Green Hydrogen and Power to X
Silver Bullet for Decarbonizing Transport?

Lecture at TCCW 2020
Wednesday, 4th March 2020, 2 – 3pm

Charlotte Hussy & Heino von Meyer

International PtX Hub – Berlin
Catalysing green hydrogen solutions on a global scale
Clip explaining Power-to-X can be found online: https://www.changing-transport.org/video-power-to-x-how-does-it-work/
Why Power to X in transport?
The transport sector still heavily depends on fossil fuels and cannot be electrified directly.

Transport energy use by fuel type

- 96% Fossil fuels
- 3.1% Renewable energy
- 1.2% Biofuels
- 0.3% Renewable electricity
- 0.01% Non-renewable electricity
- 1.6% Biomethane
- 1.0% Ethanol
- 3.1% Other renewable fuels

CO₂ emissions in transport

- 24% Transport
- 5.2% Aviation & Shipping
- 6.6% Surface Freight
- 11.8% Surface Passenger Transport
- 11.8% Surface Passenger Transport
- 11.8% Surface Passenger Transport

Source: IEA (2017); ITF (2017); Irena, IEA, & Ren21 (2018).
The transport sector is testing and investing in hydrogen and Power to X systems.

Source: Amelang (2018); Hill (2020); Kanter (2013); Ohnsman (2019); Pico (2020); U.S. Air Force (2006).
How does it work – Power to X?
Power to X is the conversion of electric power to other forms of energy carriers for use in different sectors.
Example: PtX for fuel production in Germany and The Netherlands

Source: KIT (2019); Zenid & Climeworks (2020).
How to use Power to X in transport?
How efficient would you rate the three different technology options?

<table>
<thead>
<tr>
<th>Technology</th>
<th>Overall efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery-electric</td>
<td></td>
</tr>
<tr>
<td>Renewable power 100%</td>
<td></td>
</tr>
<tr>
<td>Fuel cell</td>
<td></td>
</tr>
<tr>
<td>Renewable power 100%</td>
<td></td>
</tr>
<tr>
<td>Internal combustion engine with PtX</td>
<td></td>
</tr>
<tr>
<td>Renewable power 100%</td>
<td></td>
</tr>
</tbody>
</table>

Please take part at the short survey: - [www.menti.com](http://www.menti.com); digit code **77 10 85**

The direct use of electricity – if viable – is 5 times more efficient than synthetic fuels burned in internal combustion engines.

<table>
<thead>
<tr>
<th>Technology Option</th>
<th>Renewable Power</th>
<th>Overall Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Battery-electric vehicles</strong></td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Transmission (Dis-)charging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery use 86%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric motor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical losses</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fuel cell</strong></td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Transmission Electrolysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen 67%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compression/Transport Fuel cell</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity 32%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric motor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical losses</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Internal combustion engine with PtX</strong></td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Transmission Electrolysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen 67%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power-to-Liquid Transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid fuel 44%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal combustion engine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical losses</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Synthetic E-fuels should be used predominantly in areas in which the direct use of electricity is neither technically nor economically viable.

**First priority of direct use of electricity**

- Inland waterway transport

**Supplemental approach for Hydrogen**

- Trains without overhead lines
- Long haul trucks and buses without overhead lines

**Supplemental approach for CO₂-based PtG and PtL**

- Long haul trucks and buses without overhead lines

The future costs of synthetic fuels depend on the costs of power generation (CAPEX+OPEX), and the capacity utilization of conversion facilities.

**Generation costs of synthetic methane in North Africa (PV) and comparison with conventional fuel types (ct/kWh\textsubscript{methane})**

*Source: based on Agora Verkehrswende (2018).*

**Conversion costs** (electrolyser etc.) are very sensitive to the load factor.

- **Full load hours:**
  - 2000 h: approx. costs: 20 ct/kWh
  - 8000 h: 5 ct/kWh
Where Power to X?
The key factor for potential prime PtX locations is the cost of renewable energy

The main part of PtX power currently installed, is located in Germany. Countries such as Morocco and Chile are speeding up PtG project allocation differentiated according to the target products hydrogen and methane as well as activity/inactivity.

Sustainability assessments must be based on comprehensive sets of economic, social, ecological and governance criteria.

**ECONOMIC** i.a.:
- Decoupled growth
- Local added value
- Job creation
- Export Revenue

**SOCIAL** i.a.:
- Human Rights, e.g.:
  - Free, prior, informed consent
- Core labour standards
- Energy poverty
- Access to infrastructure
- Working conditions
- Training

**ECOLOGIC** i.a.:
- Additionality of renewable energy
- Closed CO₂ Cycle
- Water management
- Land use
- Biodiversity

**GOVERNANCE** i.a.:
- Political stability
- Rule of law
- Transparency
- Institutionalisation
- Property and user rights
- Connectivity

Reference Docs:
- RED II,
- UNGP, UN Global Compact, ILO
- OECD MNE Guidelines and Due Diligence Guidance
Sustainability concerns have to be considered at every step of the PtX global value chain.

Assessing:
- Opportunities
- Risks
- Impacts

Power generation location
Transmission Networks
Electrolyser Location
Impact / Risks
CO₂ capture
H₂ storage transport infrastructure

Domestic
Supply / Demand

International
Import / Export

Use options in transport
Use options in industry
Type of Liquid / Gas
Refinery / Fischer-Trobsch Synthesis

X = Various Use Options

Customer

Power to H₂
H₂ to X
Clip explaining Power-to-X can be found online: https://www.changing-transport.org/video-power-to-x-how-does-it-work/

POWER TO X

and reduce dependence on petroleum and natural gas worldwide.
The International PtX Hub

@giztransport
Changing-transport.org