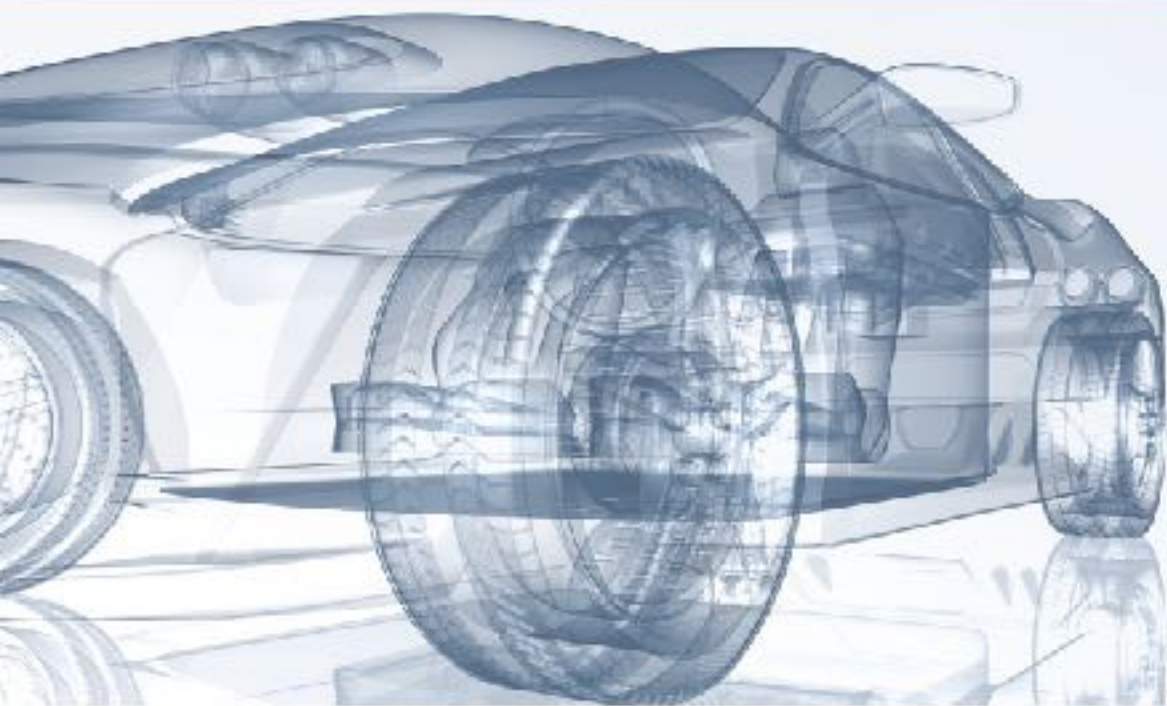


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Onsite hydrogen generation and hydrogen recycling for refuelling FCEVs using an electrochemical hydrogen compressor

M. Eng. Linda Schorer, DHBW Mannheim

Prof. Dr.-Ing. Sven Schmitz, DHBW

Mannheim



Agenda

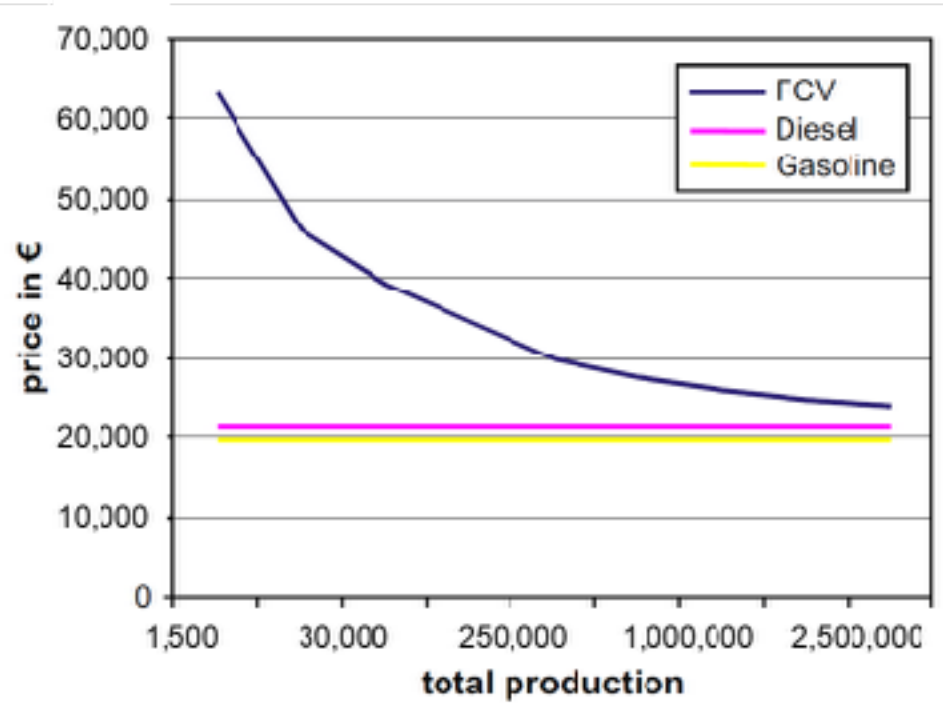
- ***Introduction***
- ***Electrochemical Hydrogen Compressor***
- ***Onsite Generation and Refuelling***
- ***Hydrogen Recycling***

Introduction

Challenges of Fuel Cell Electric Vehicles (FCEVs)

1. Costs

2. Infrastructure



Source: Keles et. Al. (2008) *International journal of hydrogen energy* 33(2008)4444–4455

Introduction

*planned hydrogen refuelling stations (HRS) in Germany**

50	until 2016
100	until 2018
400	until 2023

56 stations

in operation 27

no information

3

maintenance/out of order

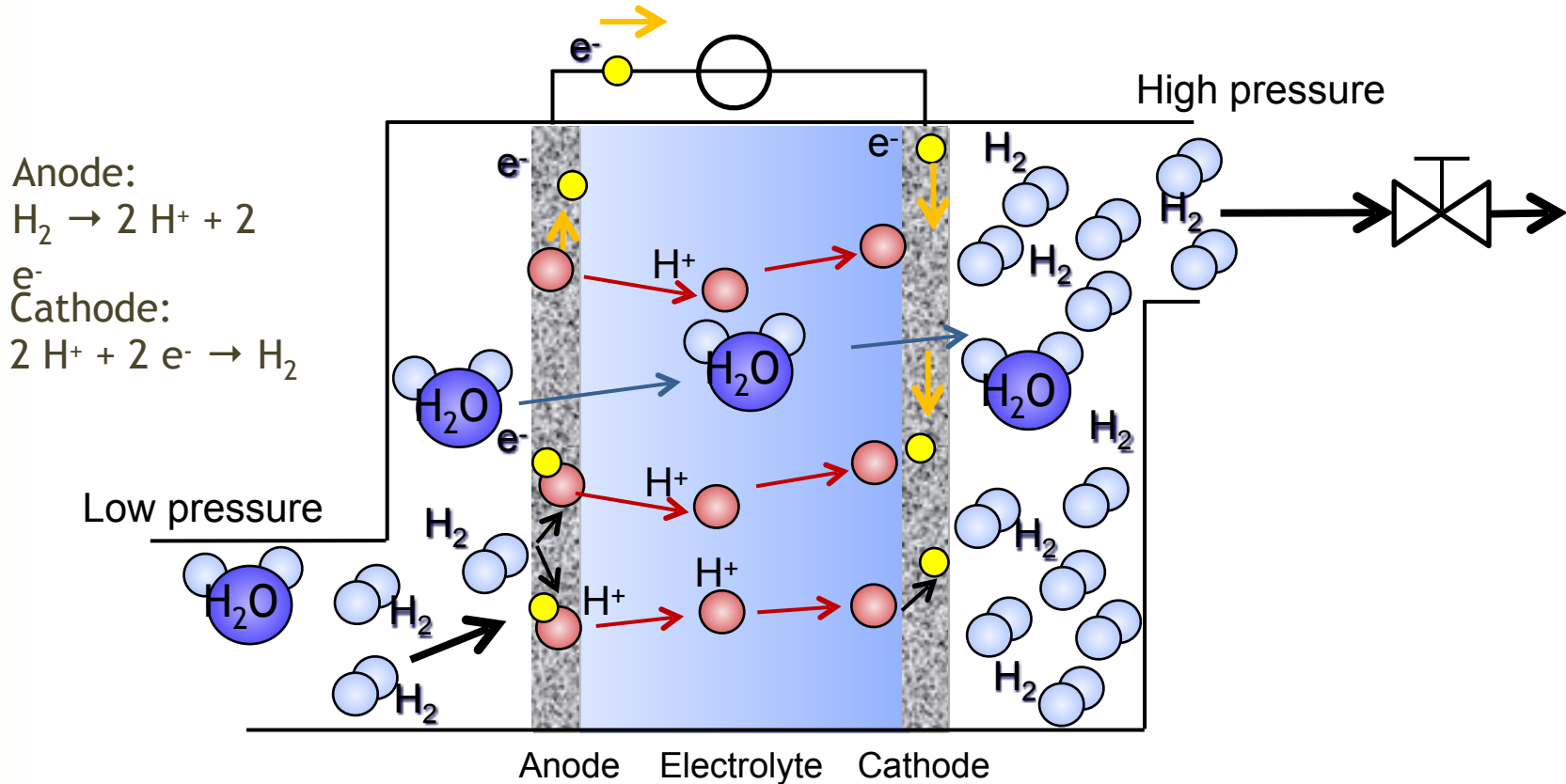
5 → compared to 14,500 petrol stations coming soon 21

* Clean Energy Storage Group, H₂ Mobility

current situation (28/09/17)

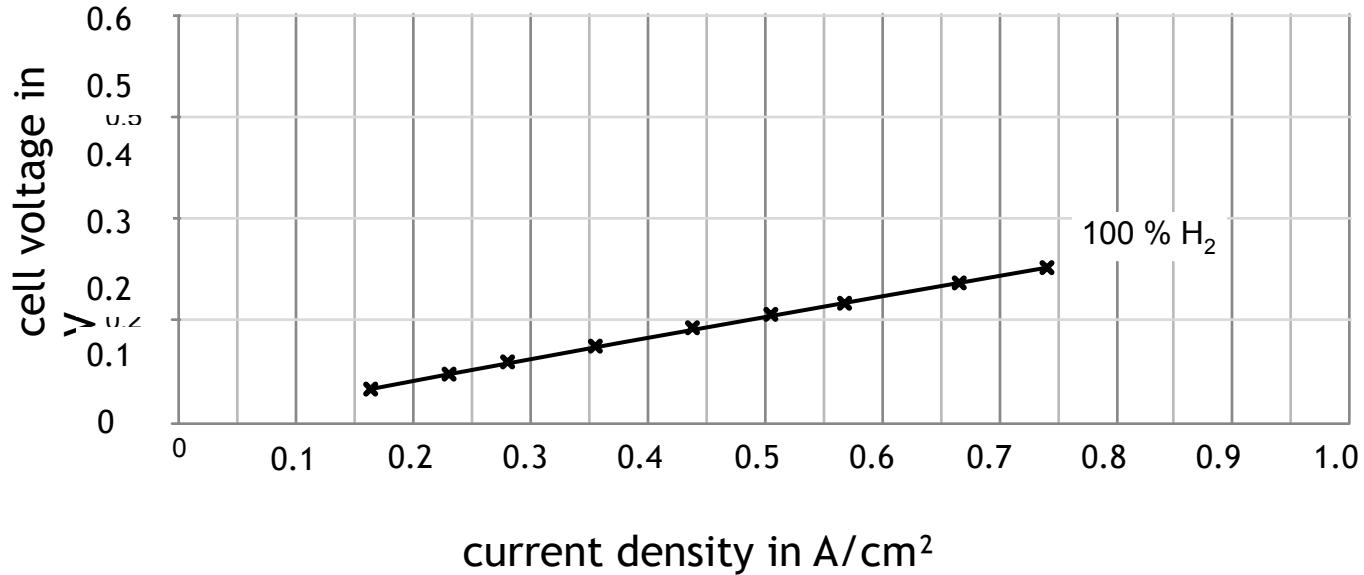


Electrochemical Hydrogen Compressor (EHC)



Electrochemical Hydrogen Compressor (EHC)

Single Cell Testing



current-voltage-characteristics of a measured cell for 80 °C and relative humidity of 80 %

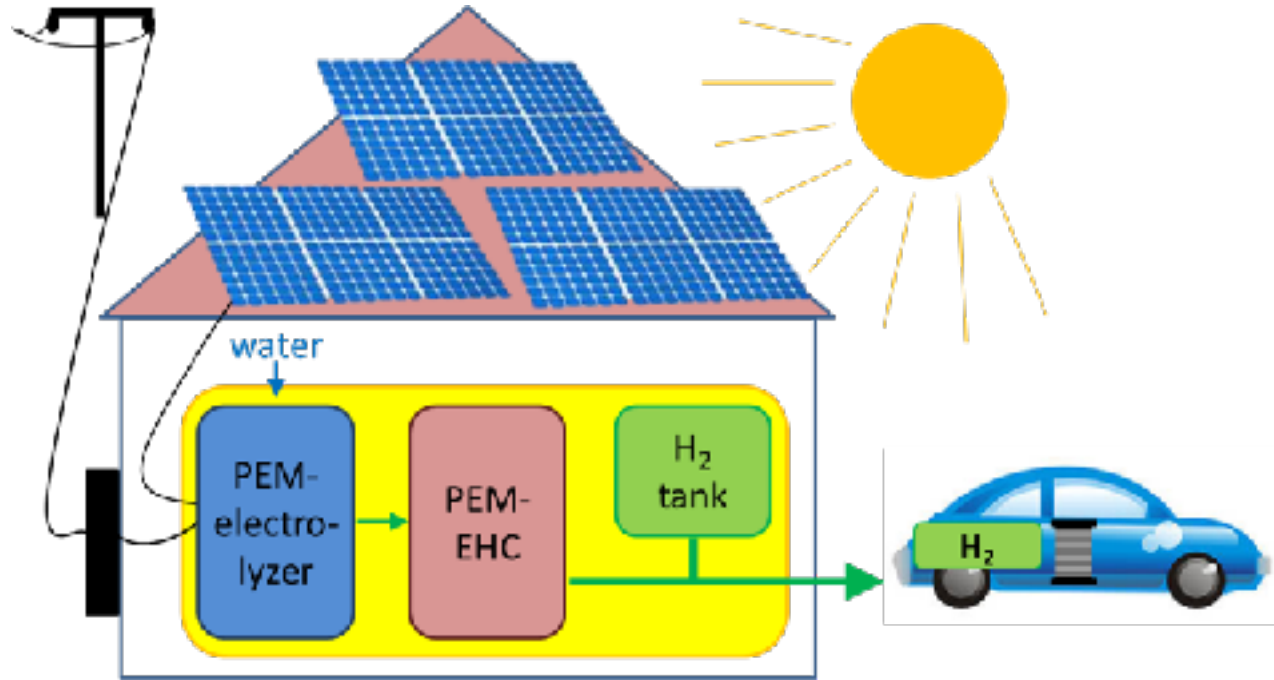
Electrochemical Hydrogen Compressor (EHC)

advantages

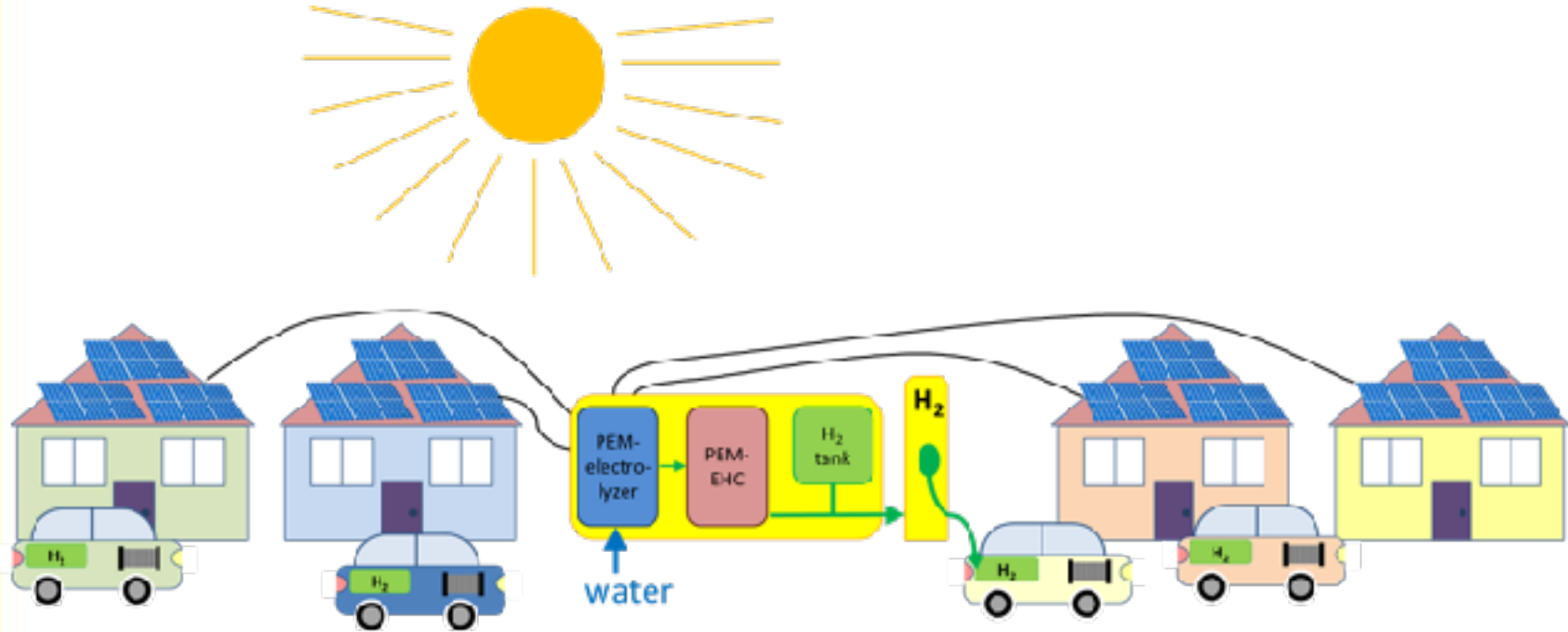
- ***low cell temperature (20 – 80 °C)***
- ***hydrogen is transported almost isothermal through the membrane, that leads to a higher efficiency***
- ***contains no moving parts, that means no friction, no lubrication, no risk for hydrogen contamination and less maintenance, makes no noise***
- ***easy integration and simple working principle, scalable***
- ***low platinum loading down to 10 µg/cm² feasible****

**** Source: D. Bessarabov, et. Al., PEM Electrolysis for Hydrogen Production: Principles and Applications, Taylor & Francis Group LLC, 2015***

Onsite Generation and Refuelling Family Household Concept



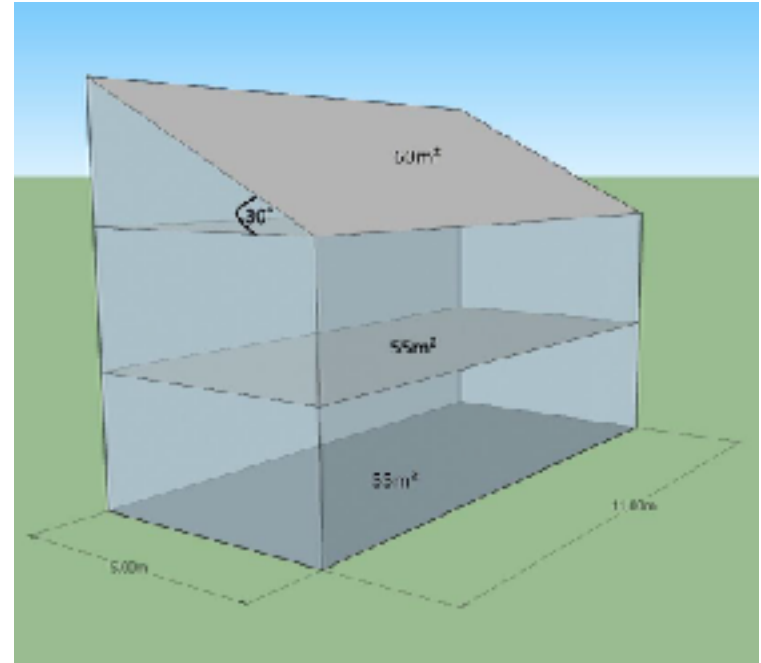
Onsite Generation and Refuelling Community Storage Concept



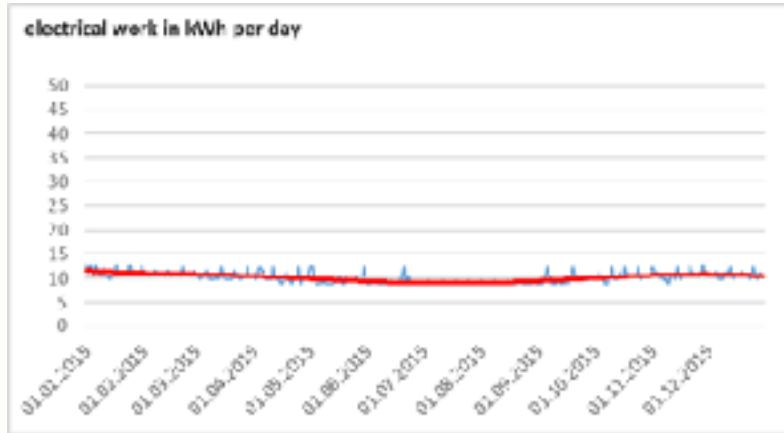
Onsite Generation and Refuelling

Model Family Household for Simulation

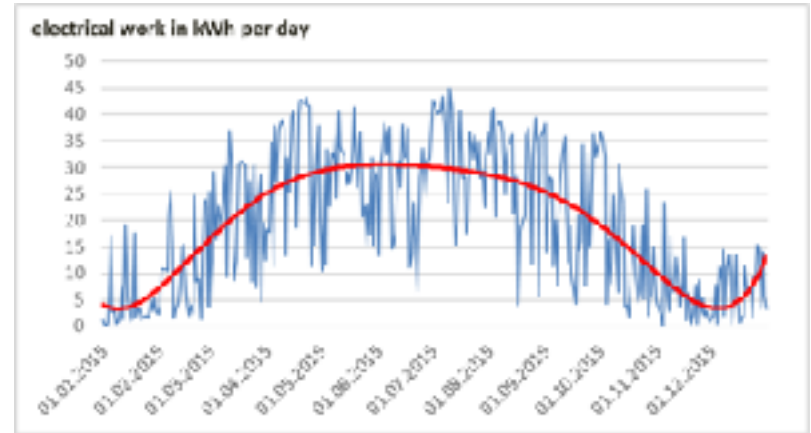
- **3 persons**
- **110 m² living space**
- **pent roof with 60 m² for photovoltaics usage**
- **installed PV power 6.76 kW**
- **electricity consumption per year 3,750 kWh (1,250 kWh each person), load profile from VDI4655**



Onsite Generation and Refuelling Simulation of Family Household for the Year 2015



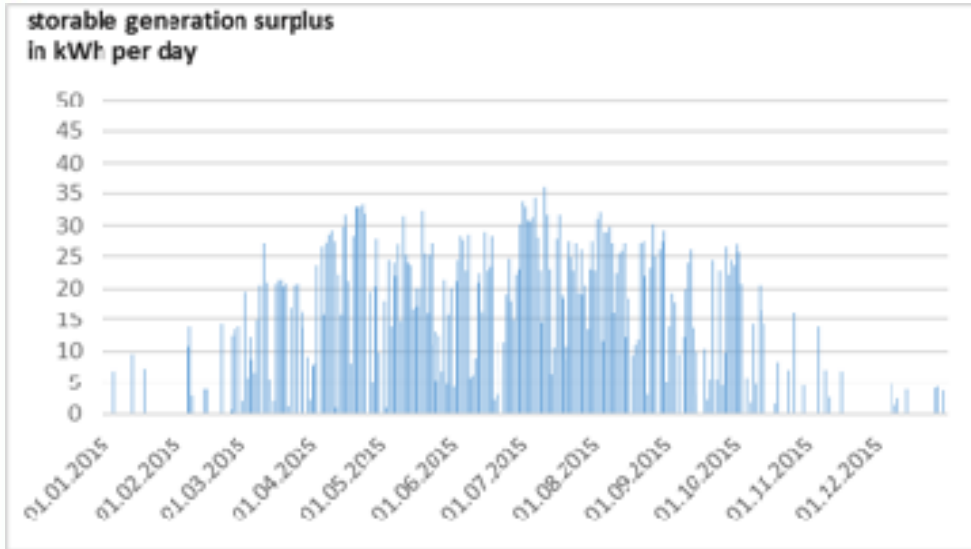
consumption = 3,750 kWh per year



generation = 7,074 kWh per year

Onsite Generation and Refuelling

Simulation of Family Household for the Year 2015



4,151 kWh of electricity could be stored per year

→ **loss by transformation:**

η electrolyzer = 70 %

η compressor = 85 %

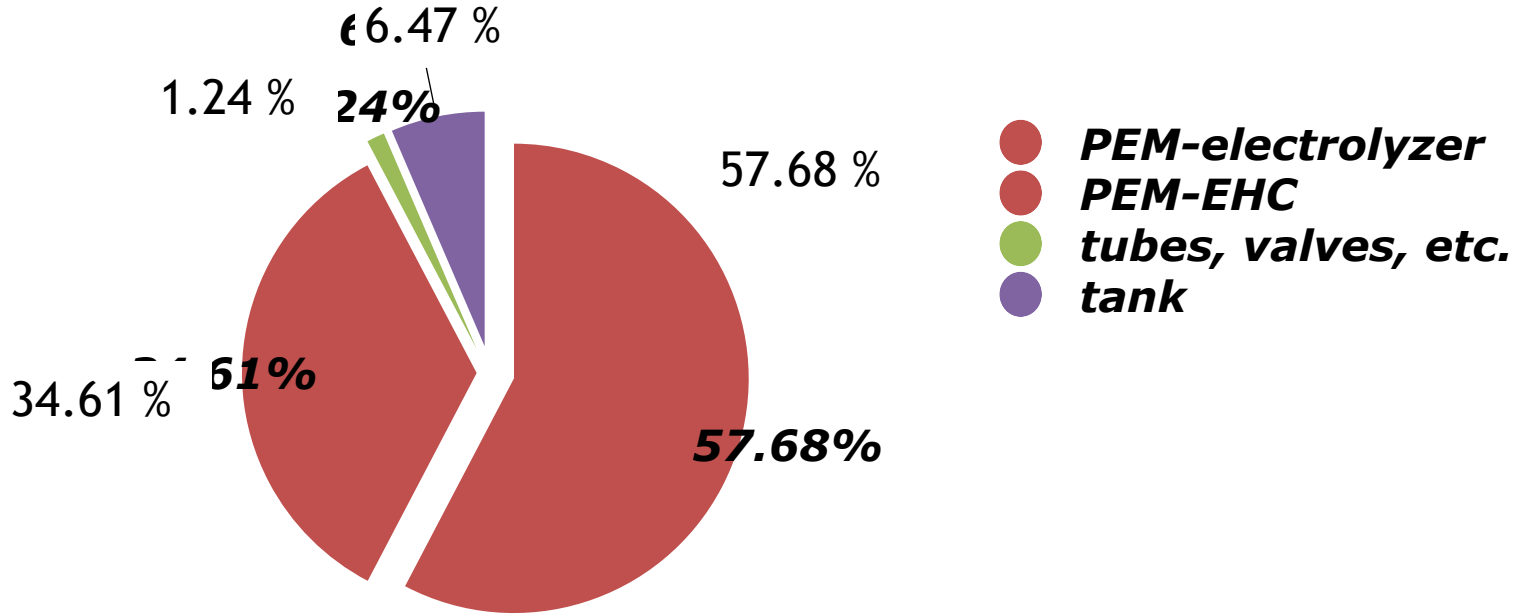
→ **2,469.85 kWh**

\triangleq 74.17 kg H₂ per year

\triangleq 7,417 km per year with

FCEV

Onsite Generation and Refuelling Cost Distribution of Home Refuelling System

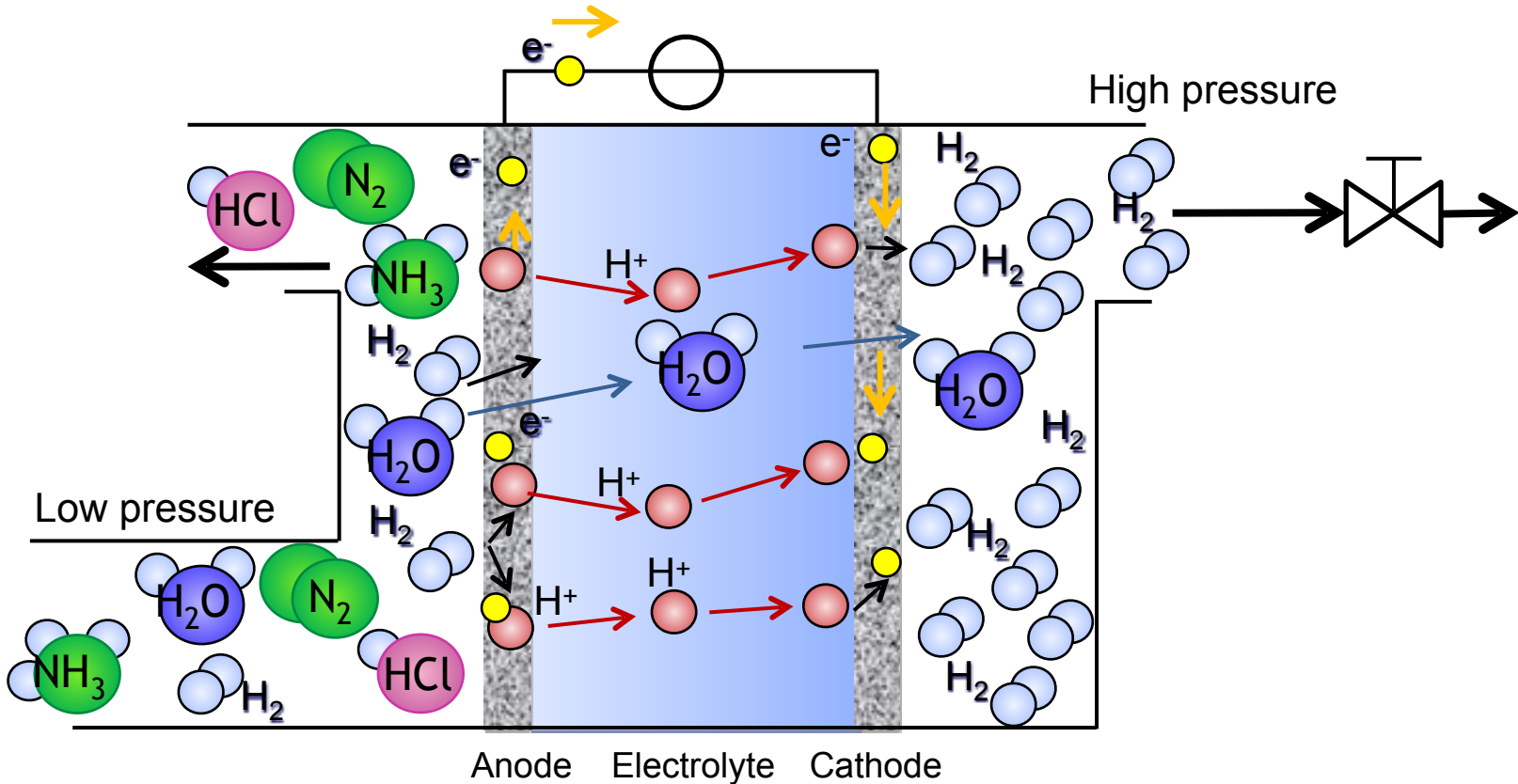


Hydrogen Recycling

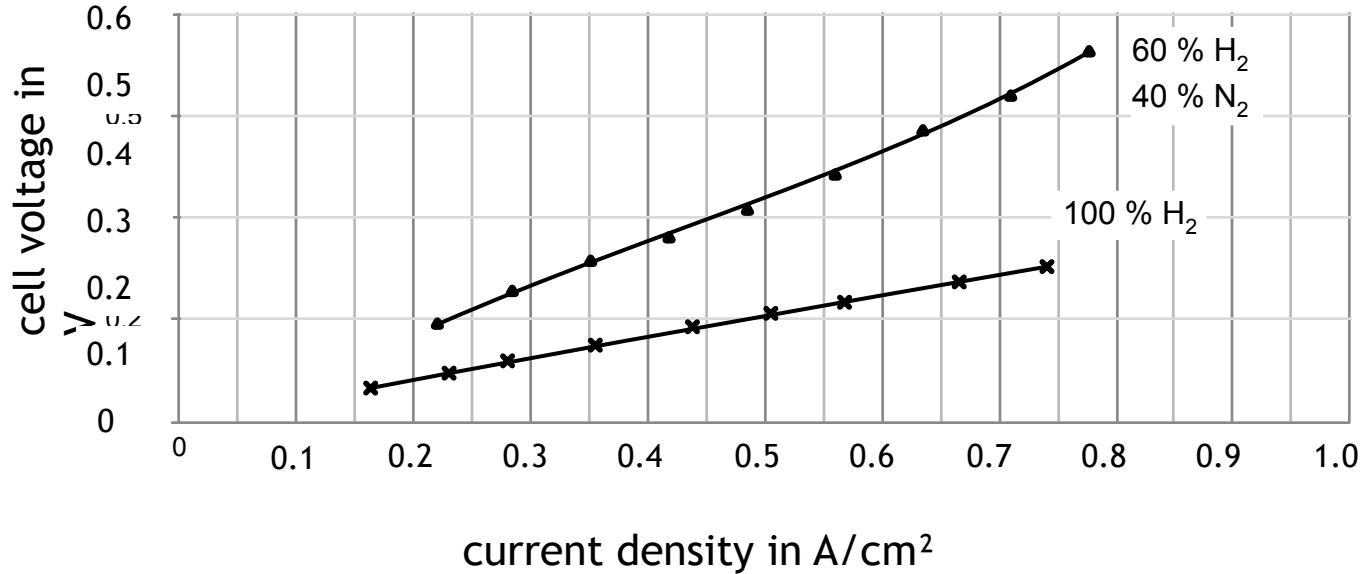
Gas compositions of waste gas from different sources

Source/ Molar % disregarding water	H₂	N₂	O₂	CH₄	CO₂	CO	Possible traces
Microelectronics industry	100 - 50	50 - 0					HCl, TCS
Semiconductor industry	60	40					HCl, PH₃, AsH₃, NH₃
Steel factory recycling	93	1	0.5	5	0.5	0.05	S, NH₃
Biomass gasification	30 - 60			20 - 25	3 - 40	1	S, NH₃
Forming gas (float glass)	75	25					S, NH₃

Hydrogen Recycling

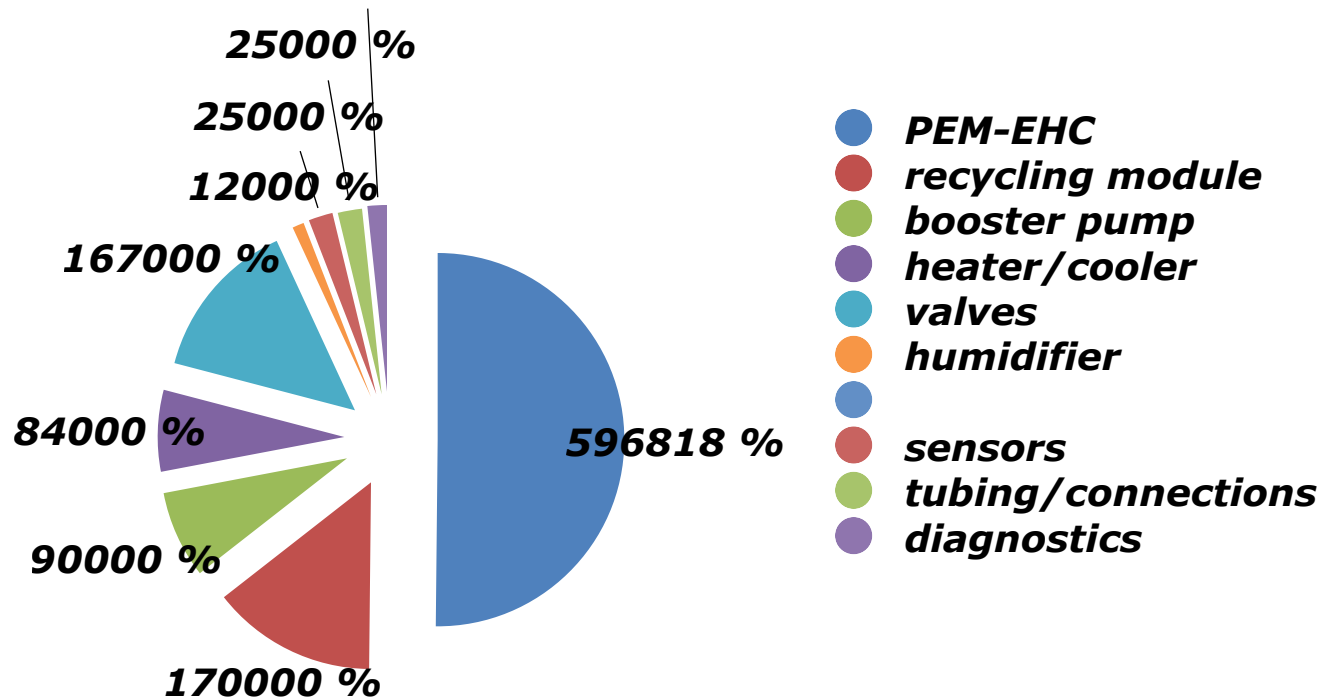


Hydrogen Recycling Single Cell Testing



current-voltage-characteristics of a measured cell for 80 °C and relative humidity of 80 %

Hydrogen Recycling Cost Distribution of Hydrogen Recycling System



Hydrogen Recycling

Project

„MEMbrane based Purification of HYdrogen System“ - MEMPHYS

01/2017 - 12/2019

Funded under Horizon2020



MEMPHYS is founded by the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement number 735533. The Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and N.ERGHY.

Thank you for your
attention.

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