

Dezentrale Erzeugung elektrischer Energie und Elektromobilität mit Brennstoffzellen (AFC Annex 31 und 35)

IEA Vernetzungstreffen: Urbane
Energieinnovationen – Beitrag zur Energiewende
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Content

1. Technology Collaboration Programme (TCP) on Advanced Fuel Cells: Annex 31 / Annex 35
2. IEA Report: Energy Technology Perspectives 2016 - Towards Sustainable Urban Energy Systems
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Technology Collaboration Programme (TCP) on Advanced Fuel Cells



Annex 30: Electrolysis

Annex 31: Polymer Electrolyte Fuel Cells

Annex 32: Solid Oxide Fuel Cells

Annex 33: Fuel Cells for Stationary Applications

Annex 34: Fuel Cells for Transportation

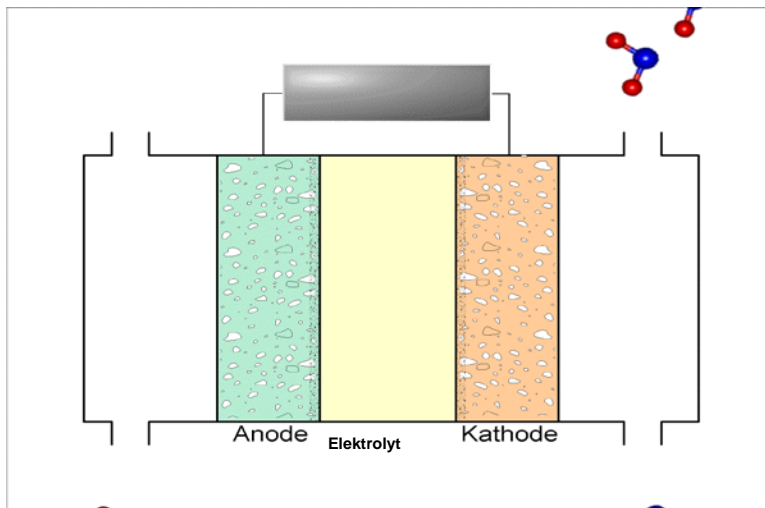
Annex 35: Fuel Cells for Portable Applications

Annex 36: Systems Analysis

Annex 37: Modelling of Fuel Cells Systems

<http://www.ieafuelcell.com/links.php>

Annex 31: Polymer Electrolyte Fuel Cells



TU Graz Fuel Cell Development

- Development of **Low Cost** High-Temperature Polymer Electrolyte Fuel Cell Membrane-Electrode-Assemblies for **Combined Heat and Power Plants in Single Family Homes**, *ECS Trans. 2016 75(14)*.
- Phosphoric Acid **Tolerant Oxygen Reduction Reaction Catalysts** for HT-Polymer Electrolyte Fuel Cells, *ECS Trans. 2016 75(14)*.
- Project result: **Resource-saving and highly durable Pt-alloy catalysts for the HTPEM.**

Annex 31: Polymer Electrolyte Fuel Cells



TU Graz Hydrogen Production and Purification

- High purity **pressurised hydrogen** production from syngas by the steam-iron process, *RSC Advances* 2016, 6, 53533-53541.
- Selective **real-time quantification of hydrogen** within mixtures of gases via an electrochemical method, *Int. J. Hydrogen Energy*. 40 (2015) 2055.
- Verfahren zum **Herstellen von Wasserstoff**, WO 2016011473 A1, PCT/AT2015/050177 (2016).
Project result: **pressurized hydrogen with a purity of 99.958–99.999%.**

Annex 31: Polymer Electrolyte Fuel Cells



TU Graz Real-time monitoring Stacks

- **Generic tool** for the simulation of electrochemical **fuel cell monitoring techniques**, *submitted*.
- Verfahren zum **Überwachen des Betriebszustandes** von Brennstoffzellen, *patent applied*.
- **Project result:** Generic fuel cell simulation tool for transient simulations upon experimental parameterization.

Annex 31: Polymer Electrolyte Fuel Cells

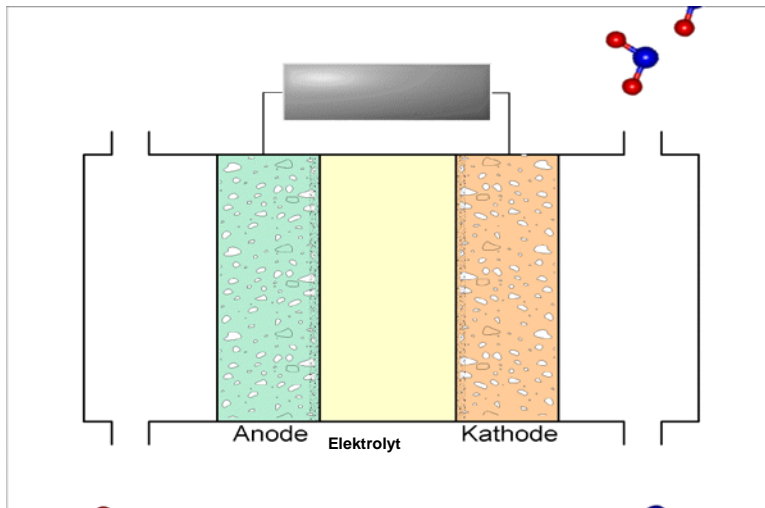


TU Graz Accelerated Stress Tests

- **Effect of pinhole location on degradation** in polymer electrolyte fuel cells, *J. of Power S.* 2015, 295, 336.
- Determining Membrane **Degradation** in PEFCs by **Effluent Water Analysis**, *ECS Transactions* 2016, 75, 703-706.
- **Air Starvation Accelerated Stress Tests** in Polymer Electrolyte Fuel Cells, *ECS Transaction* 2016, 75, 769-776.
- **Project results:** influence of pinhole locations, platinum loading and fluoride emission on **degradation of PEFCs**.

Annex 35: Fuel Cells for Portable Applications

TU Graz Direct Fuel Cells



- **Chitosan-Based Anion Exchange Membranes** for DEFCs, *J. Membrane Science & Technology* 2016, 6:1, 145.
- The **electrooxid. of borohydride**, *Appl. Catal. B Environ.* 180 (2016) 614.
- C supported nanocryst. manganese oxide: Surpassing platinum as oxygen reduction catalyst in **DBFCs**, *JES* 163 (2016) F885.
- Project results: **Long-term stable Pt-free electro-catalysts** for the alkaline ethanol oxidation reaction.
Passive, **air-breathing direct fuel cell** with power of 4 W.

Annex 35: Fuel Cells for Portable Applications

TU Graz Metal-Air Cells



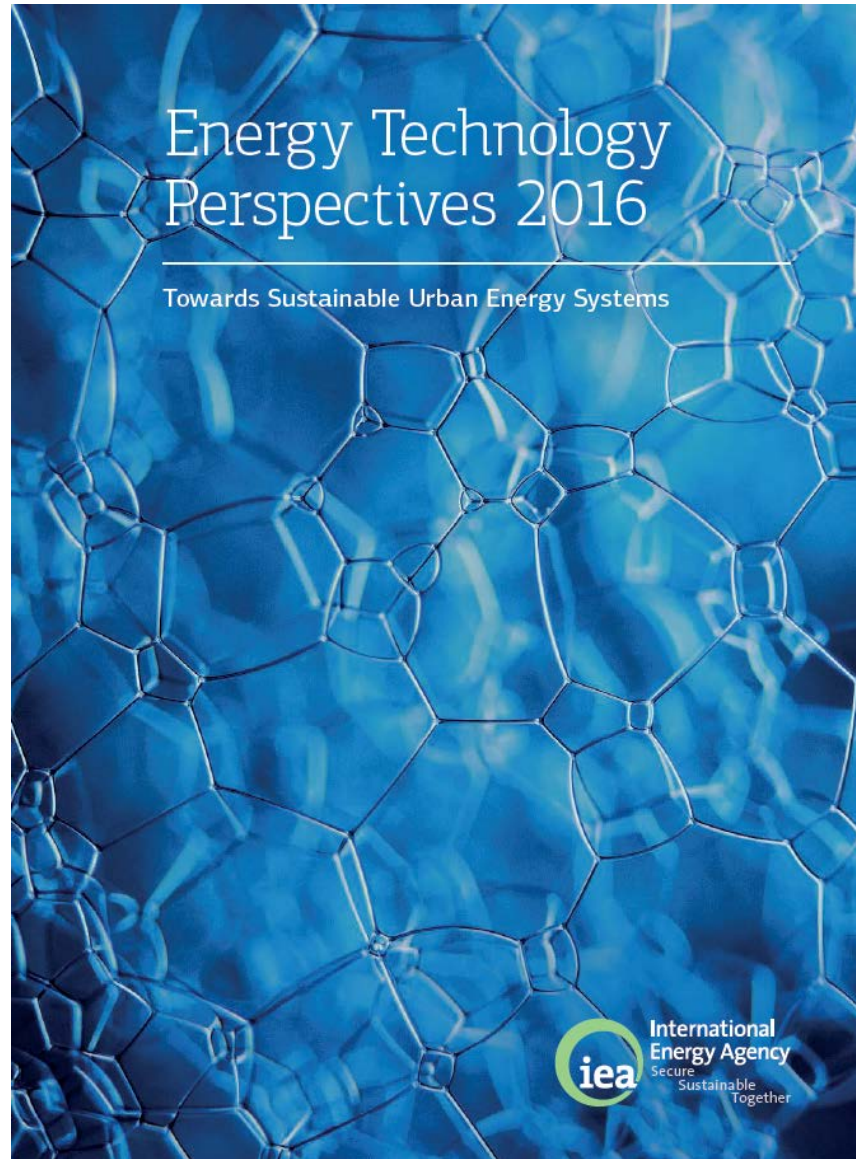
- Design of **bifunctional air electrodes** for Zn/air redox flow batteries, “*The 67th Annual Meeting of the International Society of Electrochemistry*”, Den Haag (2016).
- Project result: **stable bifunctional air electrodes** up to 50 mA/cm² current density.

Annex 35: Fuel Cells for Portable Applications

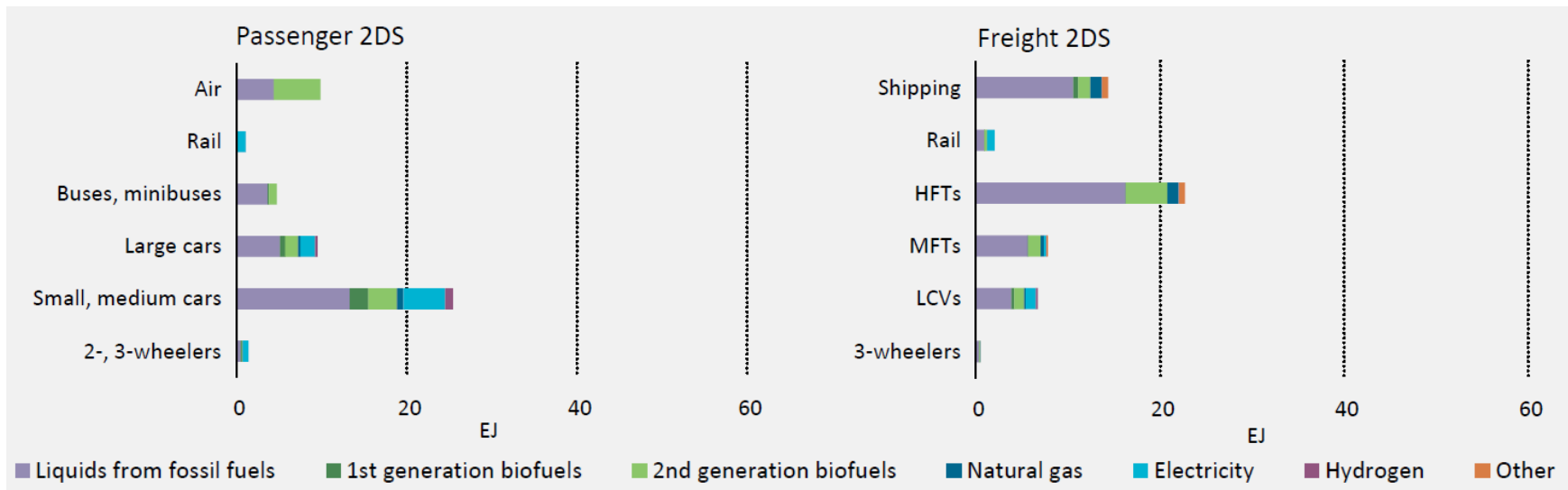
TU Graz Hydrogen Storage with Ionic Liquids



- **Novel Borohydride-Based Ionic Liquids as Hydrogen Carrier**, *CIT* 86 (2014) 1443–1443.
- **Borohydride based Ionic Liquids as novel Hydrogen Storage**, in: *5th Eur. PEFC H2 Forum - Proc.*, 2015: p. B0503; 1-8.
- **Project result:** pressurized hydrogen with a purity 99.999%.



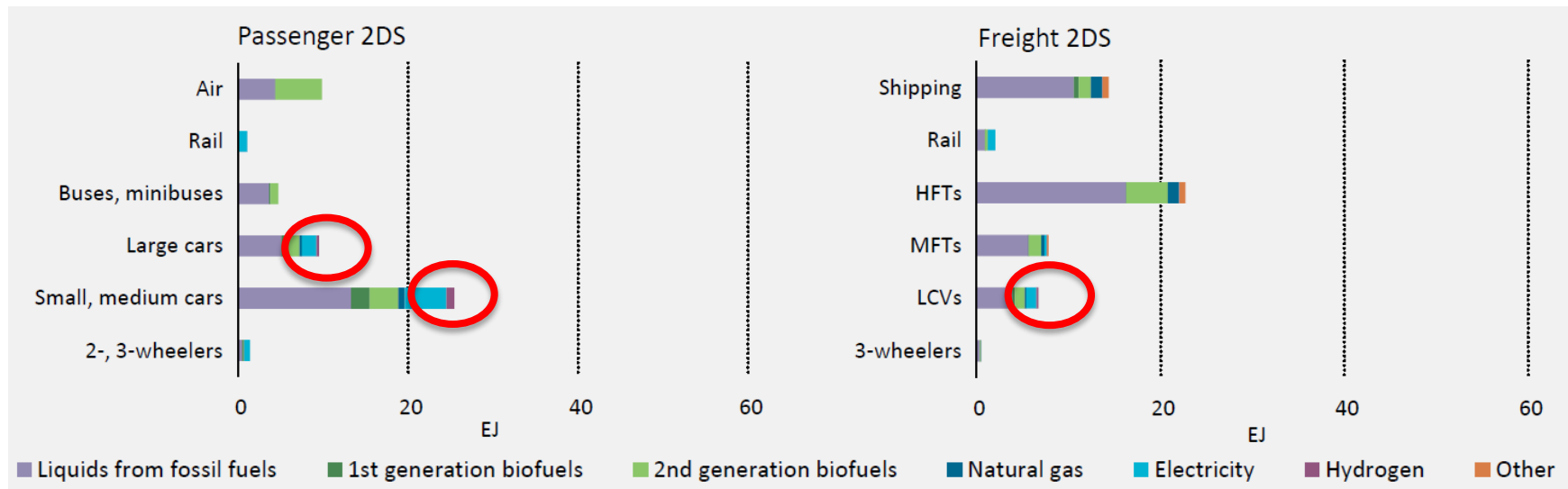
Energy Technology Perspectives 2016 - Towards Sustainable Urban Energy Systems [OECD/IEA, 2016]



Fuel shares in 2050 for passenger and freight modes: Low-carbon fuels (incl. biofuels, electricity, hydrogen, and NG) account for 41% of final energy consumption in the 2DS [ETP2016].

[ETP 2016, p. 48]

Energy Technology Perspectives 2016 - Towards Sustainable Urban Energy Systems [OECD/IEA, 2016]



Fuel shares in 2050 for passenger and freight modes: Low-carbon fuels (incl. biofuels, electricity, hydrogen, and NG) account for 41% of final energy consumption in the 2DS [ETP2016].

- The deployment of fuel cell electric vehicles (FCEVs) occurs primarily in the LDV (**light-duty vehicles**) fleet, but is limited by high **investment risks**: hydrogen use reaches 1.5 EJ by 2050, or about **1.5% of total final energy demand**.

[ETP 2016, p. 48]

Energy Technology Perspectives 2016 - Towards Sustainable Urban Energy Systems [OECD/IEA, 2016]

- The deployment of fuel cell electric vehicles (FCEVs) occurs primarily in the LDV (**light-duty vehicles**) fleet, but is limited by high **investment risks**: hydrogen use reaches 1.5 EJ by 2050, or about **1.5% of total final energy demand**.
- **Long-term prospects for hydrogen FCEVs are limited**, even in the final decade of the 2DS, by the availability of **low-cost excess electricity** from renewables.
- This reflects the **investment risks** of shifting to centralised hydrogen production and building up an adequate **hydrogen distribution infrastructure**.
- For FCEVs, the potential for **cost reductions** by mass production of **fuel cells** is significant.
- Containing costs of mass-produced, **high-pressure hydrogen storage** tanks is likely to be more difficult, as these costs are largely determined by prices of composite materials.
- Fuel cells could deeply decarbonise heavy-duty road freight transport, but their **efficiencies decline with increasing power output** and constant speed highway driving requirements.
- For long-distance transport, hydrogen storage would also **require large tanks**; (four times more space as conventional diesel).
- **Surplus PV** generation may be absorbed by smart-charging of EVs or stationary batteries, or converted in power-to-gas plants into gas or in **electrolysers into hydrogen**.

[ETP 2016]

20.10.2016



Technology Roadmap

Hydrogen and Fuel Cells

Techno-economic parameters of FCEVs as computed in the model for the United States

	Today	2030	2050	Unit
FCEV costs	60 000	33 600	33 400	USD
Thereof				
Glider*	23 100	24 100	25 600	USD
Fuel cell system**	30 200	4 300	3 200	USD
H ₂ tank**	4 300	3 100	2 800	USD
Battery**	600	460	260	USD
Electric motor and power control**	1 800	1 600	1 400	USD
Specific costs				
Fuel cell system (80 kW)	380	54	40	USD/kW
H ₂ tank (6.5 kg H ₂)	20	14	13	USD/kWh
Battery (1.3 kWh)	460	350	200	USD/kW
Other parameters				
Tested fuel economy	1.0	0.8	0.6	Kg H ₂ /100 km
Life time	12	12	12	Years

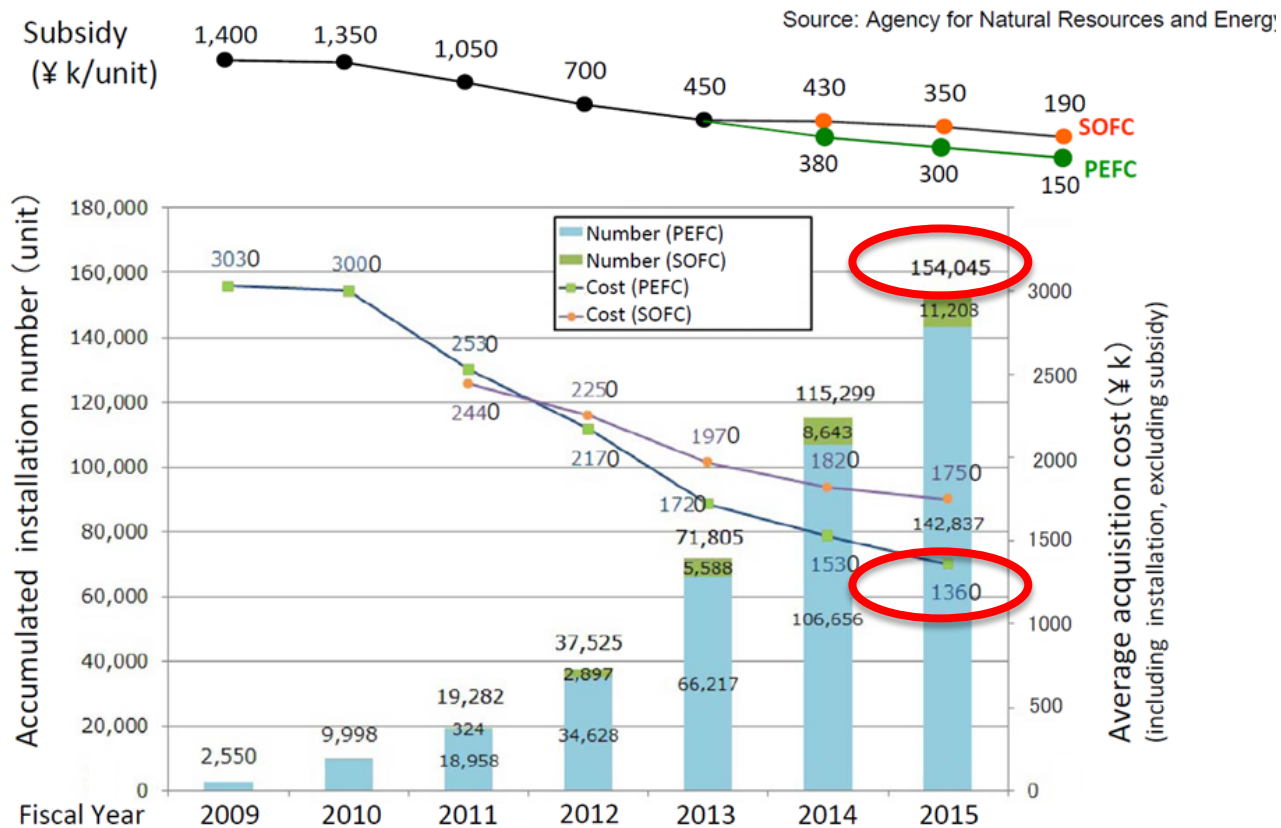
* future cost increase is due to light-weighting, improved aerodynamics, low resistance tyres and high efficient auxiliary devices.

** future costs are based on learning curves with learning rates of 10% (H₂ tank), 15% (electric motor, power control, battery) and 20% (fuel cell system) per doubling of cumulative deployment.

Annex - Updates

Japan

Ene.farm - Market Condition in Japan

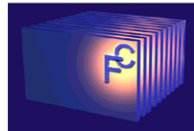


Denmark

FCEV fleet & outlook (from the industry)

Target of at least 500 FCEVs in Denmark by 2018 – a conservative target.

LOW scenario of 300 FCEVs and a HIGH scenario of 2.000 FCEVs in 2018.



Hyundai ix35 FCEV

Present fleet: 37 units

Binding orders: 16 units

Pending orders: 20 units



Toyota Mirai

Binding orders: 3 units

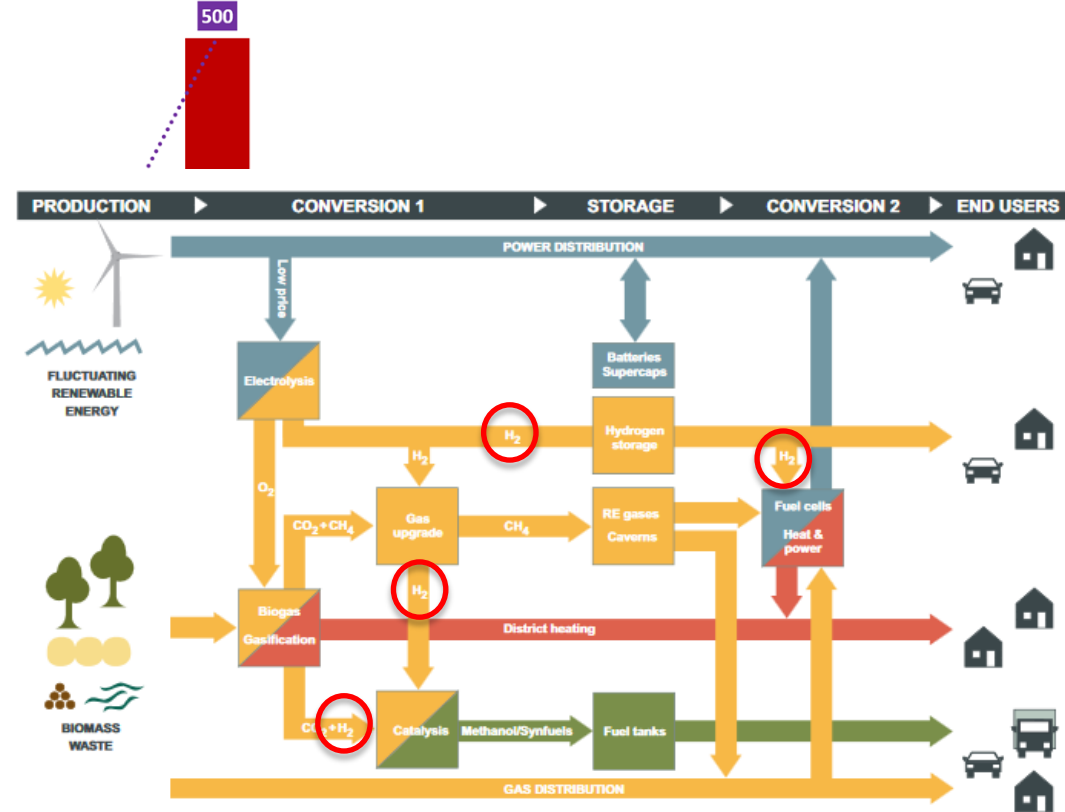
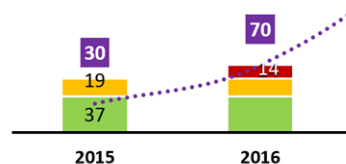


Honda

Deployment 2016

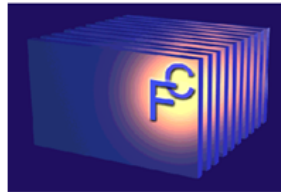
- Present fleet
- Secured sales contracts
- Required annual sales
- Target fleet (end of year)

Status: Sep. 2015

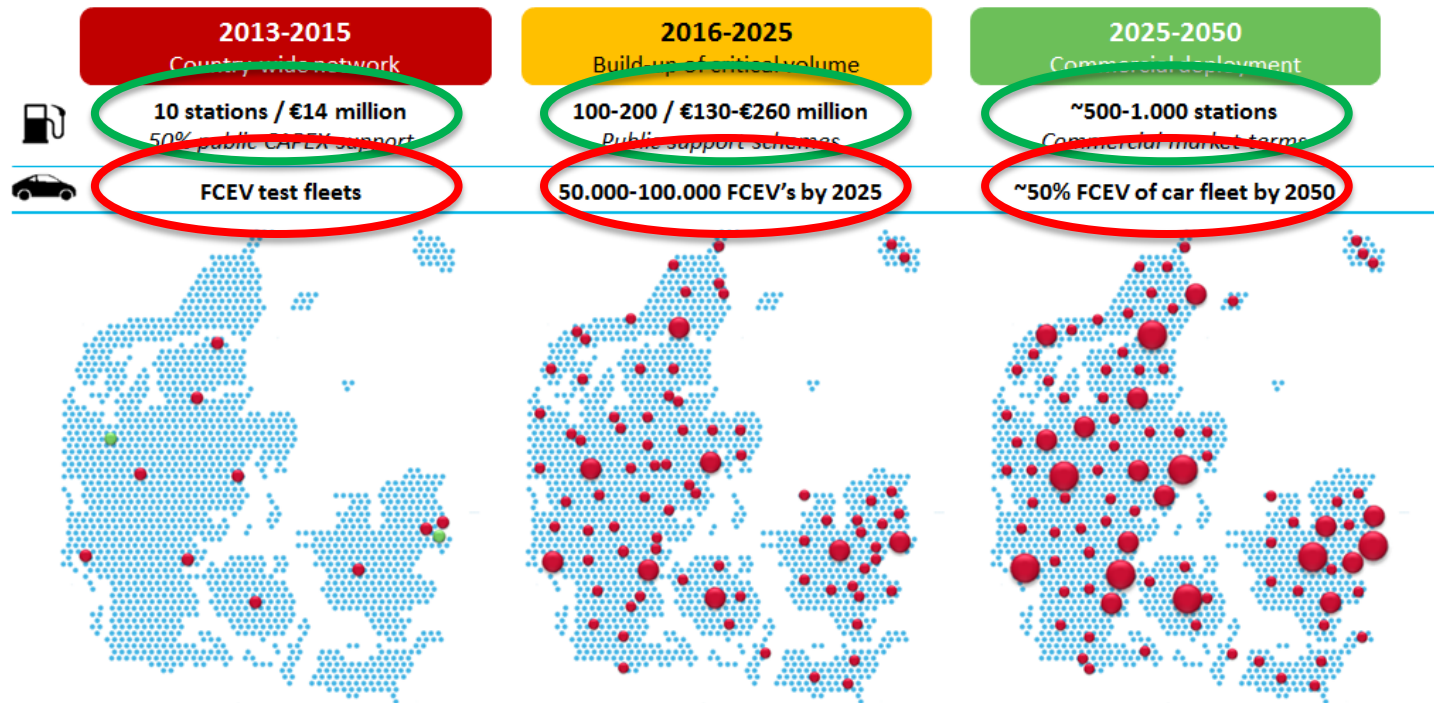


The future Danish energy system as forecasted by the Danish Partnership for Hydrogen and Fuel Cells

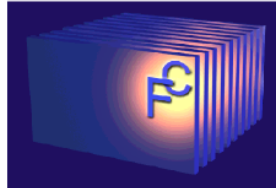
Denmark



Roll out HRS and FCEV (plans from the industry)



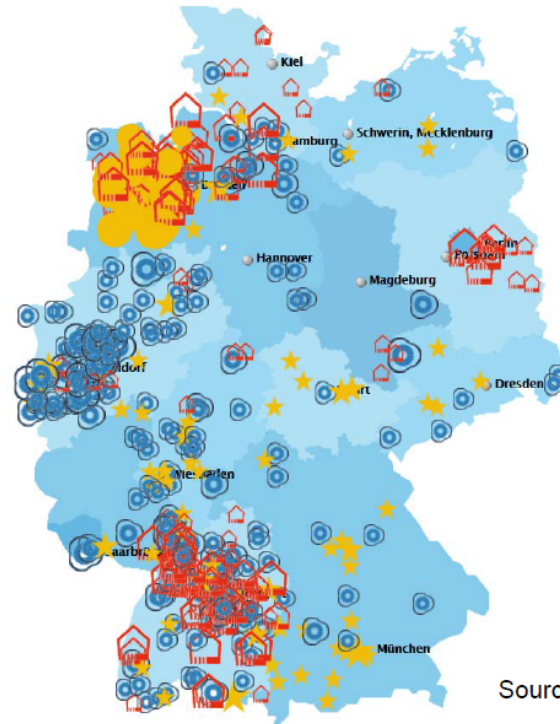
Germany



Demonstration Highlights

Fuel cell heating appliances in Germany

 Callux
  ene.field
  FuelCell@Home
  Sonstige Projekte



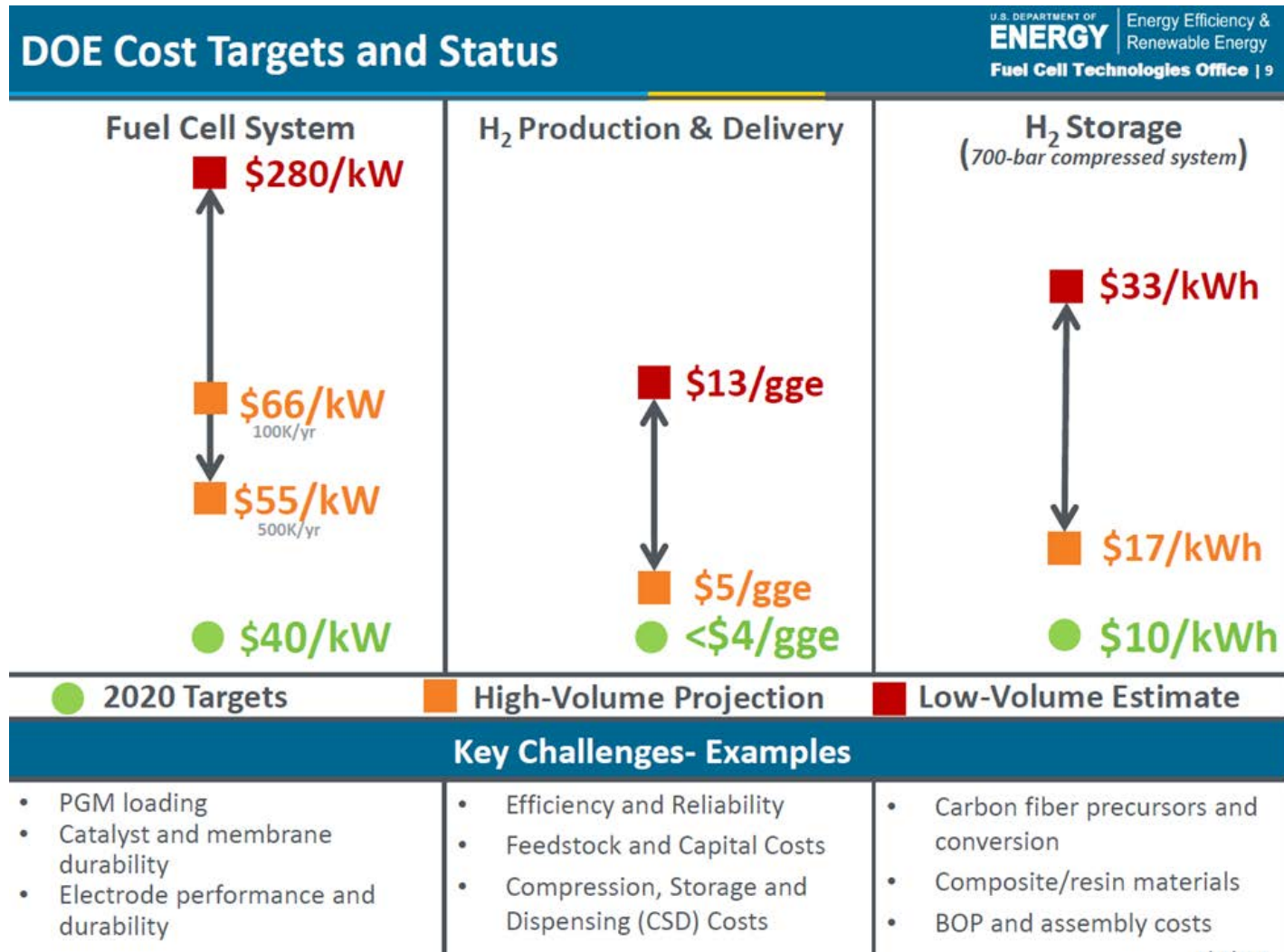
In total 1000 fuel cell heating appliances:

- Callux
- Ene.field
- FuelCell@home
- other projects

Source: Initiative Brennstoffzelle, 25.09.2015

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U.S. Department of Energy



Conclusion

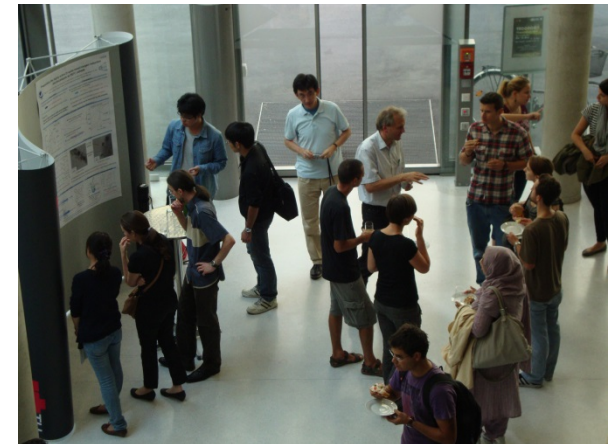
- Successful participation of Scientists of the Fuel Cell Group of TU Graz in Annexes 31/35 - intensive knowledge exchange.
- Role of fuel cells as future clean and high efficient power producer is underestimated in the ETP 2016 report.
- Barriers for Hydrogen are overestimated.
- Huge international efforts are on the way:
 - R&D Fuel Cells and Electrolysis;
 - Hydrogen as energy carrier / for energy storage / infrastructure.
- Electromobility: FCEVs incl. centralised and decentralised hydrogen production are introduced on a worldwide scale.
- Decentralised power: Fuel cells are regionally commercially available for low emission, high efficient CHP based on hydrocarbons and hydrogen.

Dissemination – Workshop TU Graz

2nd International Workshop on Hydrogen and Fuel Cells

Die Veranstaltung wurde in Kooperation mit der Yokohama National University durchgeführt.

TU Graz, 31. August 2016



A grayscale background image of a large, ornate classical building with multiple domes and columns, likely a university or historical institution. The building is shown from a low angle, emphasizing its grandeur.

Science ■ Passion ■ Technology