Session 1: Energies Policies - Challenges and Opportunity for Transformation

Options for Future Mobility Systems - M. Fichtner (Helmholtz-Institute Ulm for Electrochemical Energy Storage)
Options for future mobility systems

EURO – CASE 2020, Zagreb

20. November 2020
Options for drivetrains

**Drive**
- Combustion engine
- Fuel Cell + Electric motor
- Electric motor

**Energy source**
- Gasoline; Diesel; Synfuel
- Methane; CNG
- Hydrogen
- Electric current

**Storage**
- Plastic tank
- 300 bar pressure tank
- 700 bar Pressure tank
- Battery
Consumption of fossil fuels on a historic timescale...
Situation crude oil: is there need for action?

(Ref.: IEA, World Energy Outlook 2018, p.159)

Independent institutes
(Ref. EWG, The Supply Outlook, 2013, p. 22)
From 2025 > 50% of the oil (from 2030 > 80%) must be provided from „unconventional sources“:

- Oil from fracking (shale gas)
- Oil from tar sands
- Oil from arctic region
- Oil from deep sea
How long does the „unconventional“ part last....?

<table>
<thead>
<tr>
<th>Source</th>
<th>Reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil from fracking (shale oil)</td>
<td>ca. 300 bn. barrel</td>
</tr>
<tr>
<td>Oil from tar sands</td>
<td>ca. 150 bn. barrel</td>
</tr>
<tr>
<td>Oil from the arctic</td>
<td>ca. 100 bn. barrel</td>
</tr>
<tr>
<td>Oil from deep sea</td>
<td>Total 550 bn barrel</td>
</tr>
</tbody>
</table>

(ref. Wirtschaftswoche 2015)

**How long does that last?**

- Daily consumption worldwide: 110 Mio barrel / day  
  → 550 bn. ÷ 0.11 bn./day = 5000 days

The residual oil lasts for approx. 13,5 years
Other options for energy supply in cars
Storage of renewable energy in batteries

stationary / home

portable

mobile

(www.bauen.de)

(www.hp.com)

(i2.wp.com)

(www.catchuk.org)
Development of costs and energy density from 1991 - 2015

Since market introduction:
Energy density x3
Costs ÷15

Cost goal for 2020

The great industrial challenges

Provision of storage applications of > 1000 GWh/year

Production capacities

Availability of raw materials
Sustainability

Battery costs

Recycling capacities

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Worldwide largest recycling plant from UMICORE for Li ion batteries at Hoboken/Belgium
- capacity 8,000 t/year
- for 17 metals, including Co, Ni, Cu, ...
- no Li

Batteries sold today in cars have a lifetime of ca. 0.8-1 Mio km → several uses after the „first life“

For 2030 and beyond, > 10 more plants of this capacity would be needed in Europe
Electric Drives as more efficient method for propulsion
Losses from „well“-to-wheel: All electric versus Hydrogen/FC

**Production**

- **Hydrogen (H₂):** 100%
- **30-40% Reduction**

**Processing**

- **12-40% Reduction**

**Transport**

- **5% Reduction**

**Fuelling**

- **30-40% Reduction**

**Conversion (FC)**

- **50% Conversion**
- **5-10% Efficiency**

**Electric motor**

- **Rest: 15-18%**

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**All Electric (Battery)**

- **100% Efficiency**
- **0% Losses**
- **5% Efficiency**
- **10-15% Efficiency**
- **0% Conversion**
- **5-10% Efficiency**

**Electric motor**

- **Rest: 70%**
Losses from „well“-to-wheel: All electric versus E-Fuels

**ALL ELECTRIC (BATTERY)**
- **Processing:** 0%
- **Transport:** 5%
- **Charging (Battery):** 10-15%
- **Conversion:** 0%
- **Electric motor:** 5-10%
- **Rest:** 70%

**E-FUELS**
- **H2 Gen + FT**: 40-50%
- **Conditioning**: 5-10%
- **Transport**: 5%
- **Fueling**: 0-5%
- **Combustion Engine**: 75-80%
- **Rest**: 8-10%
Energy demand transport sector with H₂–FC oder all-electric

Scenario for required energy demand

Transport 2018: 751 TWh

150-200 TWh
only BEV
only H₂-FC

(Umweltbundesamt/AG Energiebilanzen, 2020)

Fahrzeug mit Verbrennungsmotor: ca. 20-24% Wirkungsgrad
Kette für H₂/BZ: nur 15-18% Wirkungsgrad → höherer Energiebedarf
Conclusion

▪ The CO₂ requires turning away from the fossil resources. The resource situation makes it mandatory.

▪ In addition to technical requirements such as energy content, lifetime, safety, and cost, sustainability has become another major factor for the development.

▪ General alternatives: H₂ has a higher energy content and may have advantages in heavy duty vehicles, ships, and airplanes.

▪ Problem: H₂ or e-Fuels need 4-8x more energy in the chain.

→ there is no „ideal solution“.

→ Batteries should be used for cars and home storage.

→ H₂ or „Power-to-X“ for heavy duty, ships, airplanes and seasonal storage.
www.hiu-batteries.de
www.celest.de

Thank you !
Zusatzfolien
Hydrogen and fuel cells

- Fast charging (5 min)
- CO₂ reduction potential
- Zero emissions at car
- Heavy duty trucks possible

Fuel Cell

\[ 2H_2 + O_2 \rightleftharpoons 2H_2O + \]

Electrolysis

- \(H_2\) only indirectly generated via electricity or other fuels. Losses.
- Infrastructure hardly exists, low efficiency, losses.
- 40 fillings per day/station
- Converter (fuel cell) with 50% losses
- Storage on board in 700 bar pressure tanks
- Platinum in fuel cell and electrolyzer: rare metal, bad mining conditions
Kumulated CO₂ Emissions battery cars / Diesel / Gasoline

**Charging times**

50 L in 3 min

1 L ≈ 0.75 kg → 37.5 kg Gasoline
Gasoline ≈ 11.5 kWh/kg → 432 kWh

3 min = 1/20 h

➔ 8.6 MW power when refueling

➔ 22.2 kW power at charging station

Factor 400 less

High energy in chemical bonds

Flow of electrons through metal

TESLA Model 3: charges **500 km driving range** in 20 min.
(Supercharger)
Nutzung der Batterie in unterschiedlichen Phasen

First Life

End of First Life

ca. 10 Jahre 4.000 Zyklen

Second Life

End of Second Life

ca. 20 Jahre 8.000 Zyklen

Recycling oder Remanufacturing

Batteriekapazität

100%

80%

50%

Grafikquelle: E. Rahimzei/VDE 2017
Fraction of cobalt in cathode material of Li ion-batteries

- Fractions:
  - Tesla: 2.8% Co
  - NMC 111
  - NMC 622
  - NMC 811
  - Mn-spinel
  - BASF

(NMC: $\text{Ni}_x\text{Mn}_y\text{Co}_z\text{O}_2$)