Assessment of system variations for hydrogen transportation by LOHCs

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Agenda

Introduction

System definition

Environmental assessment

Economic assessment

Conclusions

Introduction

Hydrogen for mobility in Germany mainly from wind energy in northern parts

→ long transport distances to supply southern parts e.g. Munich

Source: Fotolia© DeVIce

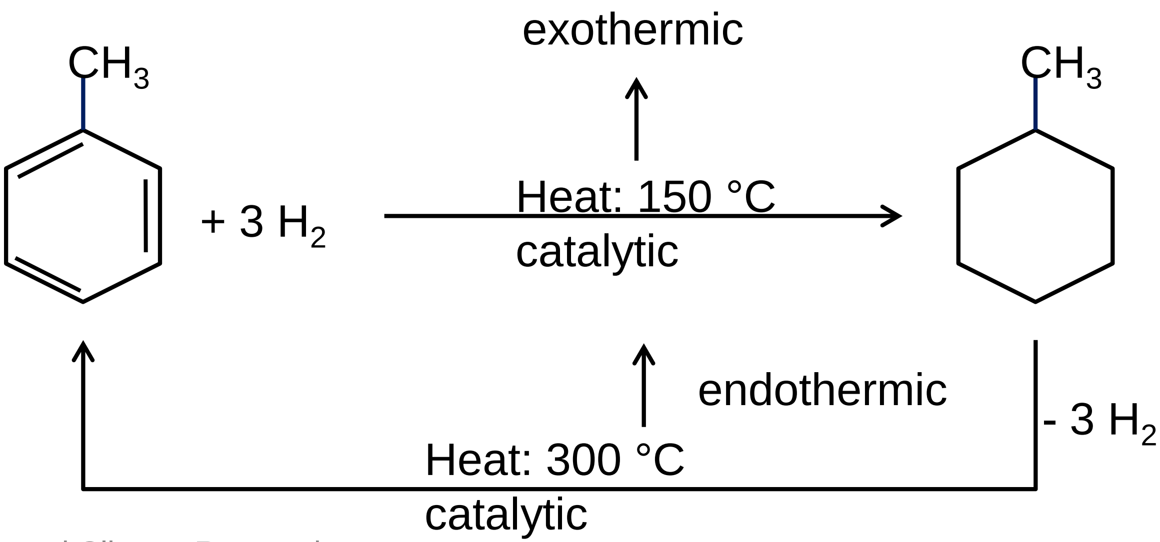
Road transport of hydrogen for long distances

→ Liquefied hydrogen

→ Liquid organic hydrogen carriers (LOHC)

Long distance distribution: Liquid Organic Hydrogen Carriers

- Chemical compounds that bind hydrogen
- Up to 6.2 wt% stored hydrogen in LOHC possible
- Liquid can be handled like mineral oil products
- Possible compounds: e.g. dibenzyltoluene or toluene/ methylcyclohexane



Long distance distribution: Liquefaction of H_2

Hydrogen is liquid below -253 °C → complex process

- Compression to 25 till 80 bar
- Precooling with liquid nitrogen to -140 till -190 °C
- Cryocooling with Brayton cycle (expansion turbine)
- Expansion of pressurized gas in a valve (usage of Joule-Thomsen effect)

→ electric energy intensive

Goal and Scope

Provision of 1 kg hydrogen at 700 bar for mobility applications at a hydrogen refuelling station in Germany

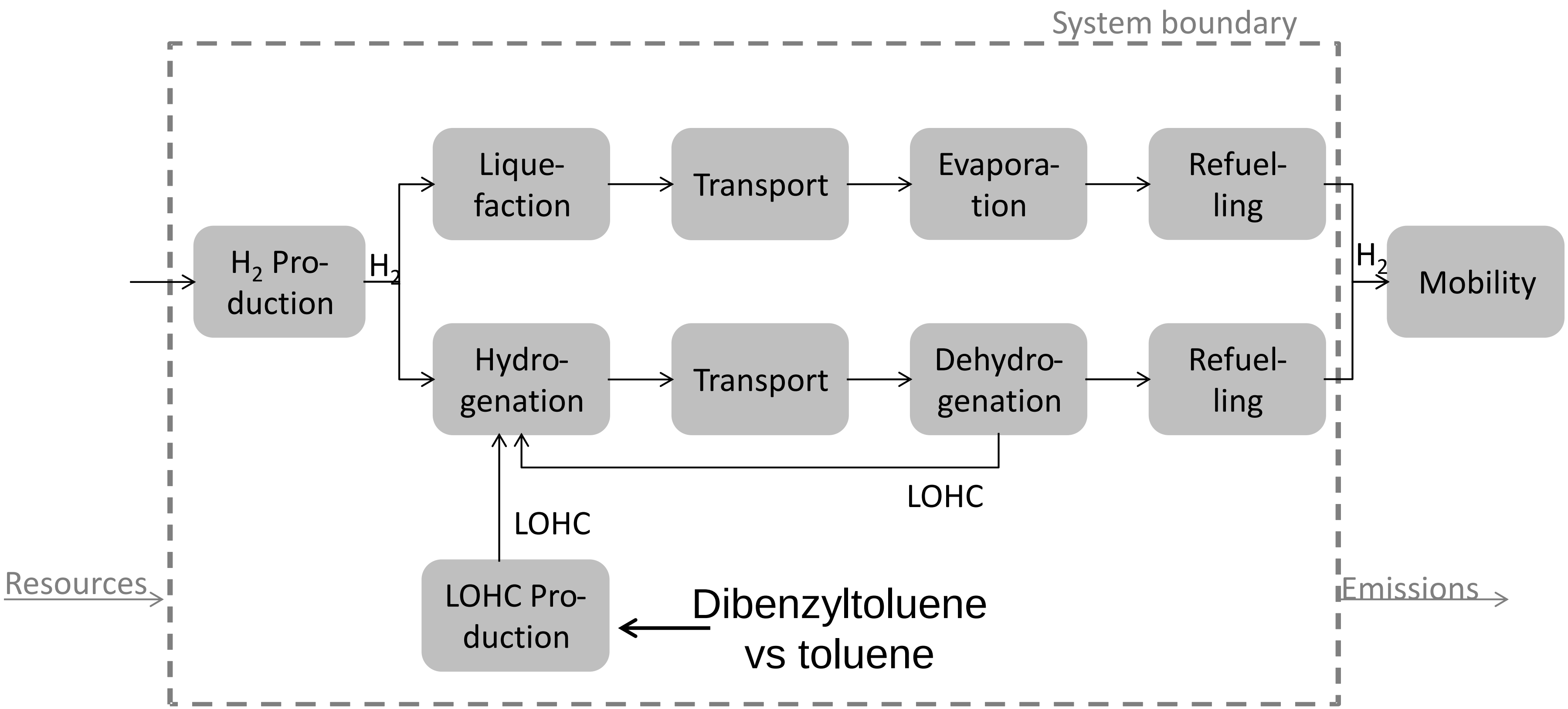
Comparison of truck transport within LOHCs with transport of liquefied H_2

State of the technology 2050

Analysis of impact categories according to ILCD

- Climate change
- Acidification
- Eutrophication
- …

System Definition



Important Parameters

Alkaline water electrolysis:

- Production capacity: 118 kg H_2/h
- Electricity: 49 kWh/kg H_2

Transport

- Travelling distance: 400 km
- Average speed: 50 km/h

Liquefaction

- Electricity demand: 6.76 kWh/kg H_2
- Transport capacity: 4300 kg/trip

Hydrogenation/Dehydrogenation

- Heat demand: 9.5 – 10 kWh/kg H_2
- Transport capacity: 1800 kg/trip

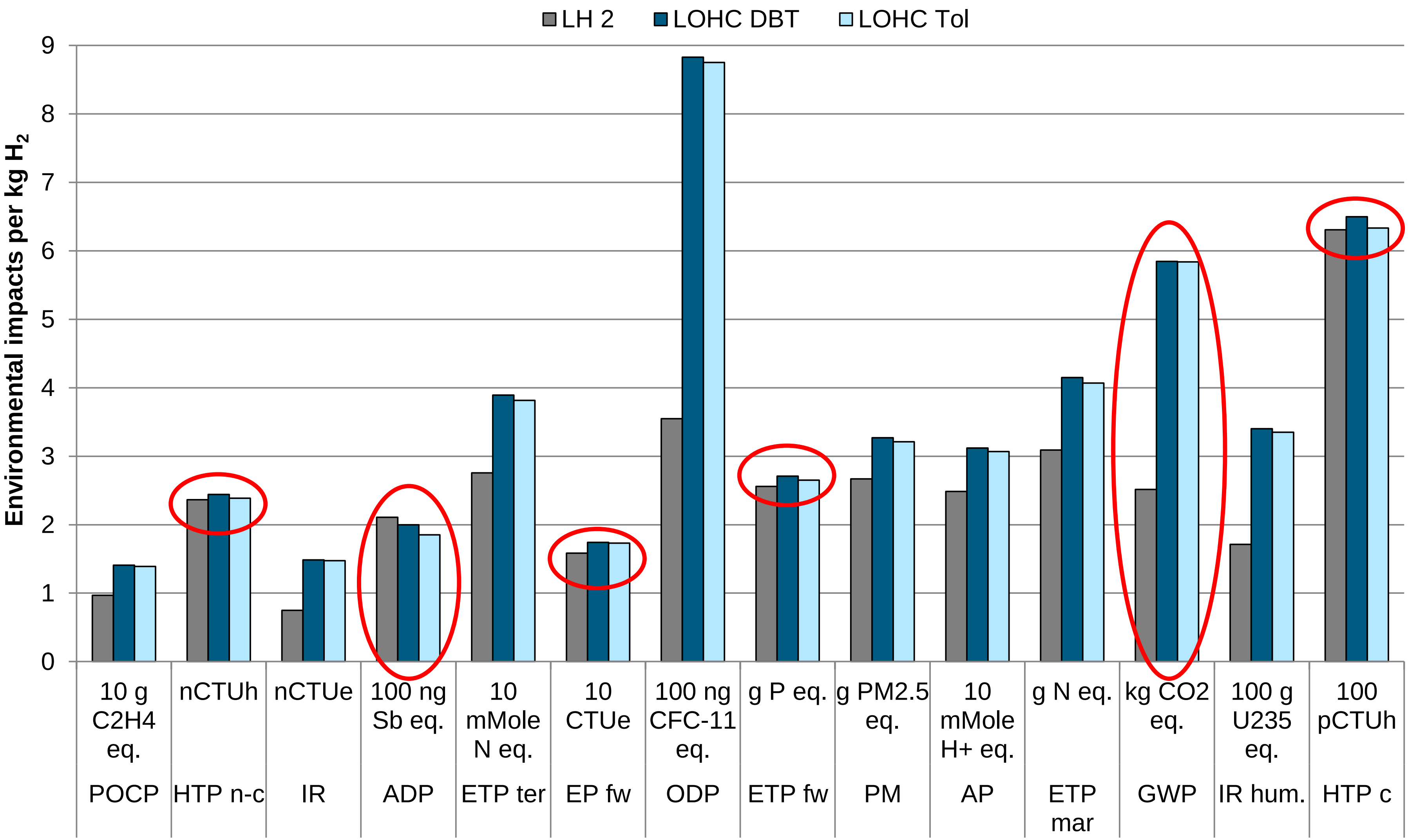
Cost analysis

- Interest rate: 3.5 %
- Depreciation period: lifespan

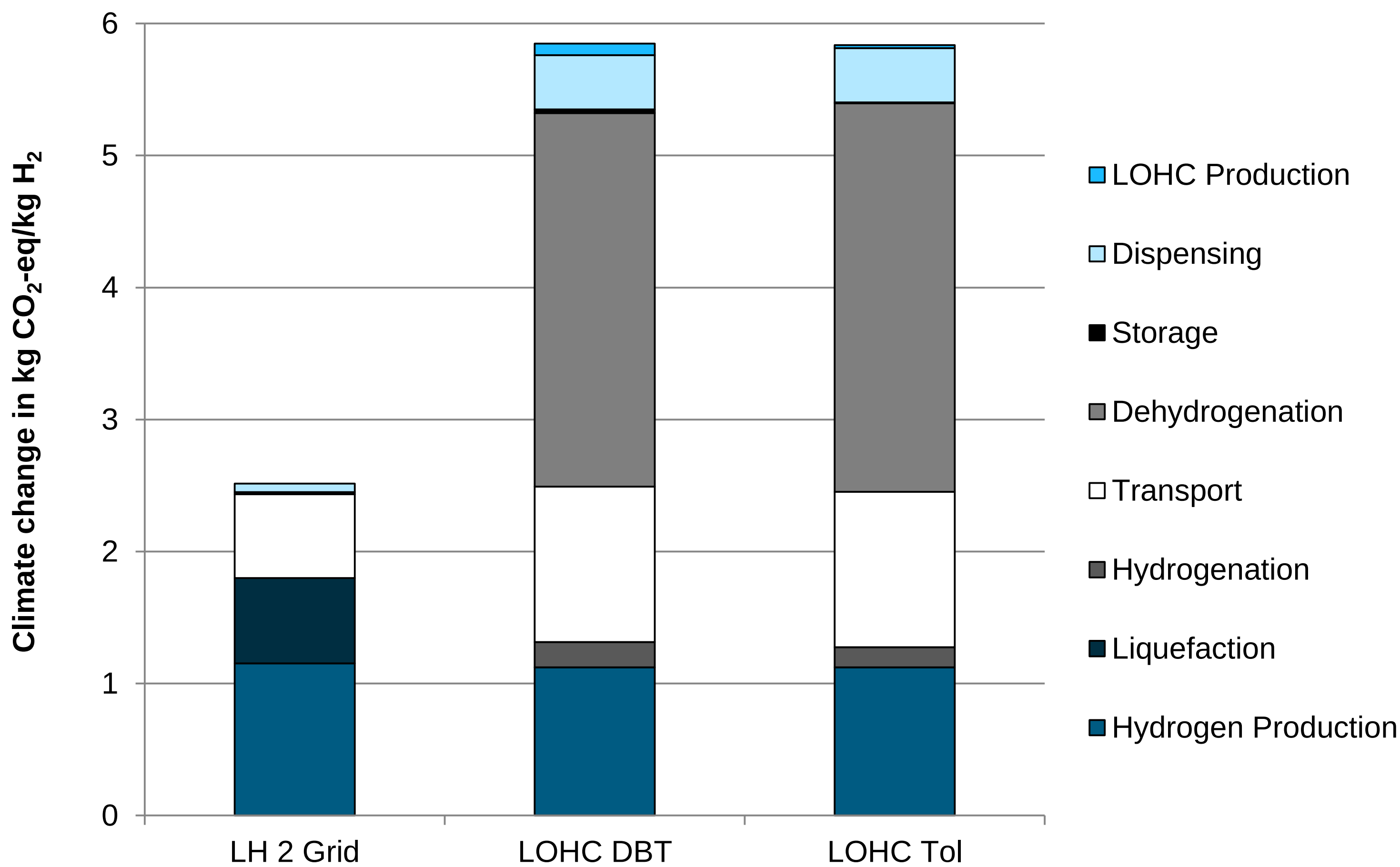
Refuelling station

- 850 kg/day
- 70 % capacity utilization

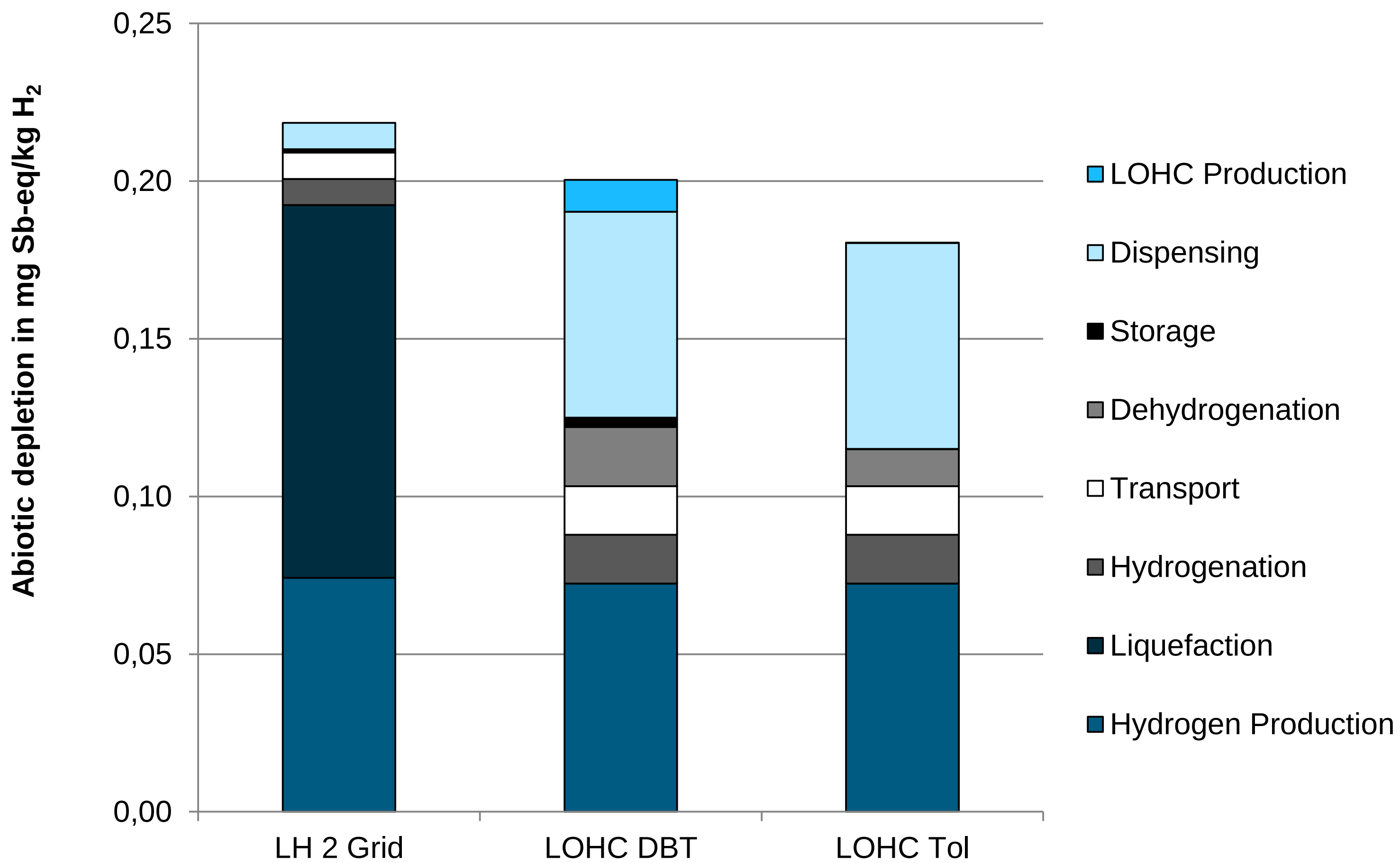
LCA results


LH 2
LOHC DBT
LOHC Tol
Environmental impacts per kg H_2
9
8
7
6
5
4
3
2
1
0
10 g C2H4 eq.
POCP
nCTUh
HTP n-c
nCTUe
IR
100 ng Sb eq.
ADP
10 mMole N eq.
ETP ter
10 CTUe
EP fw
100 ng CFC-11 eq.
ODP
g P eq.
ETP fw
g PM2.5 eq.
PM
10 mMole H+ eq.
AP
g N eq.
ETP mar
kg CO2 eq.
GWP
100 g U235 eq.
IR hum.
100 pCTUh
HTP c

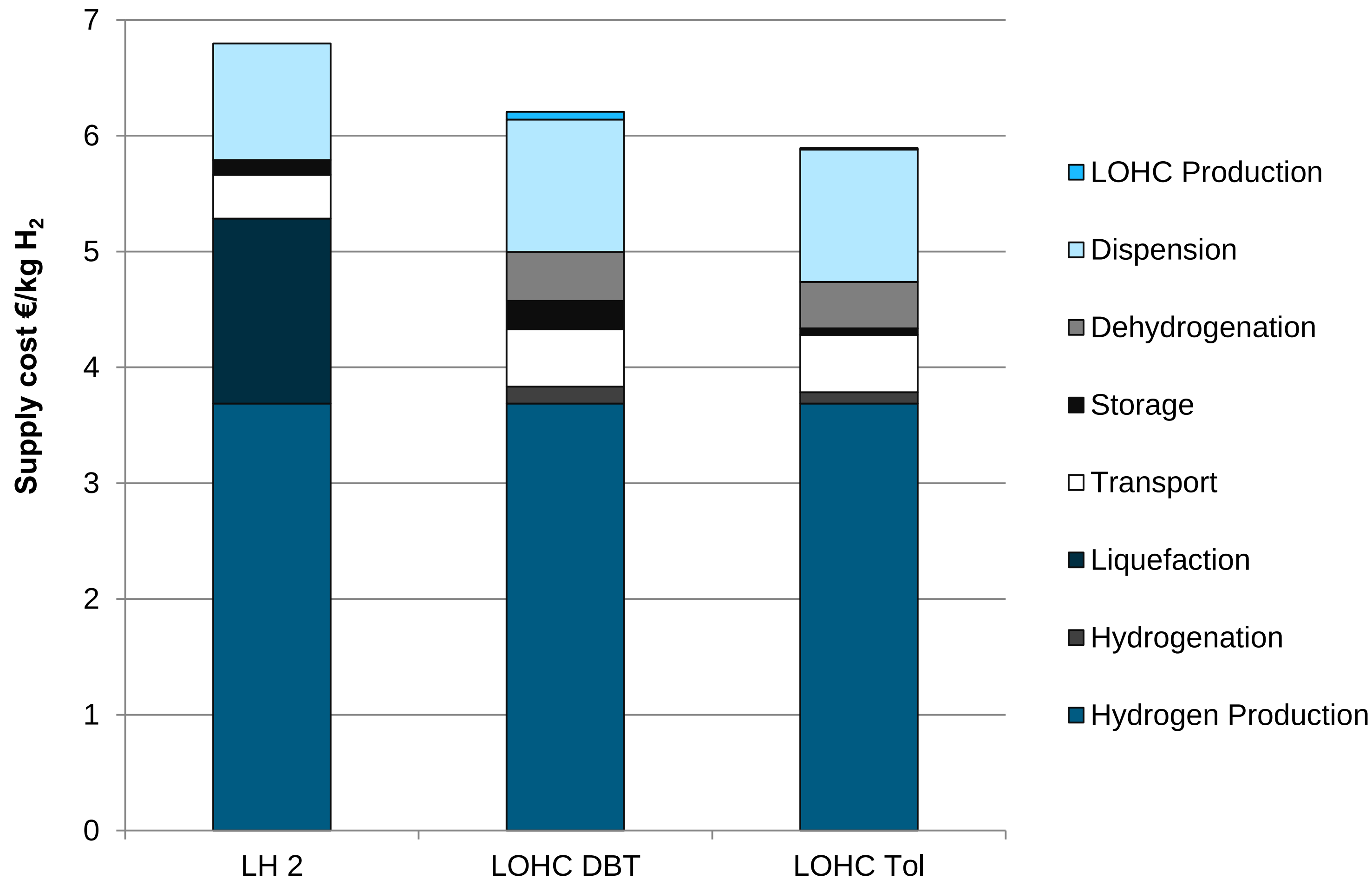
LCA results climate change



LCA results resource depletion



Cost results



Conclusions

- Costs for LOHC transport with toluene is better than LH2 transport (lower invest)
- Due to high heat demand higher impact on climate change and other impact categories for LOHC than LH2
- For human toxicity and freshwater impacts all analyzed options at the same level
- Depletion of resources only environmental impact category with bad results for LH2
- Toluene slightly better than dibenzyltoluene in costs as well as environmental impacts – higher risk potential due to toxicity

LCM Conference Series

JÜLICH FORSCHUNGSZENTRUM

Energy System 2050 

Thank you for your attention!

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