Supporting market ramp-up of hydrogen and fuel cell technologies

WHEC 2016
Plenary Session 2: Hydrogen and Fuel Cells National Initiatives, Strategies and Legislation

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Dr. Klaus Bonhoff | Managing Director (Chair)
NOW GmbH - National Organization Hydrogen and Fuel Cell Technology
Guiding Questions

• What have we achieved?
• What is in progress?
• What is needed?
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• What is in progress?
• What is needed?
NIP – Integrated Approach for Market Preparation

Technology
- components
- subsystems
- systems and products

Application
- cost
- reliability
- durability

Market
- customer acceptance
- safety
- approval / certification

Duration: 2007 – 2016
Funding:
- BMVI 500 Mio. Euro
- BMWi 200 Mio. Euro

Overall budget: 1.4 bn. Euro

Bosch: Wasserstoffgas-Injektor HGI
Linde: Ionic H2-Kompressor
FCCT: Gasdiffusionsschicht (GDL)

Bundesministerium für Verkehr und digitale Infrastruktur
Bundesministerium für Wirtschaft und Energie
CALLUX
Successful market preparation for residential fuel cells

- almost 500 systems
- 4.5 million operating hours
- system availability > 97 per cent
- 2.5 million kWh delivered
- proven stack life time > 20,000 h

http://www.callux.net
## Products for residential combined heat and power supply with fuel cells are available

<table>
<thead>
<tr>
<th>Hersteller</th>
<th>Buderus</th>
<th>Elcore</th>
<th>HEXIS</th>
<th>Junkers</th>
<th>Sener Tec</th>
<th>SOLIDpower</th>
<th>SOLIDpower</th>
<th>Vaillant</th>
<th>Viessmann</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typ</td>
<td>SOFC</td>
<td>HT-PEM</td>
<td>SOFC</td>
<td>SOFC</td>
<td>NT-PEM</td>
<td>SOFC</td>
<td>SOFC</td>
<td>SOFC</td>
<td>NT-PEM</td>
</tr>
<tr>
<td>Modellbezeichnung</td>
<td>Logapower FC110</td>
<td>Elcore 2400</td>
<td>Galileo 1000 N</td>
<td>Cerapower FC10</td>
<td>Dachs InnoGen</td>
<td>EnGen 2500</td>
<td>BluGen</td>
<td>G6</td>
<td>Vitovator 300-P</td>
</tr>
<tr>
<td>Leistung (el/rth)</td>
<td>0,7/0,62 kW</td>
<td>0,3/0,7 kW</td>
<td>1,0/1,8 kW</td>
<td>0,7/0,62 kW</td>
<td>0,7/0,96 kW (modulierende Anlage)</td>
<td>2,5/2 kW</td>
<td>1,5/0,61 kW</td>
<td>0,6/1,5 kW</td>
<td>0,75/1 kW</td>
</tr>
<tr>
<td>Thermische Leistung des Zusatzbrenners</td>
<td>7,3-24 kW</td>
<td>Palett Lösungen: 2,8-19,5 kW / 7,8-32,2 kW, oder extern, individuell wählbar</td>
<td>7-21 kW</td>
<td>7,3-21,8 kW</td>
<td>5,2 - 21,8 kW</td>
<td>extern, individuell wählbar</td>
<td>extern, individuell wählbar</td>
<td>5,8-27 kW</td>
<td>5,5-19 kW</td>
</tr>
<tr>
<td>Speicher</td>
<td>Warmwasserspeicher 75 l, Pufferspeicher 135 l</td>
<td>Pufferspeicher: 500 l, oder extern, individuell wählbar</td>
<td>extern, individuell wählbar</td>
<td>Warmwasserspeicher 75 l, Pufferspeicher 135 l</td>
<td>Pufferspeicher mit Frischwasserstation 300 l</td>
<td>300 l, optional</td>
<td>extern, individuell wählbar</td>
<td>extern, individuell wählbar</td>
<td>Warmwasserspeicher 40 l, Trinkwasserspeicher optional auf 300 l erweiterbar, Pufferspeicher 170 l</td>
</tr>
<tr>
<td>Elektrischer Wirkungsgrad</td>
<td>46 %</td>
<td>32 %</td>
<td>36 %</td>
<td>45 %</td>
<td>37 % (Vollast)</td>
<td>50 %</td>
<td>bis zu 60 %</td>
<td>33 %</td>
<td>37 %</td>
</tr>
<tr>
<td>Gesamtwirkungsgrad</td>
<td>85 %</td>
<td>104 %</td>
<td>95 %</td>
<td>85 %</td>
<td>90 %</td>
<td>90 %</td>
<td>bis zu 85 %</td>
<td>92 %</td>
<td>90 %</td>
</tr>
<tr>
<td>Abmessungen in mm (B x T x H)</td>
<td>1200 x 600 x 1800</td>
<td>600 x 550 x 1050</td>
<td>620 x 580 x 1650</td>
<td>1200 x 600 x 1800</td>
<td>Brennstoffteileneinheit: 463 x 729 x 1954</td>
<td>Systemtechnik: 655 x 1065 x 1800</td>
<td>630 x 830 x 1700</td>
<td>600 x 680 x 1100</td>
<td>599 x 693 x 1640</td>
</tr>
<tr>
<td>Gewicht in kg</td>
<td>Gesamtsystem 304 kg in Modulbauweise, max. Modulgewicht 112 kg</td>
<td>115</td>
<td>210</td>
<td>Gesamtsystem 304 kg in Modulbauweise, max. Modulgewicht 112 kg</td>
<td>115 kg (Brennstoffteileinheit)</td>
<td>350</td>
<td>ca. 200</td>
<td>150</td>
<td>293 (Brennstoffteileinheit 125) (Spitzenlastmodul 165)</td>
</tr>
<tr>
<td>Feldtests, Kooperationen Demonstrationssprojekte</td>
<td>ene.field (EU), Kleinserie in Kooperation mit Energieversorgern</td>
<td>ene.field (EU)</td>
<td>verschiedene Partner aus der Energiewirtschaft und dem Hausbau</td>
<td>ene.field (DE), Phaeres (CH), ene.field (EU)</td>
<td>ene.field (EU), Callux (DE)</td>
<td>ene.field (EU)</td>
<td>abgeschlossen</td>
<td>Feldtest in Callux (DE), Kleinserie in ene.field (EU)</td>
<td>Januar 2013 (Präsentation), Juli 2013 bis März 2014 (großer Feldtest)</td>
</tr>
</tbody>
</table>
Clean Energy Partnership
successful technology validation with more than 100 fuel cell vehicles (passenger cars and busses) including hydrogen infrastructure

Vehicle Performance  efficiency, cold start, range

Fast Refueling  700 bar technology

Safety standards defined and tested

Sustainable > 50% green hydrogen

Customer Acceptance
Fuel Cell Vehicles
Research and Development lead to substantial performance increase and cost reduction

- component and system development and testing
- vehicle concepts
- vehicle testing and demonstration
- involving supply industry
- production technologies and processes

Cost Reduction (Fuel Cell System) by 75 %
Hydrogen Refueling Stations
Research and Development lead to technology improvements and cost reduction

H2-station (700 bar)

Cost Reduction (Hydrogen Refueling Station) by 50%
Market introduction of fuel cell vehicles has begun

announced for 2017
Fuel Cell Busses in public transport
Example Hamburg:
„Fuel cell busses as flexible as diesel busses“

Bus Operation

- **Innovation Line 109**
  - Distance: 10 km (central station - U Alsterdorf)
  - Exclusive use of innovative buses
  - Operation of PHEV as well as BEV and FCHB
  - Hydrogen refuelling at Harbour City HRS
  - Vehicles:
    - Diesel/hybrid buses (32)
    - Plug-in buses (3)
    - Fuel cell buses (4)
    - Battery buses (3 June 2016)
    - Battery buses with FC as range-extender

- **Lessons learnt**
  - Today: only vehicles and schedule in focus of operational control.
  - Future: availability infrastructure, energy supply etc. to be monitored also
  - Opportunity charging: high demand for charging infrastructure and space
  - Overnight charging requires battery capacity beyond state of the art
  - Fuel cell buses as flexible and productive as diesel buses
  - Complexity of overall system manageable for staff (training)

- **European Joint Procurement Exercise**
  - Funded by European Commission via FCH-JU
  - 142 Buses in joint procurement (UK, Germany, N/E Europe)
  - Potential next call 2017 (300 buses)
Fuel Cells in Transportation

road
rail
air
water
Hydrogen Production based on renewable energy sources

- development and demonstration of wind-hydrogen systems
- integration of hydrogen in the energy system (transport, power, heat)
- Hydrogen facilitates power-based fuels

1.5 MW PEM WE Efficiency Achievements (prel.)

- system efficiency >75%
Guiding Questions

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• What is in progress?

• What is needed?
50 Station Program
Research and Development for hydrogen refuelling stations and building an initial network in Germany

Dr. Klaus Bonhoff, Managing Director (Chair), NOW GmbH

https://www.now-gmbh.de/en/nationales-innovationsprogramm/auftbau-wasserstoff-tankstellennetz
Joint Testing of Infrastructure Equipment
Interdisciplinary working groups address infrastructure issues

Dispensed H₂ Quality
- Stations show H₂ impurities (filter)
- Analysis of filters
- Development of sampling device for dispensed H₂

Delivered H₂ Quality
- H₂ to meet ISO standard
- 5.0 quality tolerated as sufficient
- Frequency of analysis t.b. agreed

H₂ Metering
- Precise H₂ measurement required
- Validation of metering technology
- Supplier screening

H₂ filling
H₂ quality
H₂ leak proof
H₂ flow measurement
H₂ backup

Dr. Klaus Bonhoff, Managing Director (Chair), NOW GmbH
H2 Mobility
A partnership to make refuelling hydrogen possible throughout Germany

Shareholder

Berlin
October 13, 2015

Associated Partners and Advisors

Dr. Klaus Bonhoff, Managing Director (Chair), NOW GmbH
Power-to-Gas Projects in Germany
Preparing the *Energiewende* for transportation

- currently > 30 PtG projects / activities
- designed to run on renewable energies
- including 16 operating plants with a total capacity of 16 MW (9 AEL and 6 PEMEL)
- Audi Werlte project: 6 MW AEL (3x2MW)
- 5 hydrogen retail stations with onsite electrolyzers provide fuel for vehicles
- 8 projects re-electrify hydrogen for stationary power supply
- 9 plants feed hydrogen into the natural gas grid
- 5 plants produce and ship hydrogen, by trailer and / or pipeline, for further use
- 18 plants boast electrolyzers ranging from 1 to 7 MW
- 5 plants are equipped with electrolyzers of less than 1 MW

source: Ludwig-Bölkow-Systemtechnik GmbH
Moving forward…

Research and Development
- basic research
- applied R&D
- demonstration
- cost reduction

Market Activation
- Milestones (volume / economies of scale)
  - hydrogen in transport
  - hydrogen from renewable energies
  - CHP (residential/industry)
  - reliable power supply

Macro economic benefits / global competitiveness

Dr. Klaus Bonhoff, Managing Director (Chair), NOW GmbH
National Innovation Programme Hydrogen and Fuel Cell Technology (NIP)
Partners from Industry and Academia

Dr. Klaus Bonhoff, Managing Director (Chair), NOW GmbH
National Implementation of the EU Alternative Fuels Infrastructure Directive (AFID)

AFID
2014
- minimum requirements on alternative fuels infrastructure
- common technical standards
- consumer information

NATIONAL STRATEGY FRAMEWORK
2016
- strategic plan for national implementation
- electricity, hydrogen and natural gas (LNG / CNG)
- to communicate to Commission by 18.11.2016
- monitoring reports every 3 years starting 18.11.2019

CPT
2013
- communication of EU strategy for alternative fuels
- draft directive
- action plan LNG for maritime transport
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Hydrogen and Fuel Cells
Key Technologies for an integrated energy system

Linking the energy sectors to decarbonize our economic system:
• more renewables
• higher efficiency
• lower cost

stationary fuel cells (CHP) deployment
green hydrogen production
hydrogen station infrastructure
fuel cell vehicle deployment
80% reduction of green-house gases until 2050
- increase of PV- and Wind capacity by a factor of > 4
- 75 GW installed electrolyzer-capacity

modelling the energy system in Germany (power - heat - transportation); cost-optimized scenario assuming 80% green-house-gas reduction until 2050
The International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) was established in 2003 as an international institution to accelerate the transition to a hydrogen economy.

All IPHE members collectively account for over 85% of global GDP, over 75% of the global electricity, and more than 65% of global greenhouse gas emissions.
Hydrogen – Campaign
January - February 2016
Increase of public awareness with 13.1 mio. contacts

Launch-Event with partners at the Ministry of Transportation and digital Infrastructure (BMVI)

Screenshots DISPLAY

AIRPORTS

Berlin

Frankfurt

München

Stuttgart

Düsseldorf
Guiding Questions

• What have we achieved?
  – cost reduction via large scale demonstration projects
  – Hydrogen and fuel cell product are available

• What is in progress?
  – market activation programs become available
  – hydrogen infrastructure build-up

• What is needed?
  – regulatory framework for an integrated energy system
  – visibility regarding the role of hydrogen and fuel cells in a decarbonized economic system
  – international co-operation
Thank you very much!

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