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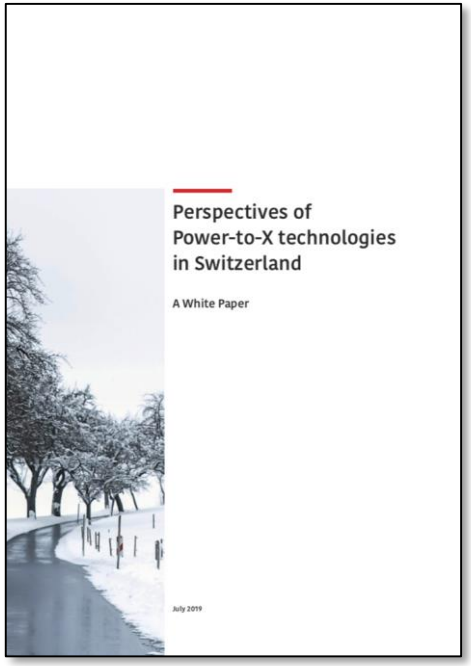
Tom Kober :: Laboratory for Energy Systems Analysis :: PSI

Perspectives of Power-to-Gas Technology in Switzerland

UNECE: Pathways to Sustainable Energy - Deep-dive Workshop on Gas**, 24 Sep. 2019, Geneva**

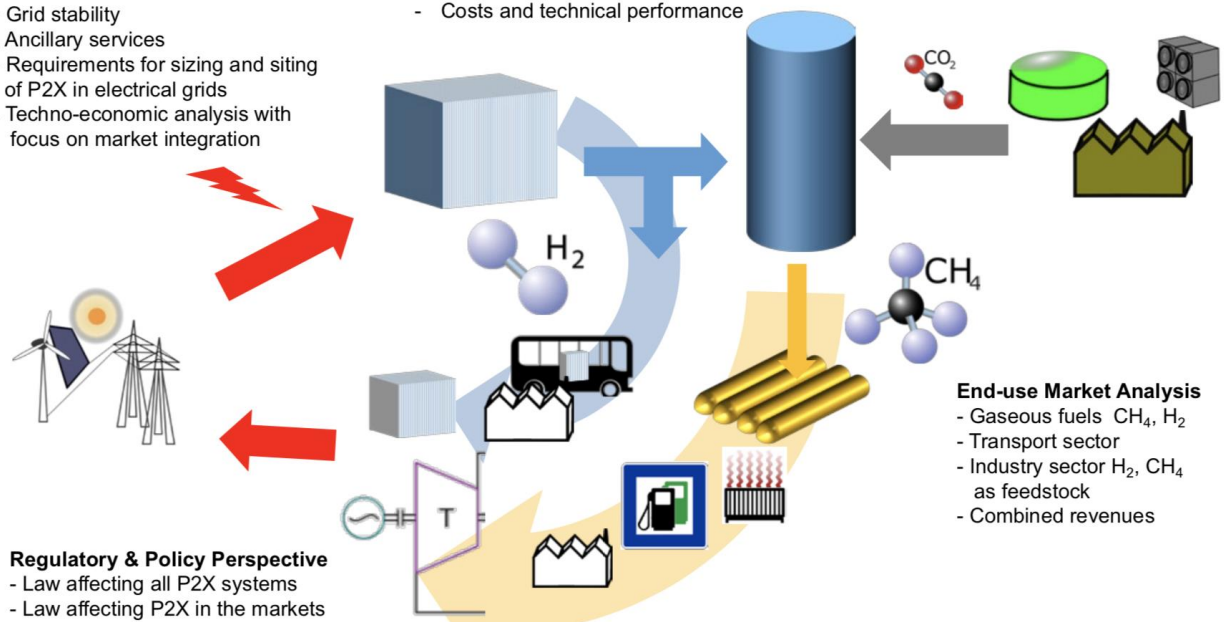
White Paper: comprehensive evaluation of Power-to-gas technology based on existing research



Power System Perspective
- Present and future situation
- Grid stability
- Ancillary services
- Requirements for sizing and siting of P2X in electrical grids
- Techno-economic analysis with focus on market integration

Techno-Economic Perspective
- P2X pathways
- Key components and processes
- Costs and technical performance

CO_2 Sources and Markets
- Biogenic
- Industrial
- Direct Air capture



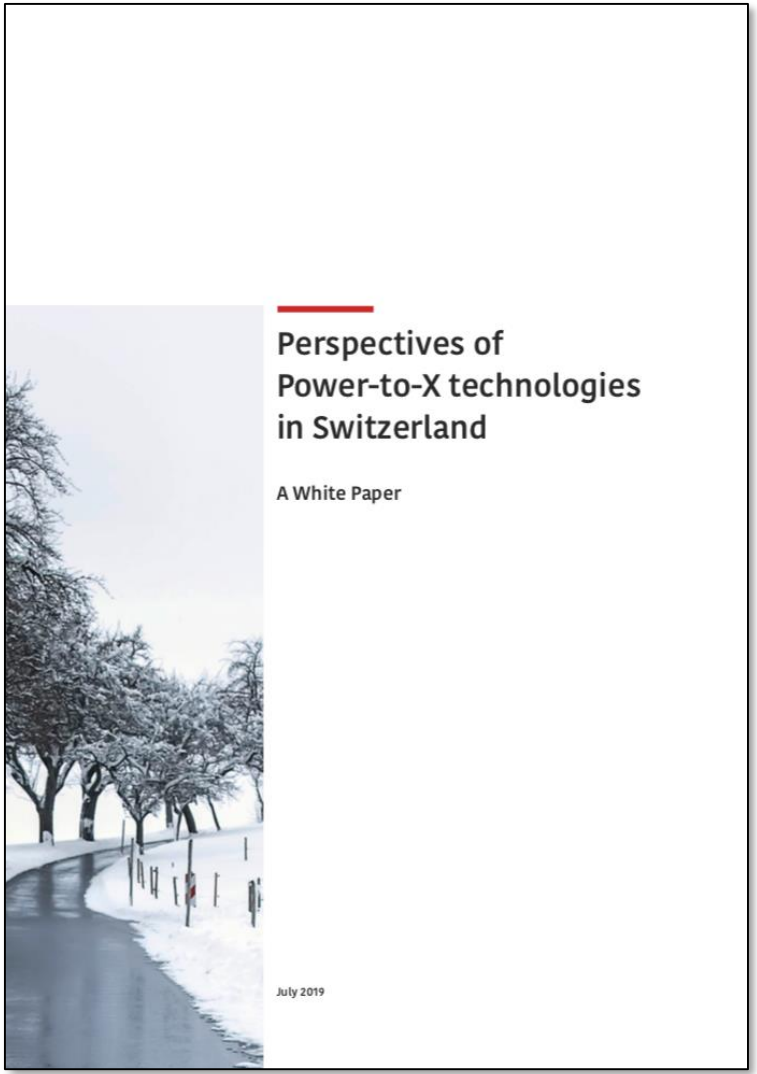
End-use Market Analysis
- Gaseous fuels CH_4, H_2
- Transport sector
- Industry sector H_2, CH_4 as feedstock
- Combined revenues

Regulatory & Policy Perspective
- Law affecting all P2X systems
- Law affecting P2X in the markets
  - Electricity
  - Transport
  - Heating
- Innovation policy

Environmental Perspective
- Life Cycle Analysis
- Compare P2X with conventional technology

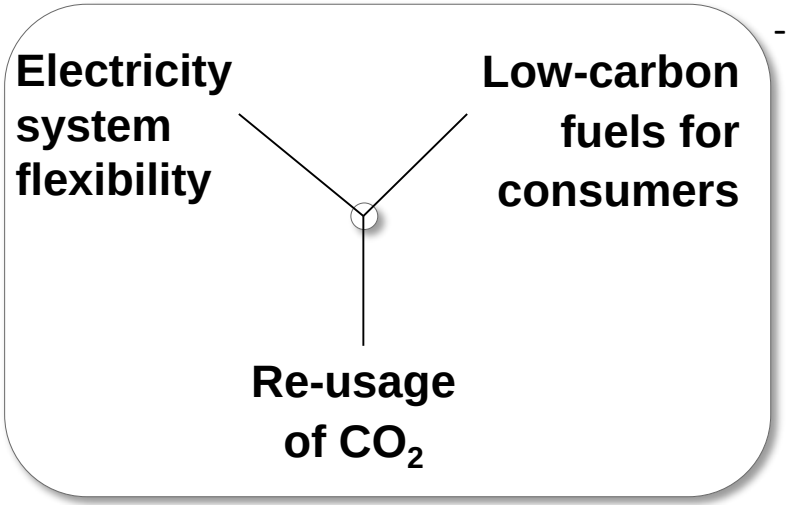
Key insights

- Benefit of Power-to-Gas unfolds in the combination of its values on multiple markets
- Low CO_2 intensity and cost of electricity is key as well as a sufficient high amount of operating hours
- At high shares of VRES, P2X is part of the cost-efficient solution to provide system flexibility
- Location of plants matters
- Competitiveness of P2X challenged if legal framework not adjusted
- Revenues from P2X by-products (heat and oxygen)
- Stringent climate policy, combined with R&I on learning by using and new business models



Value through access to multiple markets & sector coupling

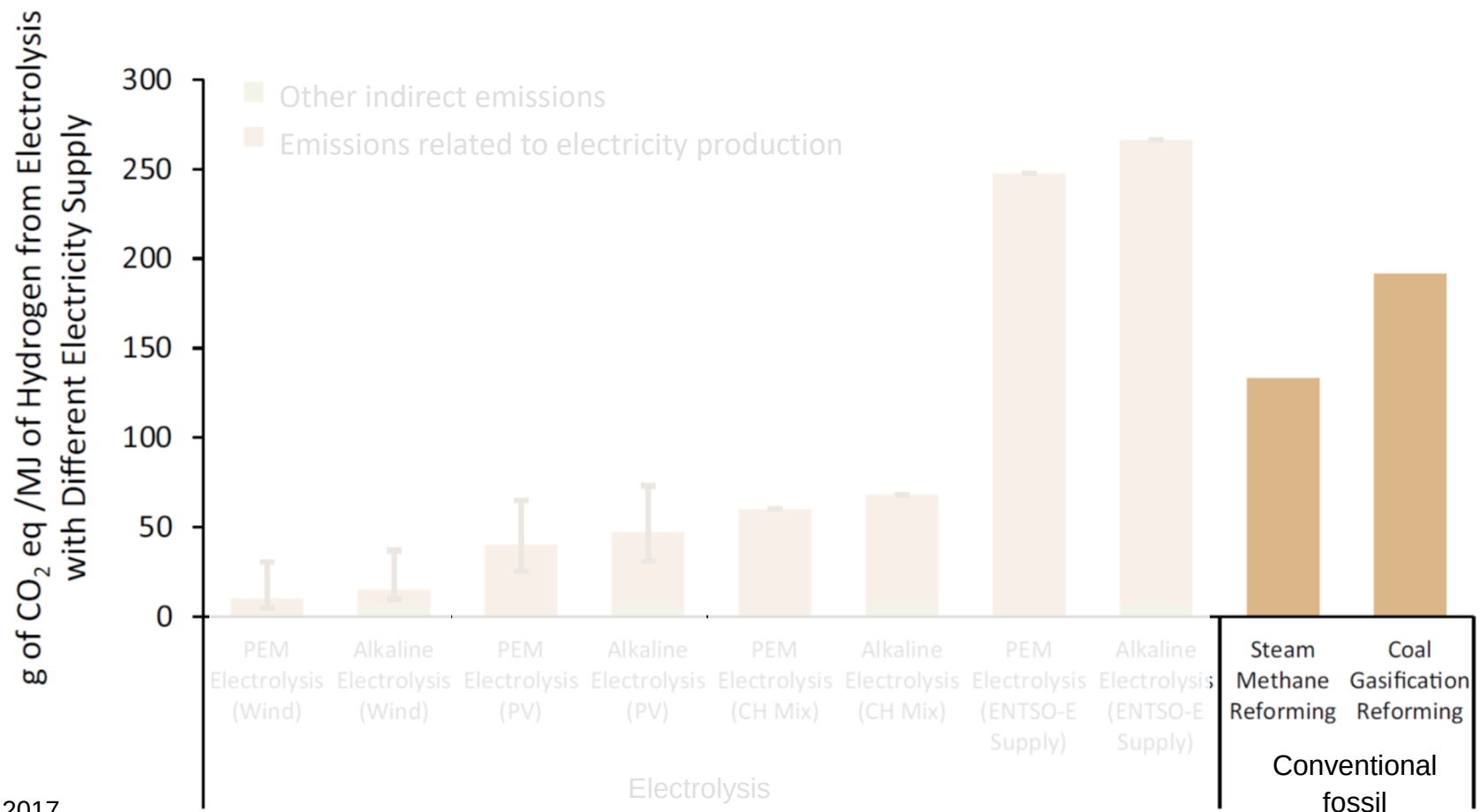
- Allows integration of high shares of wind and solar
- Seasonal energy shifts
- Provision of system services



- H_2 for long-distance heavy freight transport
- Synthetic methane and H_2 for heating purposes

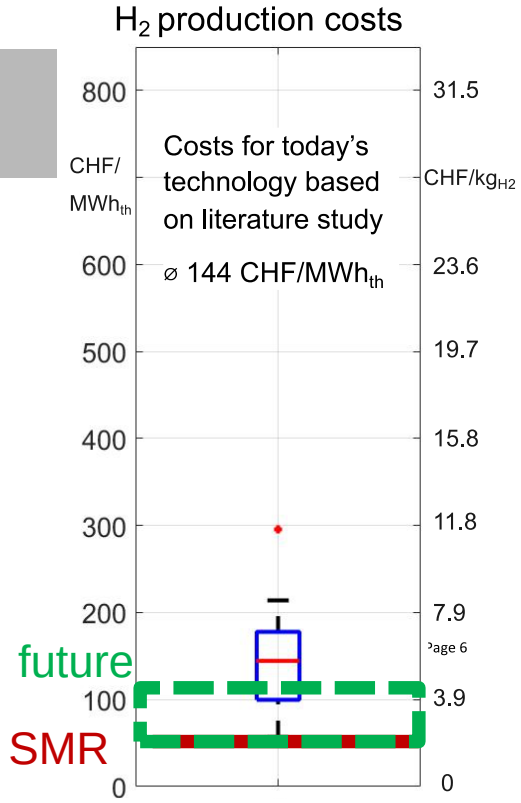
- Usage of process-related CO_2 emissions (i.e. cement)
- Direct air capture

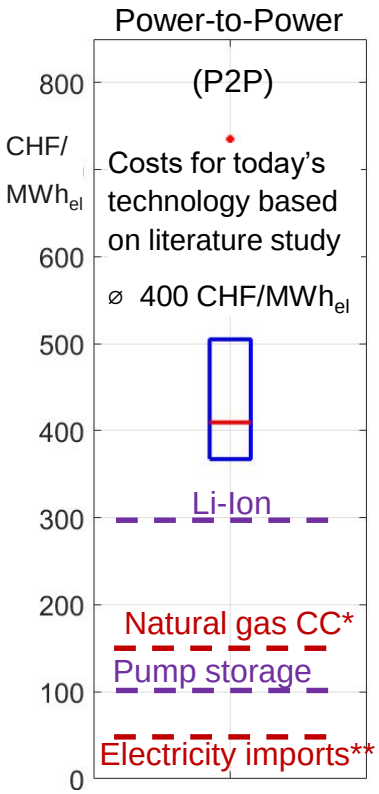
GHG performance of hydrogen production

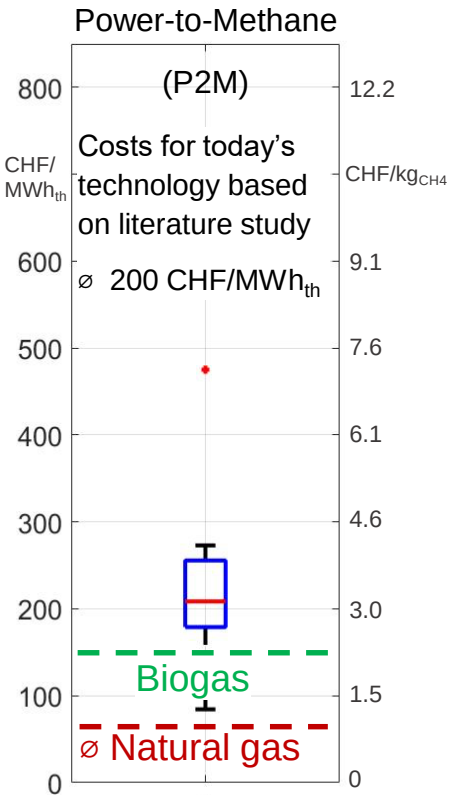


Zhang et al. 2017

Costs & markets

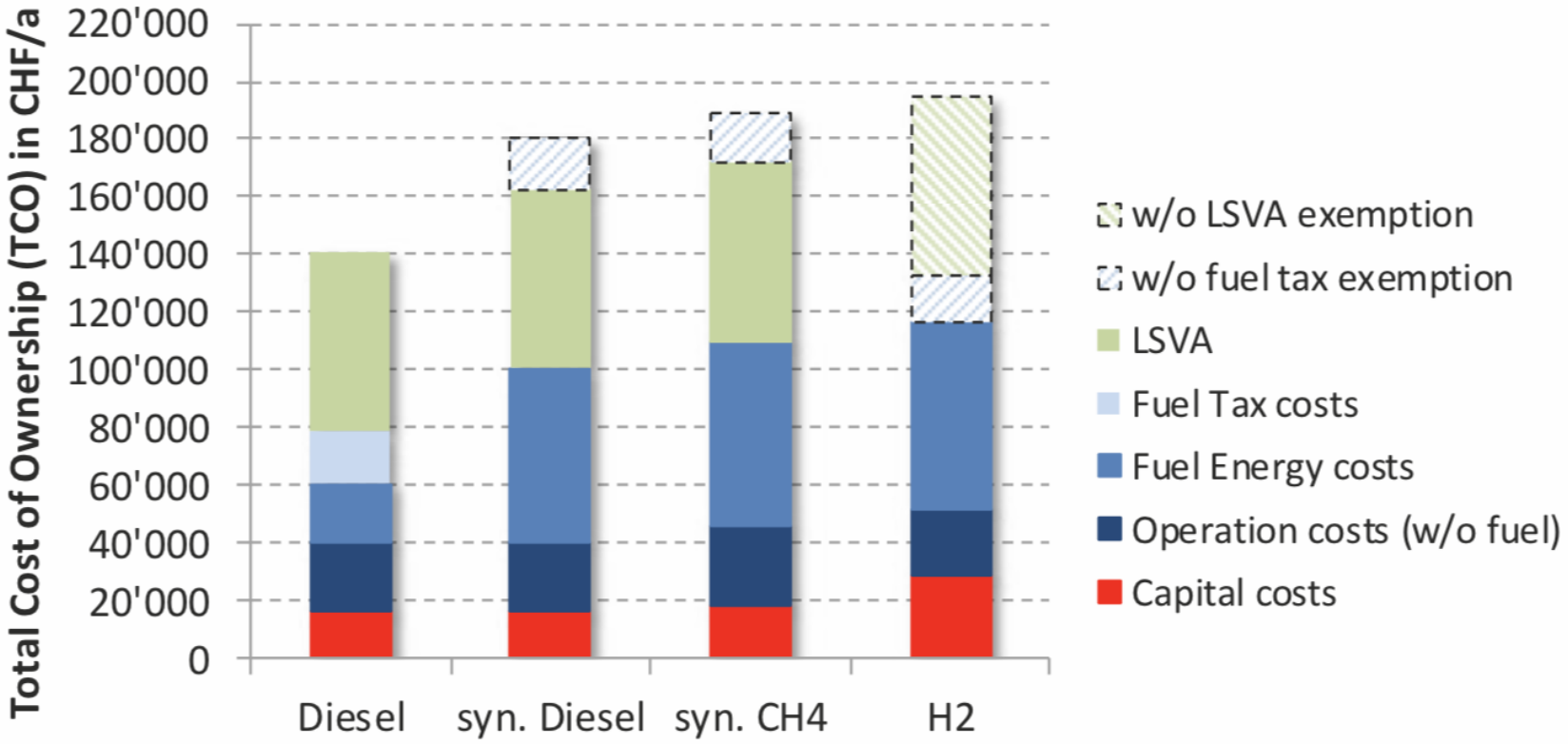






* Bauer and Hirschberg 2017; **average costs of electricity purchases from abroad in 2016 (BfE, 2018)

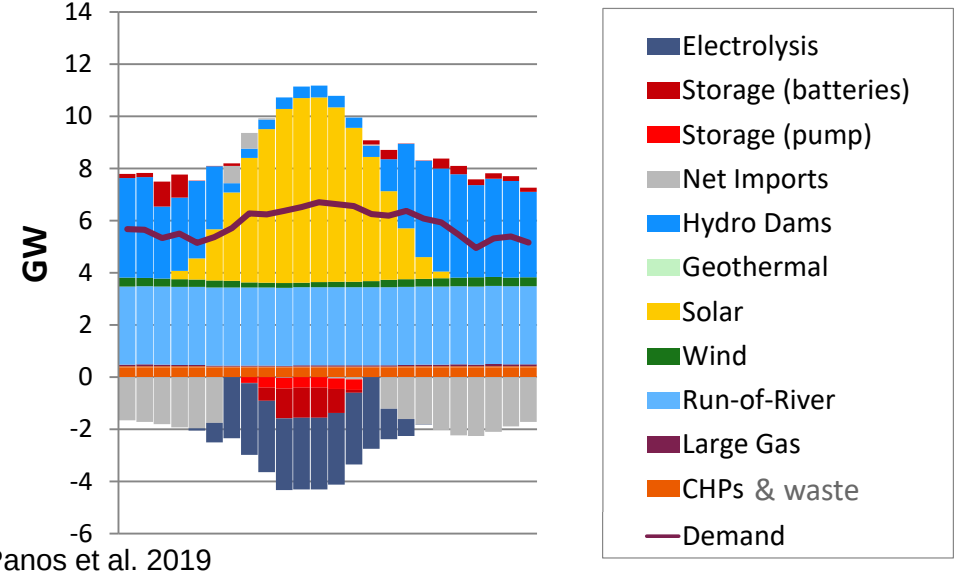
H2 fueled electric trucks benefit from tax exemption



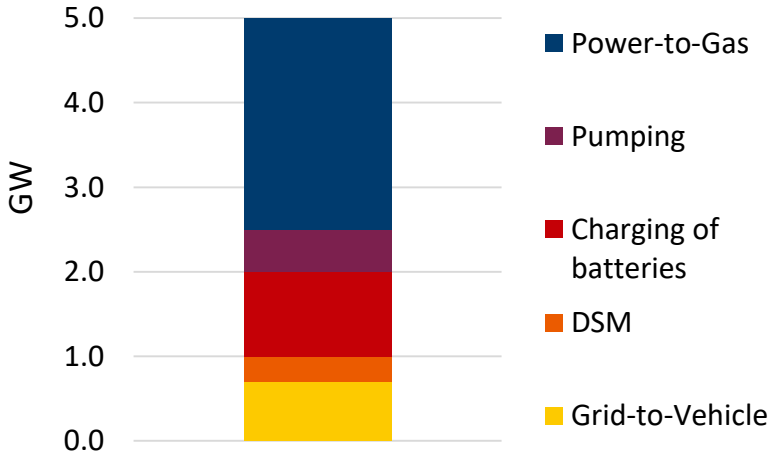
At high shares of VRES, **P2X is part of the cost-efficient solution** to provide **system flexibility**

- All options needed on the table to cope with variability in a cost-effective way
- Hydropower remains a strategic asset for renewable integration and cross-border trade

Summer Saturday electricity mix in Climate scenario, 2050



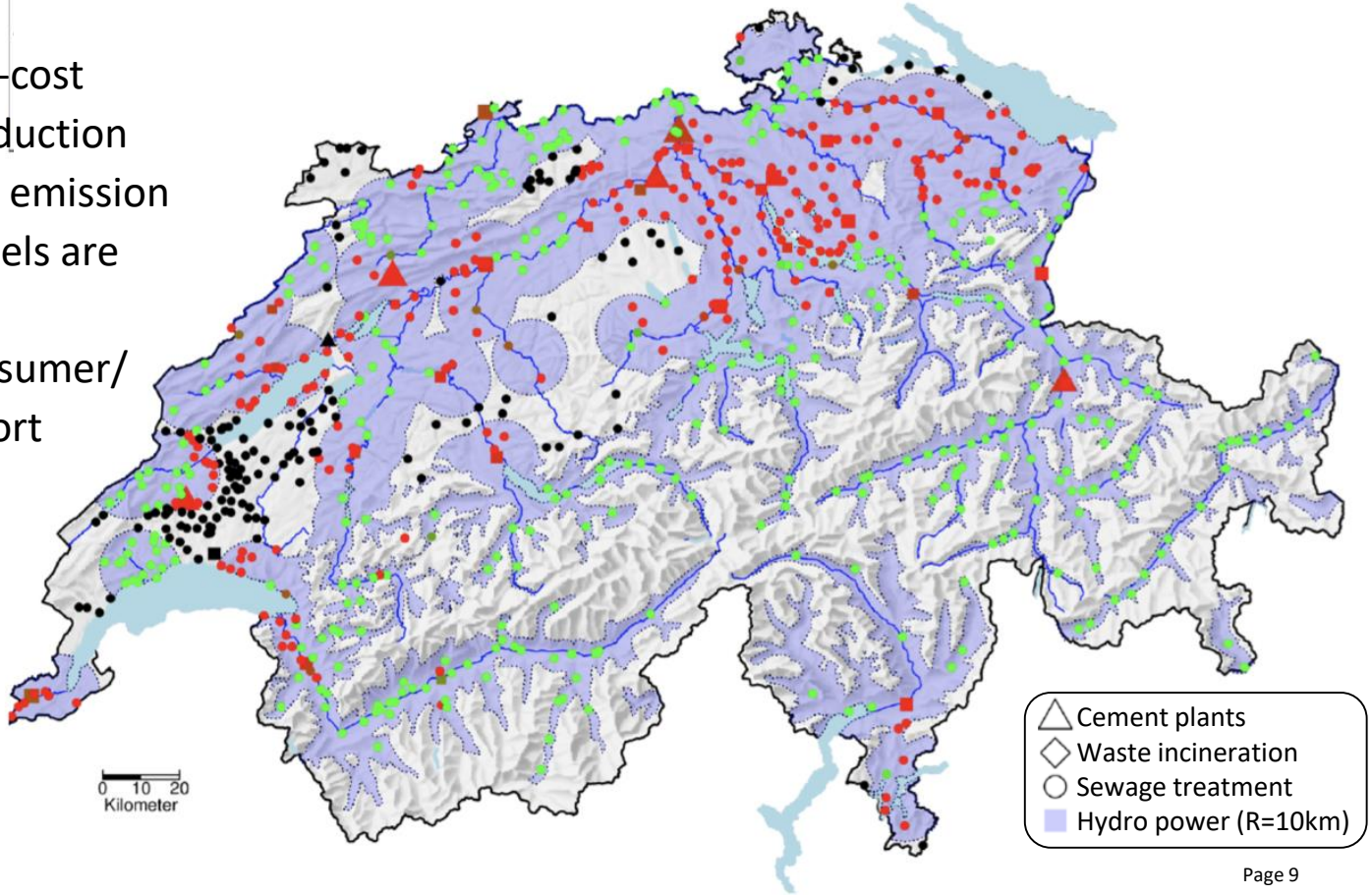
Contribution of flexibility options in absorbing excess electricity (12h, Summer Saturday)



Panos et al. 2019

Location of Power-to-gas plants matters

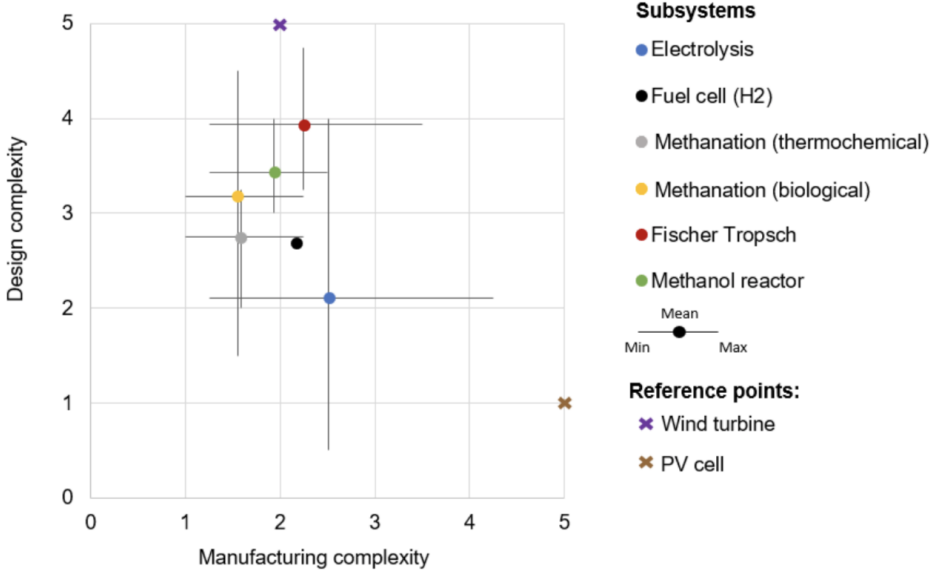
- Vicinity to low-cost electricity production
- Vicinity to CO_2 emission source if synfuels are produced
- Vicinity to consumer/ energy transport infrastructure



Teske et al. 2019

Implications for Research and Innovation

- Strengthen the domestic market
- Projects should cover complete P2X value chain
- Design-intensive technologies promoted through learning-by-using and interaction of technology integrators
- Higher scale effects for synfuel processes compared to pure H_2 processes
- Various H_2-related research activities in Switzerland



Thank you for your attention.

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Back-up slides

- BACK-UP

In Switzerland, decarbonisation mainly affects demand sectors, because power sector almost CO_2 free

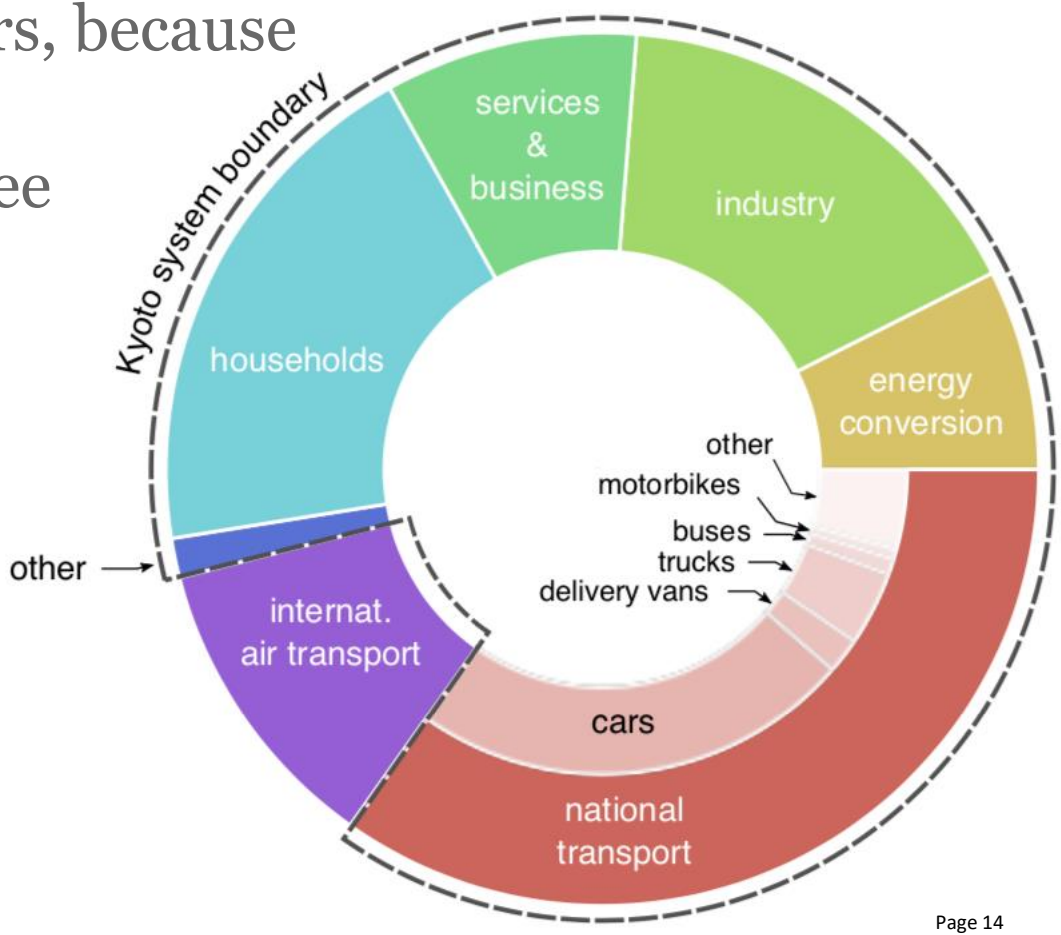


Figure: Swiss CO_2 emissions in 2015

System scheme of P2X production chains

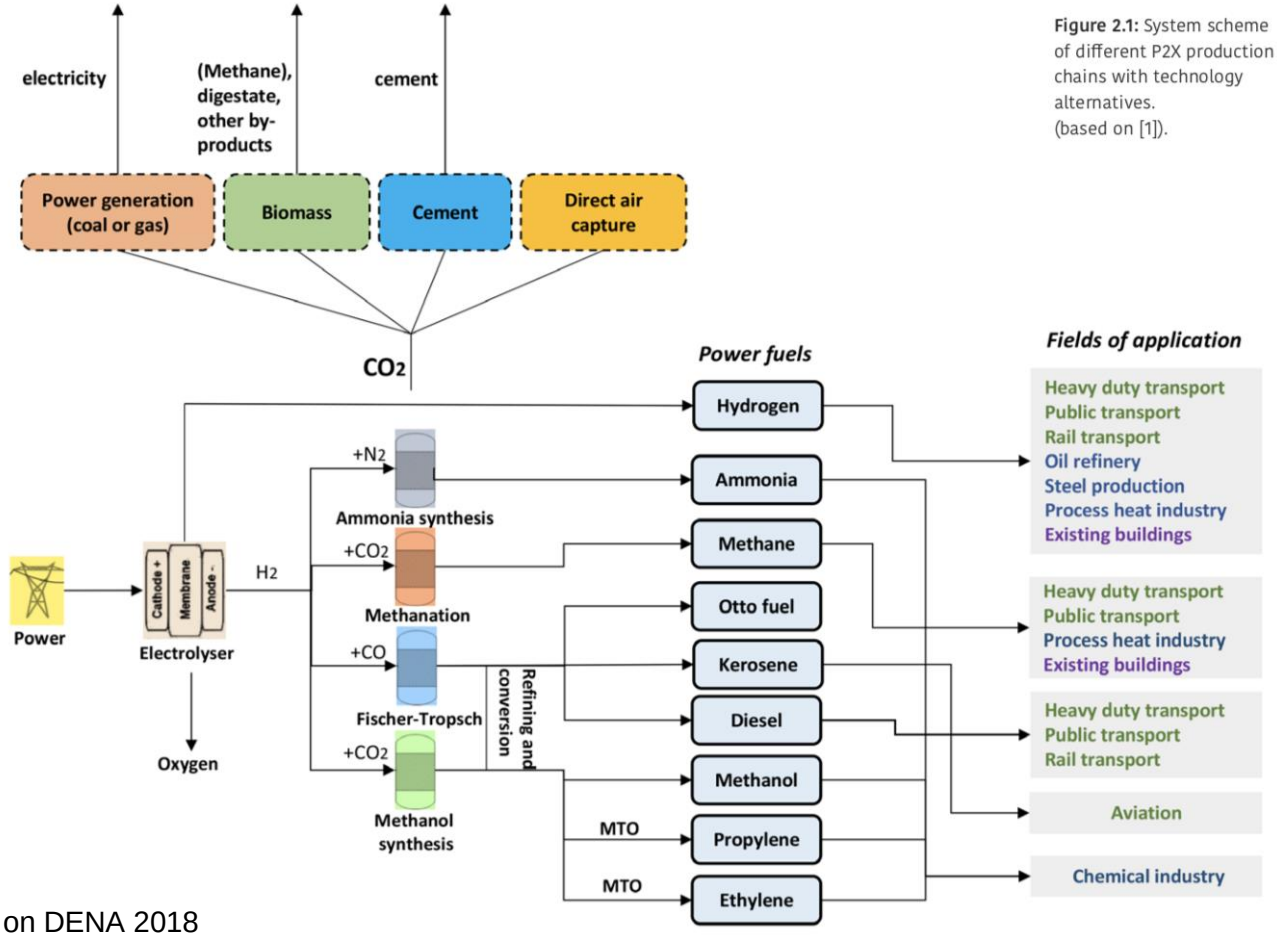
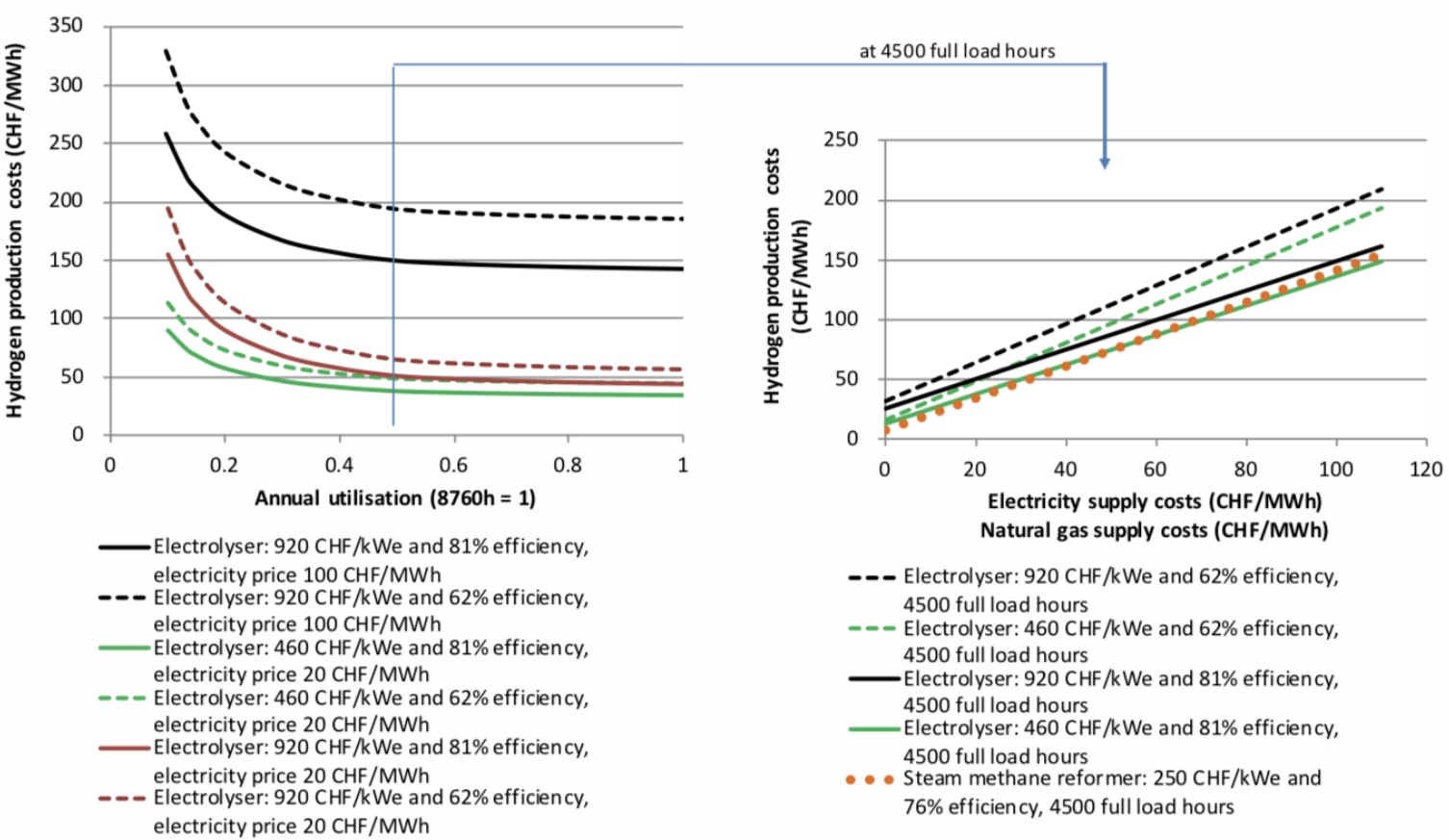


Figure 2.1: System scheme of different P2X production chains with technology alternatives. (based on [1]).

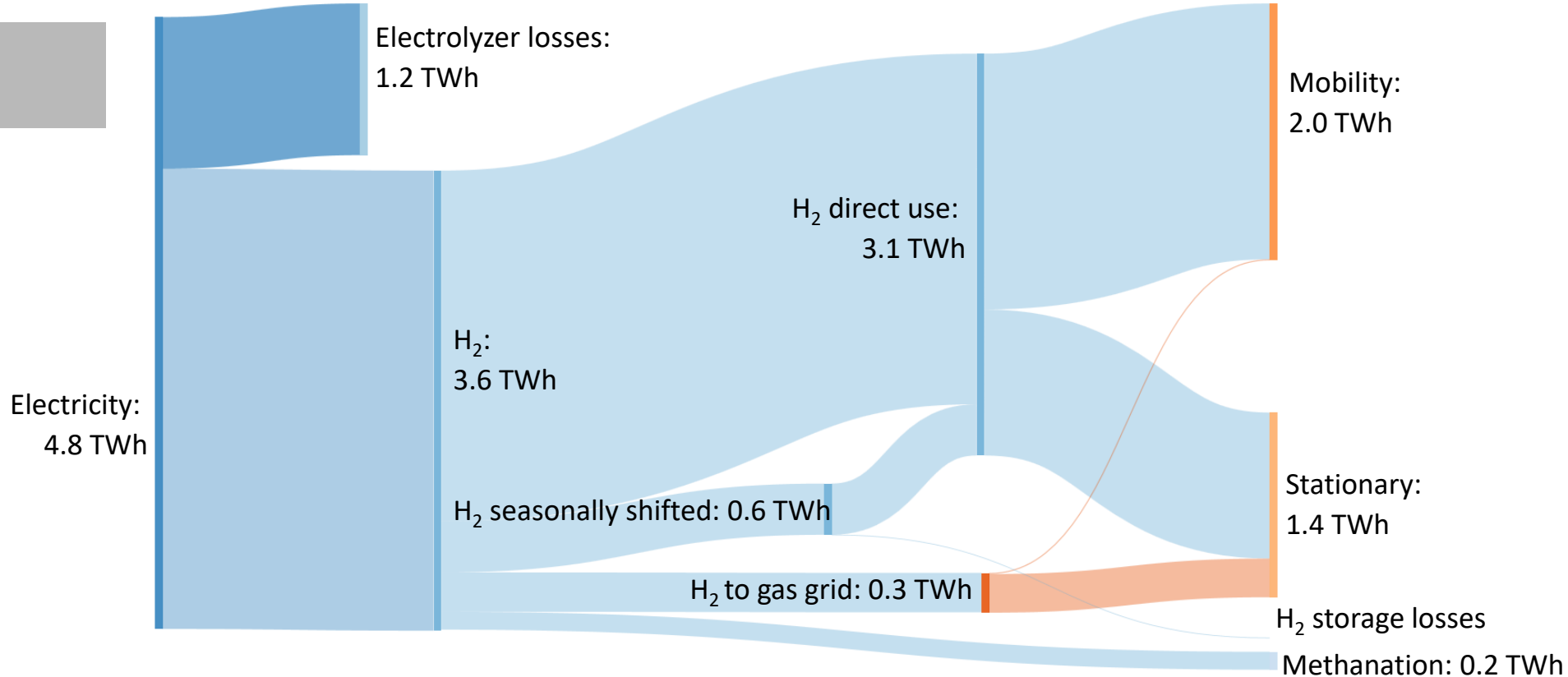
Source: Kober et al. 2019 based on DENA 2018

H2 production needs low-cost electricity and a sufficient high amount of operating hours



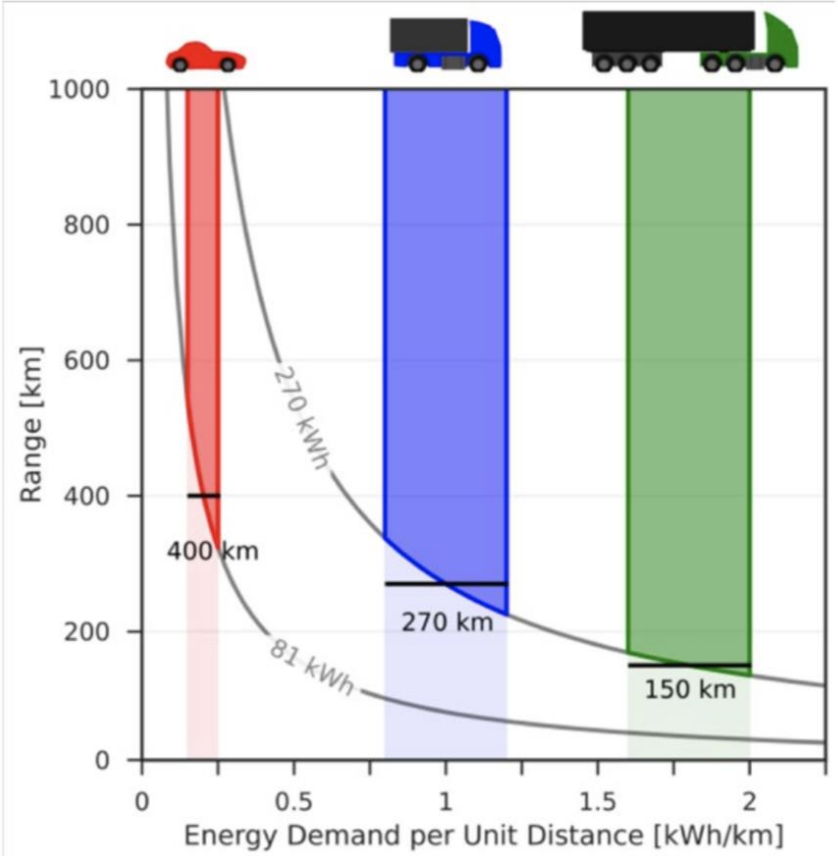
Kober et al. 2019

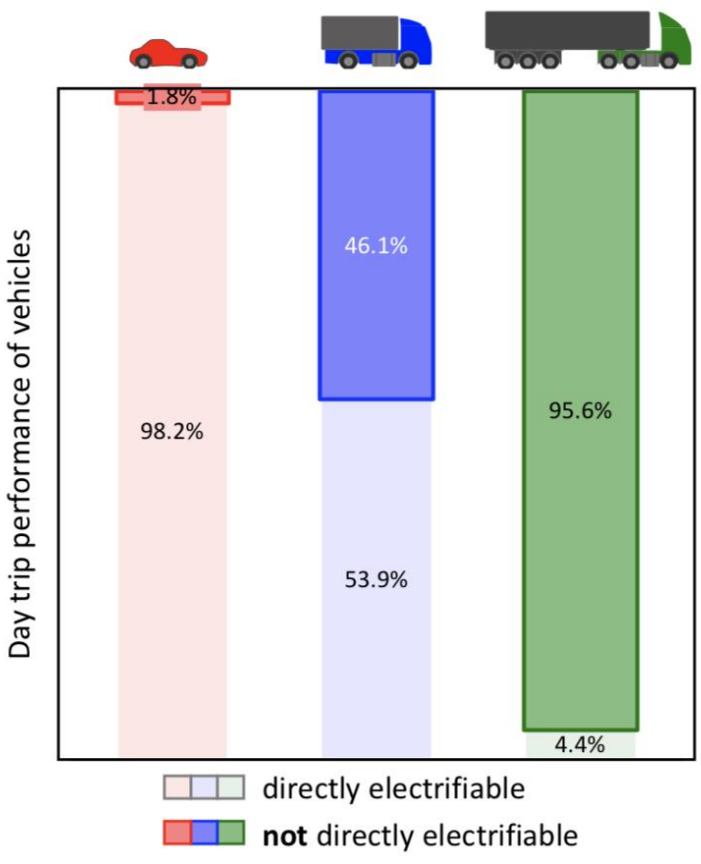
Power to gas pathways in a Climate scenario in 2050



Panos et al. 2019

Why trucks and buses can benefit from hydrogen or synfuels while cars drive on batteries





Held et al. 2018

Life-cycle GHG emissions of passenger vehicles