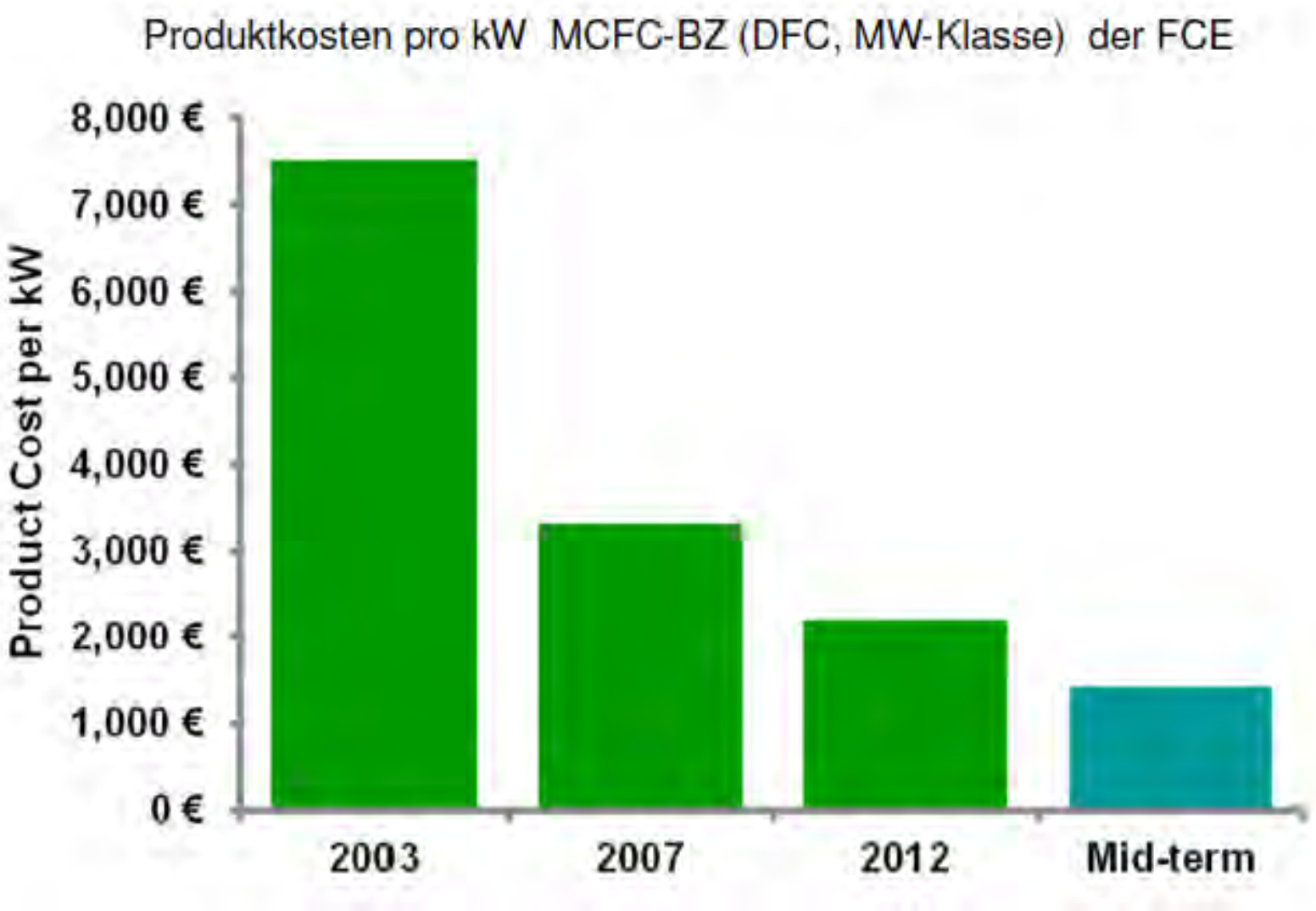
2.4 MW Kraftwerk eines Energieproduzenten

Biogas

600 kW Kraftwerk eines Lebensmittelproduzenten

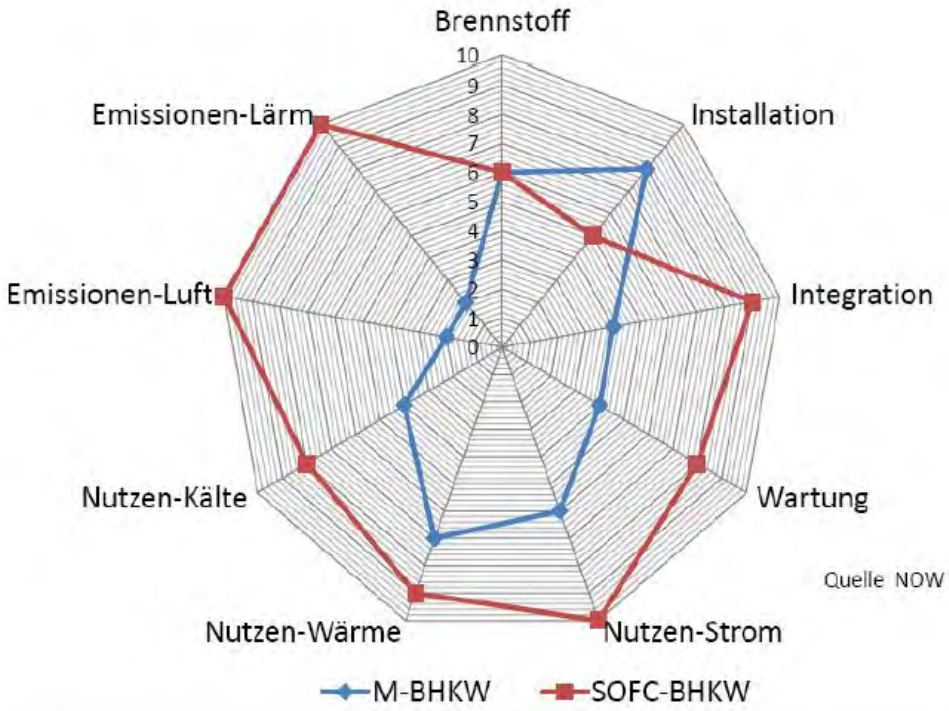
900 kW Kraftwerk eines Klärwerks

2.8 MW Kraftwerk eines Klärwerks



Stationäre Anwendungen

→ SOEC ?! (Holy grail)



Quelle NOW

Kombinierte Anlagen erreichen 65-75%
Elektrischen Wirkungsgrad

Effizienteste Dezentrale Verstromung von Erd- und Biogas

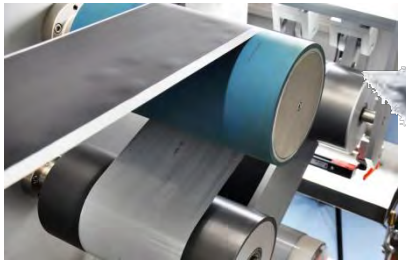
Fraunhofer IKTS

Storage technology at IKTS: NaS, NaNiCl
Li-Ion Battery → value chain / technology line

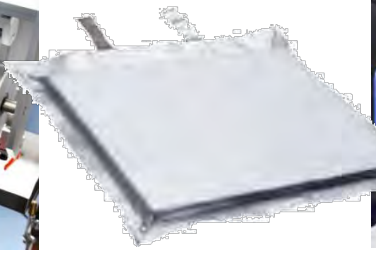
Powder processing → Slurry mixing → Electrode manufacturing → Cell assembly + packaging → Cell testing

- Powder synthesis and processing
- Methods for analysis and optimization of thermal process
- Methods for characterization of powders (FESEM, XRD; Raman; thermal properties; particle size)

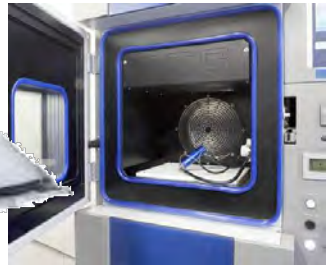
- Development of an adapted slip compositions for the coating process
- Sophisticated methods of slurry characterization and optimization



- Efficient methods for slurry mixing
- Development of technologies for coating of electrode films



- Material and electrode characterization
- Sophisticated spectro-electrochemical characterization (impedance, Raman,…)



- Electrical and thermal characterization of commercial cells
- Stationary and dynamic modeling of battery cell performance

Material development

Powder processing | Slurry mixing | Electrode manufacturing | Cell assembly + packaging

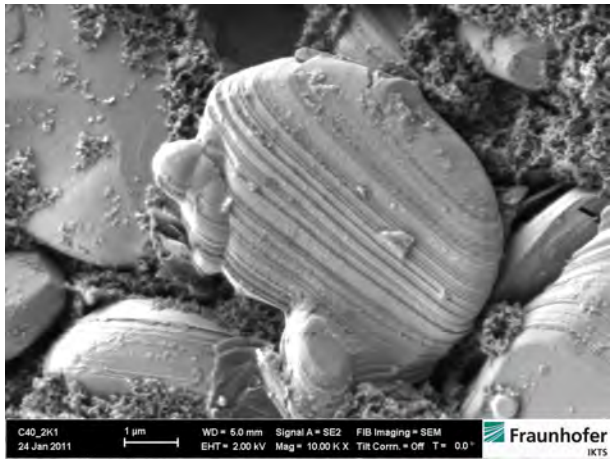
Active materials for lithium ion battery electrodes

- Cathode materials

$LiCoO_2$ (LCO),
$LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$ (NCA),
$LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ (NCM),
$LiMn_2O_4$ (LMO),
$LiFePO_4$ (LFP)

- Anode materials

graphite modifications (commercial supplier)

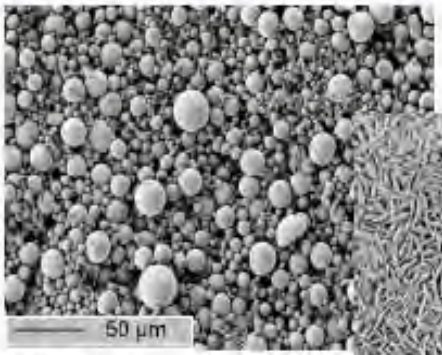


$LiCoO_2$ cathode

- Pretreatment of the raw material powders to enhance battery performance

  e.g. electrode conductivity, energy density and cycle life

Core Competency – Design of Spherical Particles

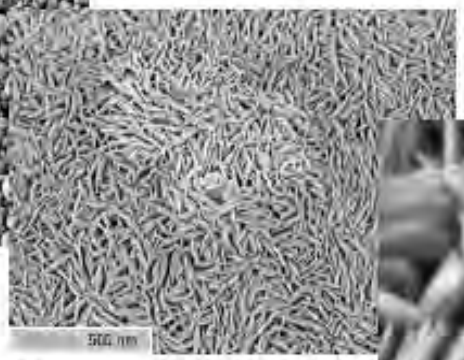


Makro-,

- *Particle Size*
- *Particle Shape*
- *Particle Size Distribution (PSD)*

...

Tap density
Capacity
Processing



Meso-,

- *Grain Size*
- *Grain Shape*
- *Porosity*

...

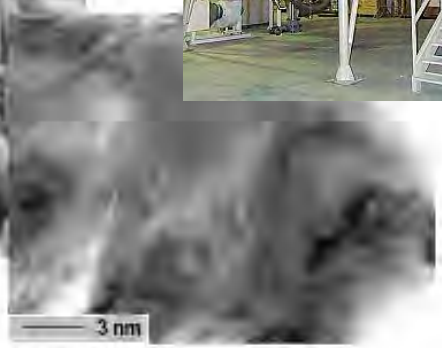
Discharge current
Cycle stabilty

Micro-,

- *Crystal Structure*
- *Crystallite Size*
- *Crystallite Shape*

...

Power density
Life time



Atomic Structure

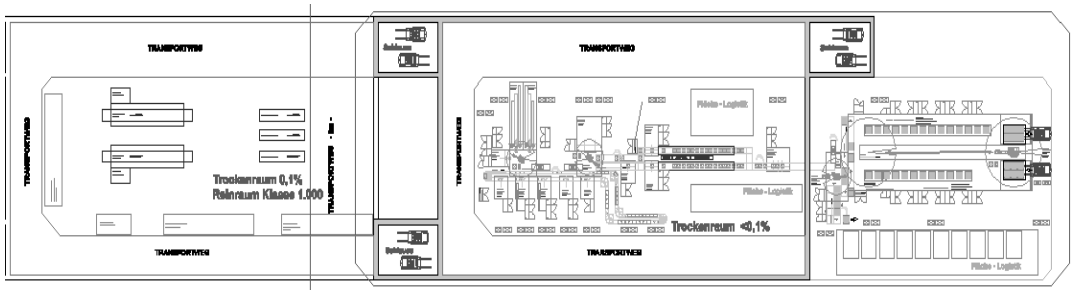
- *Vacancies, Interstitials*
- *Dislocations*
- *Stacking faults*

...

Safety

Efficient manufacturing methods for high-performance lithium ion batteries: From Lab. to Fab.

- **Pilot scale production of Li-Ion-Batteries**

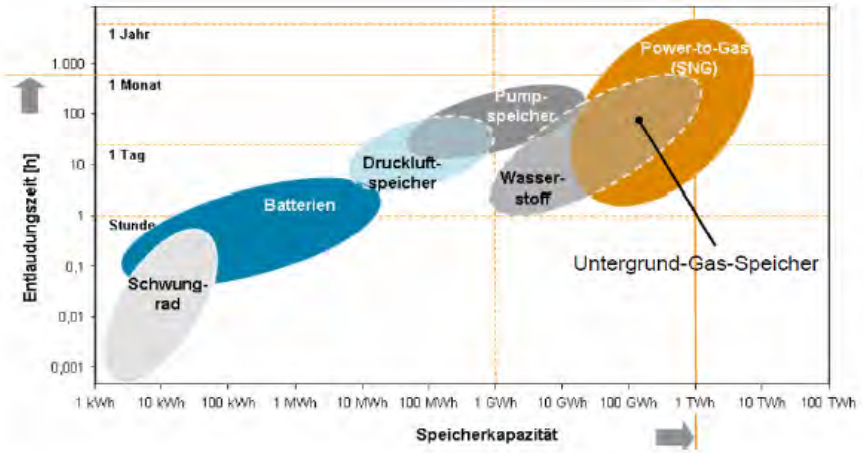


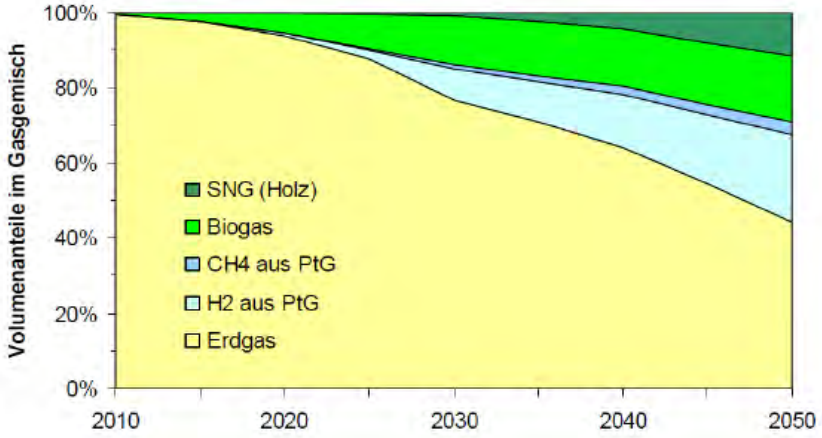
- Development of optimized manufacturing methods along the entire value chain of lithium ion cell production
- Manufacturing methods for high-performance lithium ion battery cells with a target price of 300 €/kWh

Slurry mixing → Electrode manufacturing → Cell assembly + packaging → Cell testing → Battery assembly

ThyssenKrupp System Engineering · KMS TECHNOLOGYCENTER · AWEBA Werkzeugbau GmbH Aue · Fraunhofer IKTS

Energiewirtschaftliche Bedeutung - Speicherung

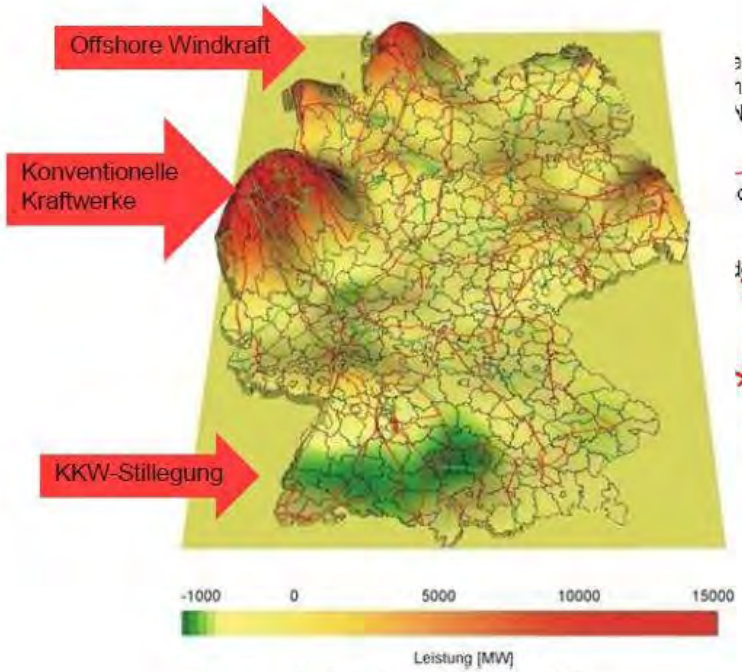


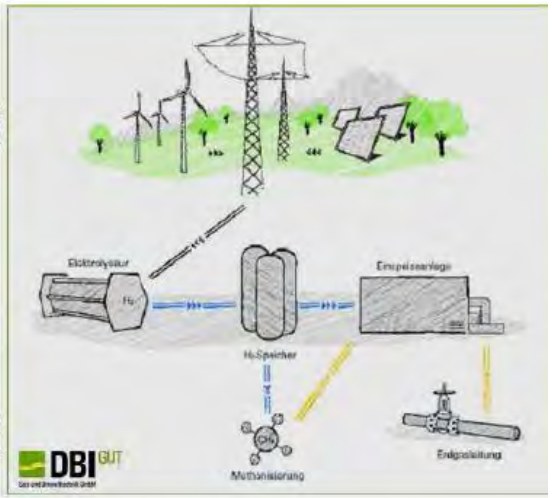


Das existierende Erdgasnetz ist das Kernelement zur Speicherung erneuerbarer Energien

→ Brennstoffzellen erforderlich zur regenerativen Gaserzeugung sowie umweltgerechter Energiewandlung aus Gas (Elektrolyse, SOEC)

Energiewirtschaftliche Bedeutung - Netze



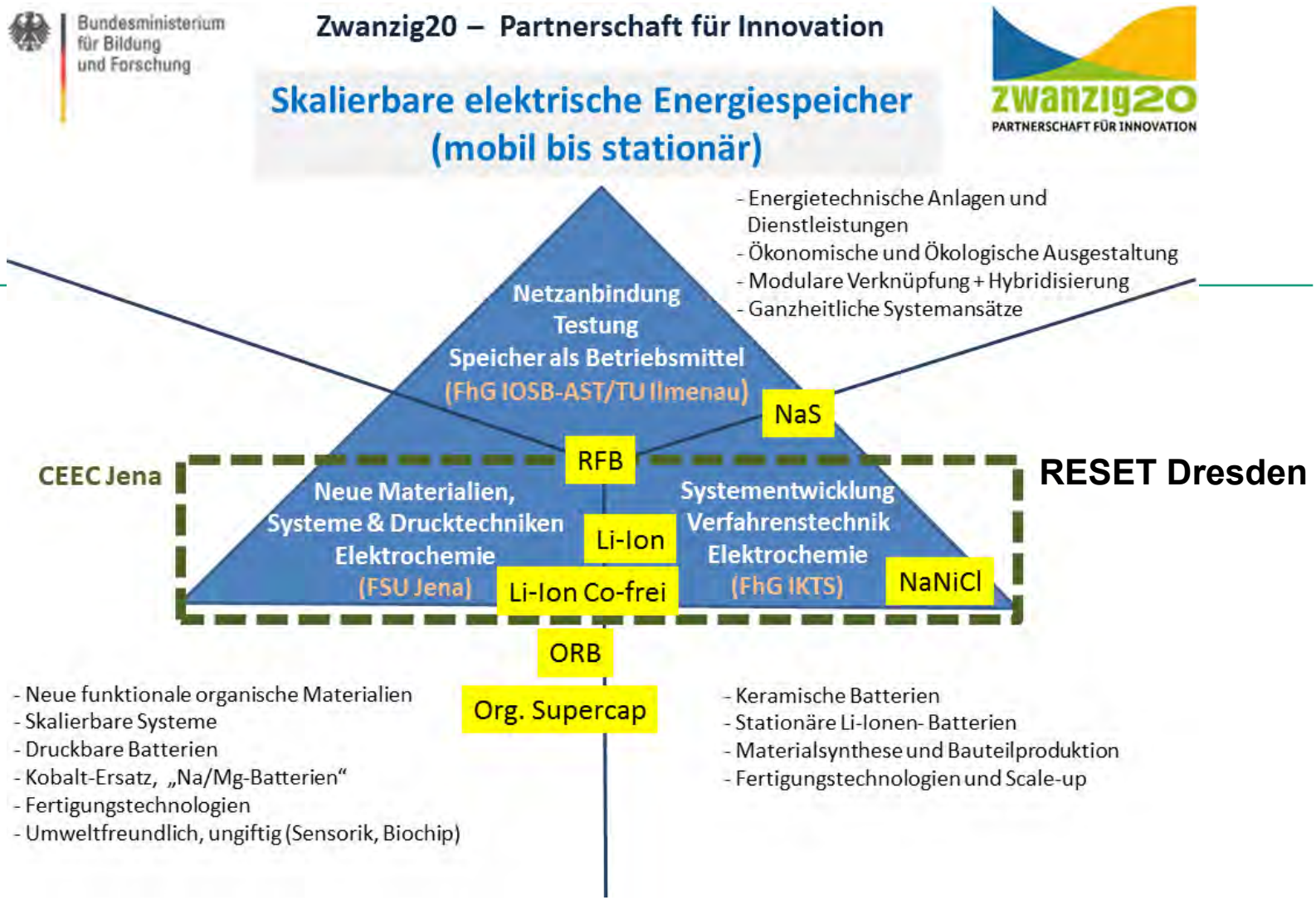


Regionale Leistungsbilanz 2030

Quelle: H. Krause, G. Müller-Syring, Integration von Wasserstoff in das Erdgasnetz - Power-to-Gas - Die Energiespeicherung der Zukunft, Vortrag 4-Sächsischer BZ-Tag Leipzig 2011

Das existierende Erdgasnetz stellt eine existierende Alternative Energieübetragungs- Infrastruktur für eneuerbare Energien dar

Projektkonzept Zwanzig20 des IKTS: Batterie 2.0



Fraunhofer IKTS

Zusammenfassung: Kombination von effizienter (regenerativer) Energiewandlung + Speicherung