USING RENEWABLE ENERGY FOR THERMOCHEMICAL CATALYTIC SYNTHESIS OF SUSTAINABLE DESIGNER FUELS

A Short-term Solution for the Mobility Sector

Courtesy: Dr. E. Jacob

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Christoph Hank

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www.ise.fraunhofer.de

E n e r g i e C a m p u s
Karlsruhe, 17. November 2017

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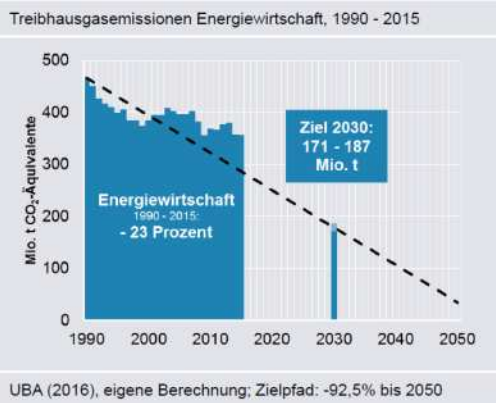
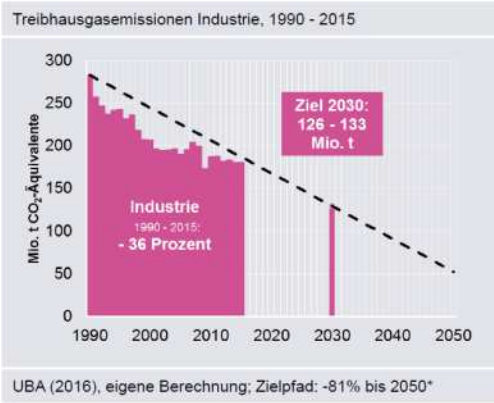
Adressing the CO_2-Mitigation Targets of COP21

The Course of CO2-Reductions in the Various Sectors (DE)

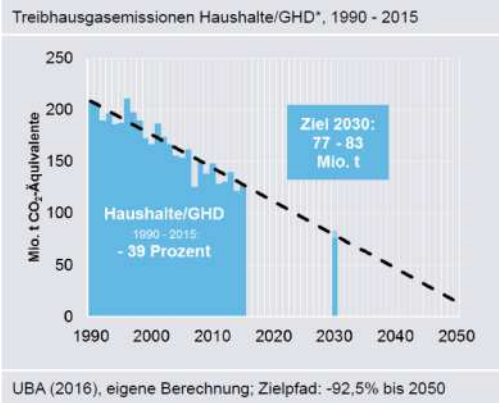
Energy (Target: -92,5%)



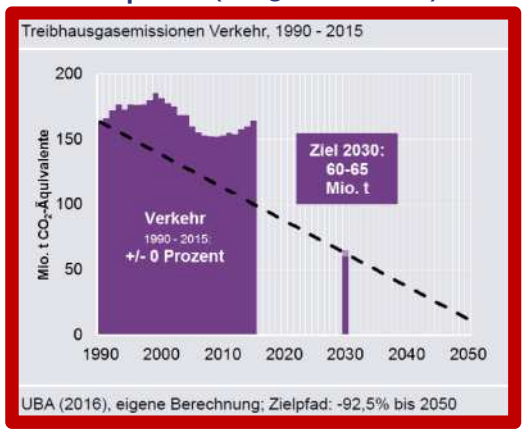
Industry (Target: -81%)



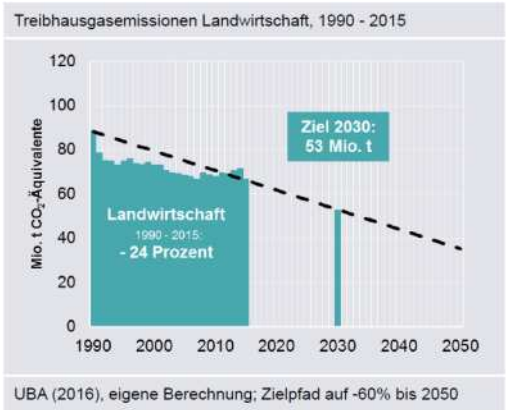
Homes (Target: -92,5%)



Transport (Target: -92,5%)



Agriculture (Target: -60%)



Graphs:
G. Rosenkranz,
Agora Energiewende (2017) & Umweltbundesamt (2016)

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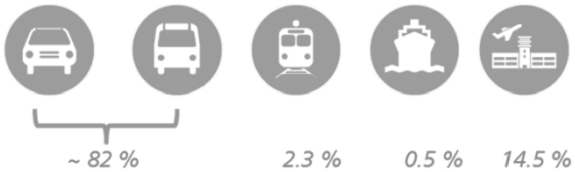
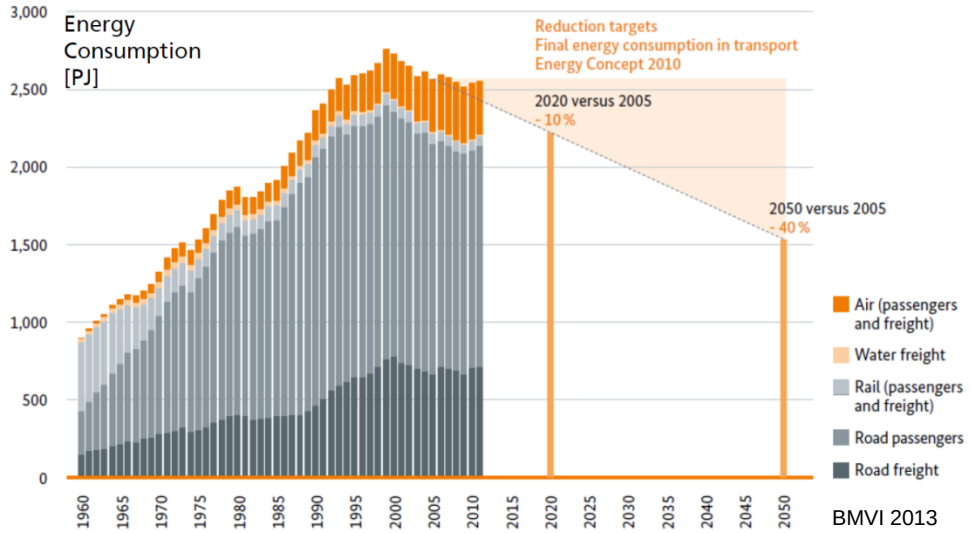
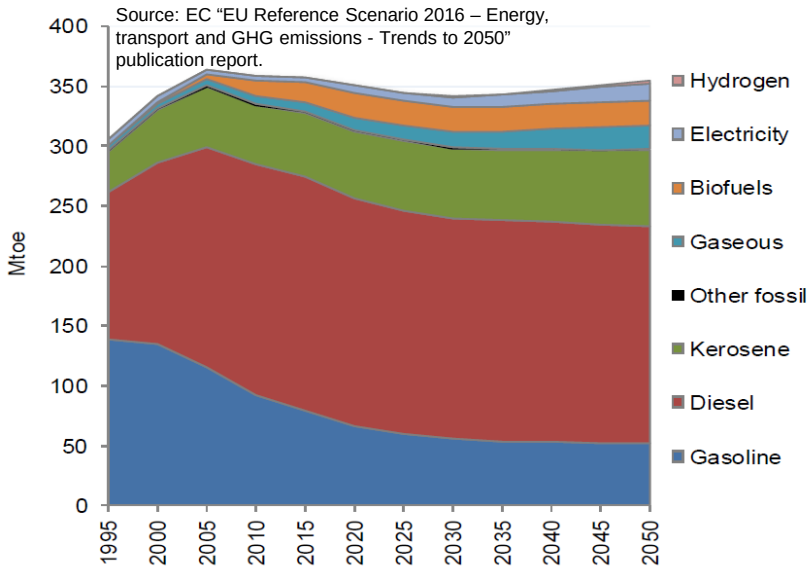
Adressing the CO_2-Mitigation Targets of COP21

Private and Freight Transport with Largest Energy Share







Recently: 2 societical fields of interest:

- General need for CO_2-equivalent-emission reductions (COP21)
- Particulate matter & soot emissions in European cities


(1)

(3) (2)

(1): http://dailymail.co.uk
(2): http://www.stuttgarter-nachrichten.de
(3): http://www.focus.de

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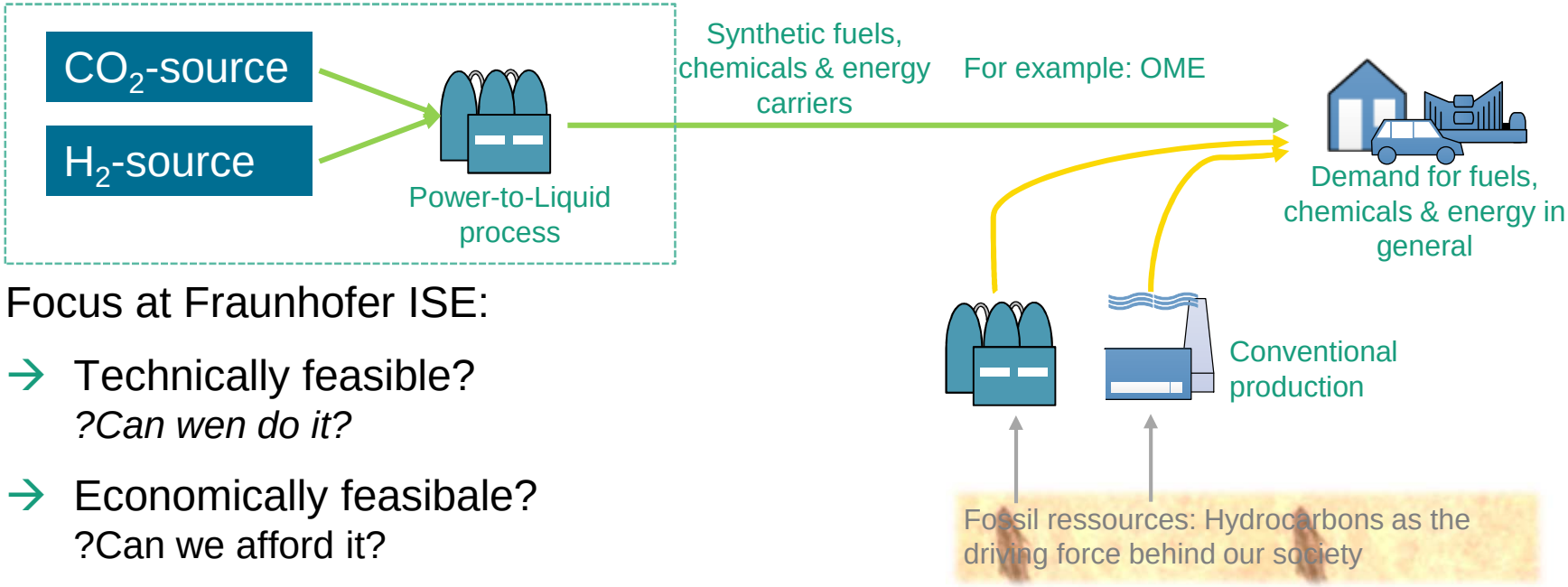
Power-to-Liquid
In a Nutshell



Focus at Fraunhofer ISE:

→ Technically feasible?
?Can wen do it?

→ Economically feasibale?
?Can we afford it?

→ Sustainabilty given?
?Is it green(er than the conventional)?

(1): https://www.convertwithcontent.com

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Mobility Sector

OME via **Power-to-Liquid** Process as a Short-term Solution for Mobility

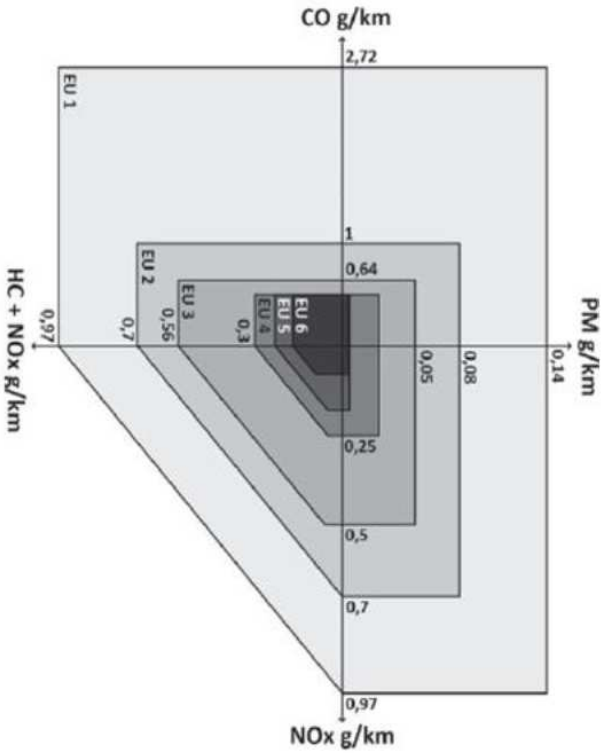

Figure: EU1-6 regulations for g/km-emissions of CO2, NOx and particulate matter

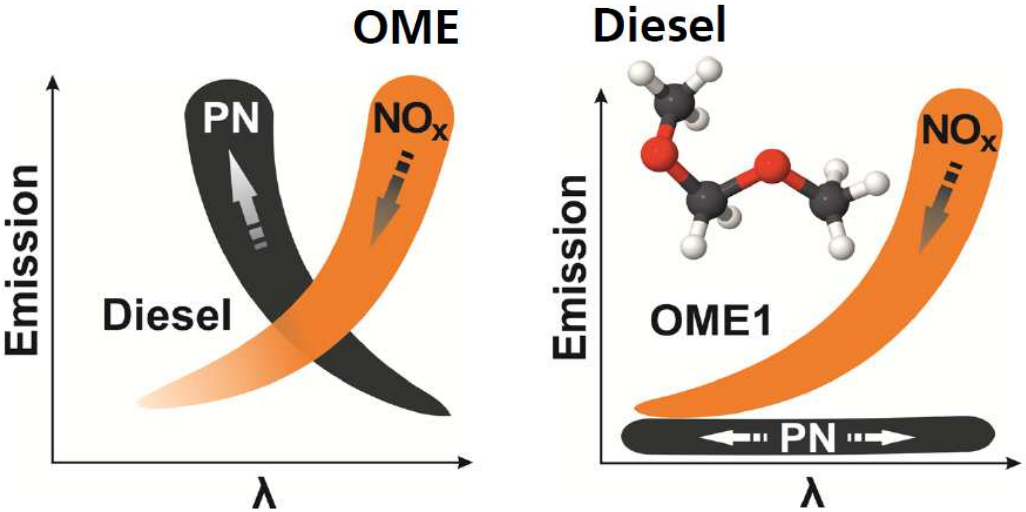

Figure:
Diesel: Trade-Off in case of efforts to reduce NOx and particulate matter.
OME: Combined significant reduction in NOx and particulate matter possible.

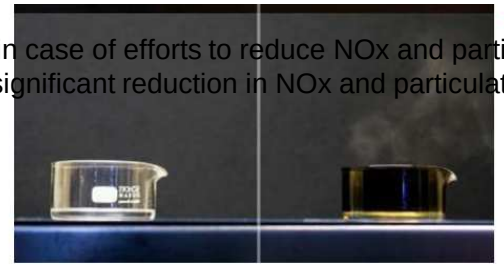

Figure: Illustration of the cleaner combustion properties of the non-toxic diesel-substitute OME

G. Wachmeister (2017) *MTZ Worldw* 78 (3), pp. 52–57
R. Schlögl (Ed.) (2016): 193–264. 37. Internationales Wiener Motorensymposium. Vienna

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Research Objective

Conception and Development of Efficient and Sustainable OME Synthesis Process – Closing the GAP

- The **bottle-neck** for sustainable OME-synthesis is an efficient and feasible **synthesis process**
- State-of-The-Art for synthesis processes 30 – 40 ktons/a capacity overall
- Synthesis efficiency (40 – 52%) with potential for improvement and a suffering economic feasibility
- A novel process concept (**FhISE process**) based on methanol endothermic dissociation to anhydrous Formaldehyde followed by OME synthesis step represents a direct and efficient synthesis (> 60%) route

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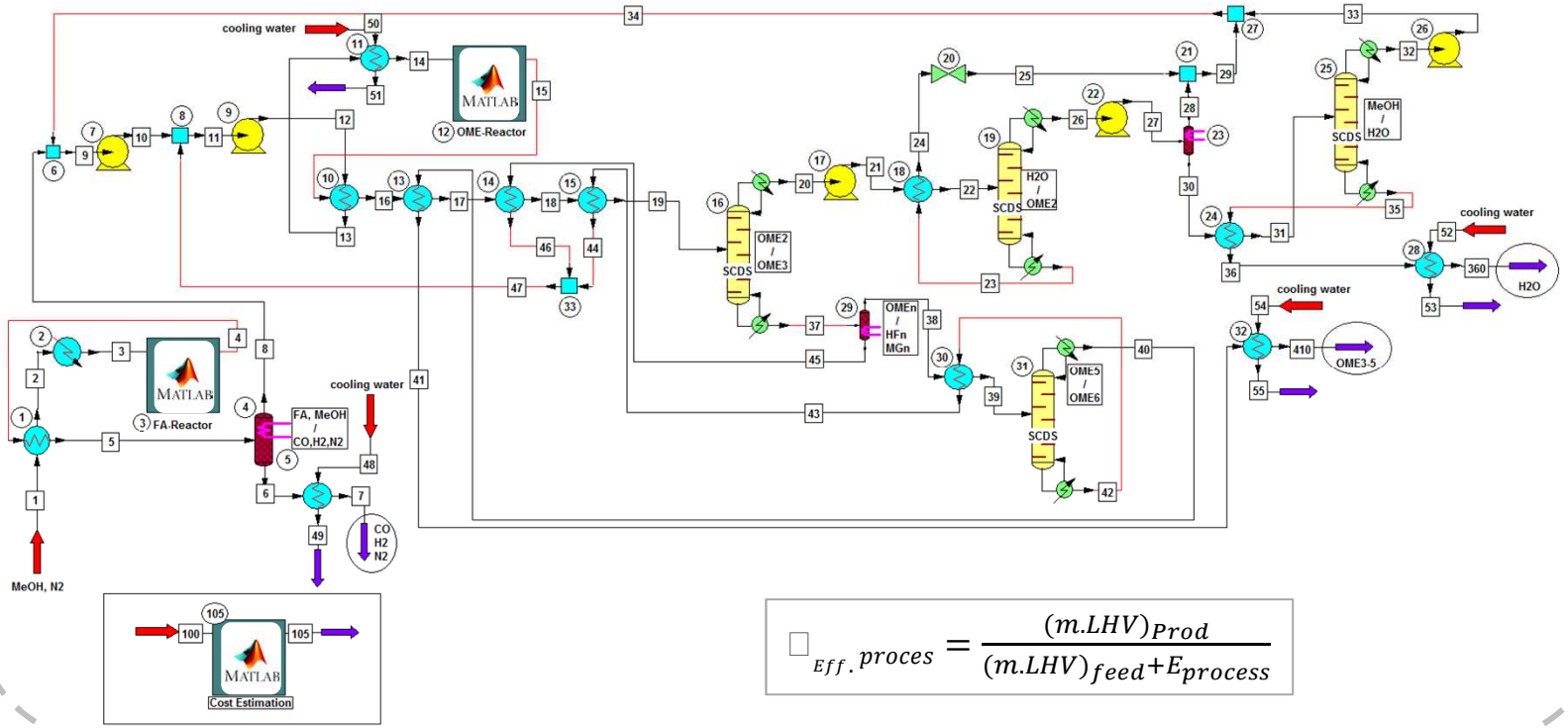
Research Objective

Hybrid Simulation Platform – Expermintally Validated

Chemstations Europe GmbH ↔ Microsoft Visual Basic for Applications ↔ MATLAB ↔ umberto® know the flow.



$$\square_{Eff.proces} = \frac{(m.LHV)_{Prod}}{(m.LHV)_{feed} + E_{process}}$$

Material & Energy Balance → Key Performance Indicators → $\square_{Eff.\,process}$ → USD/ton$_{OME}$ → $CO_{2\,eq.}$

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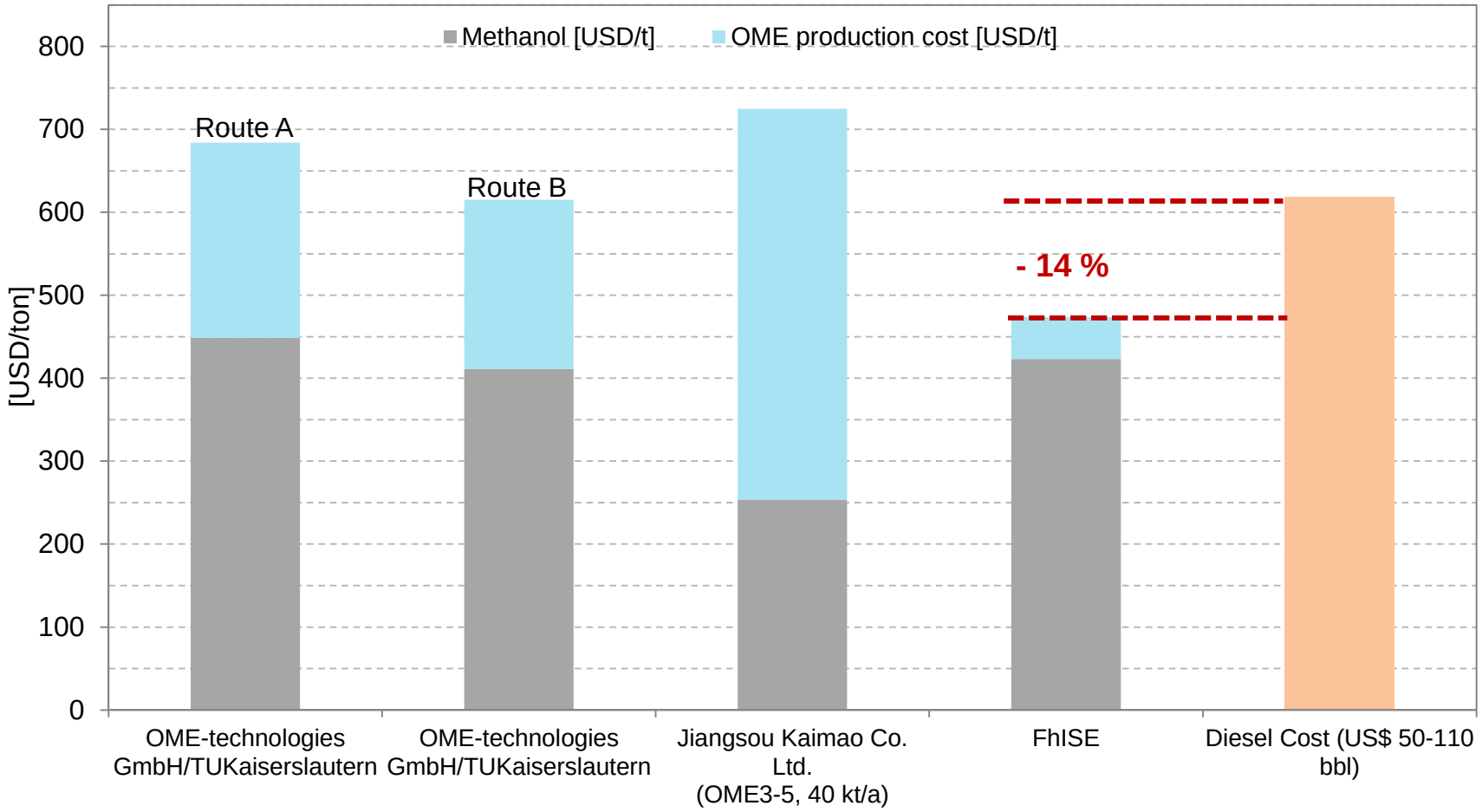
Techno-Economic Evaluation



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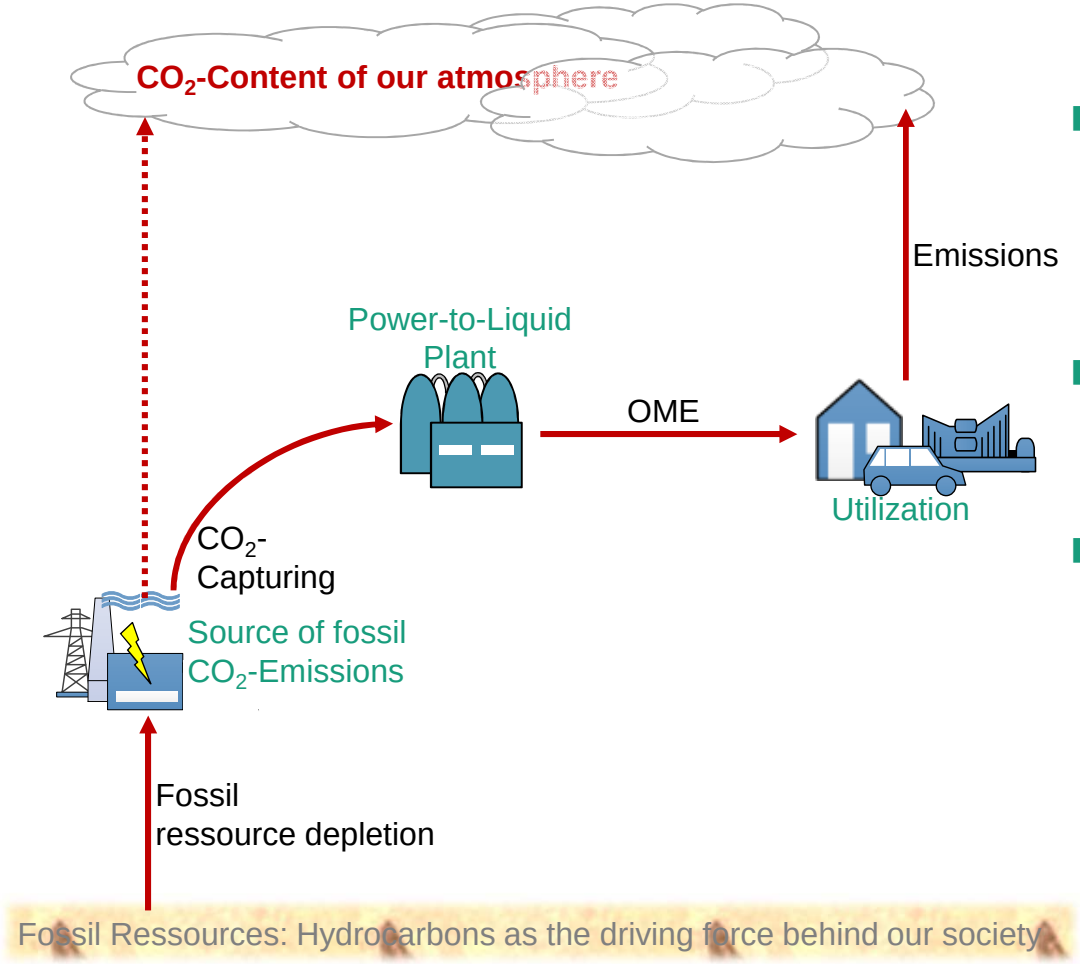
Power-to-Liquid

One Key Element for the closing of the global carbon-cycle



- Recycling of CO_2-Emissions for the generation of synthetic fuels / chemicals / energy carriers
- In case of fossil CO_2-sources no ‚CO_2-neutrality'
- Enables substitution of fossil based products

(1): http://www.wiesbadenaktuell.de/startseite/news-detail-view/article/ab-ins-kraftwerk-bio-ist-energie.html
(2): http://www.nyga.de/container/gartenabfall/gartenabfallcontainer-pauschal.php
(3): http://time2relax.ch/blog/kuehe-in-roethenbach-im-emmental; Rolf Sterch 2013

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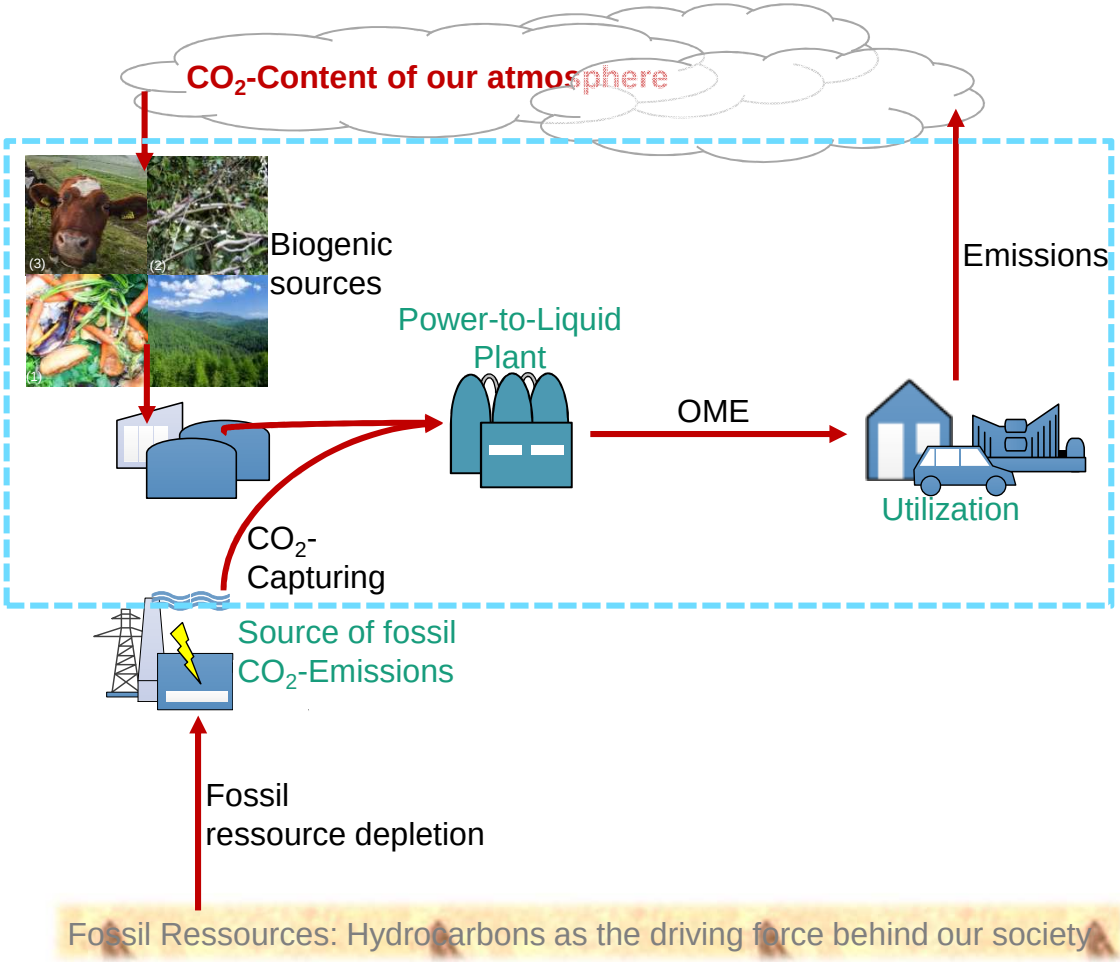

- Biogenic / Atmospheric sources offer a ‚closing' of the carbon cycle

  → CO_2-neutrality ?

- Provision with energy and materials must also be accounted for

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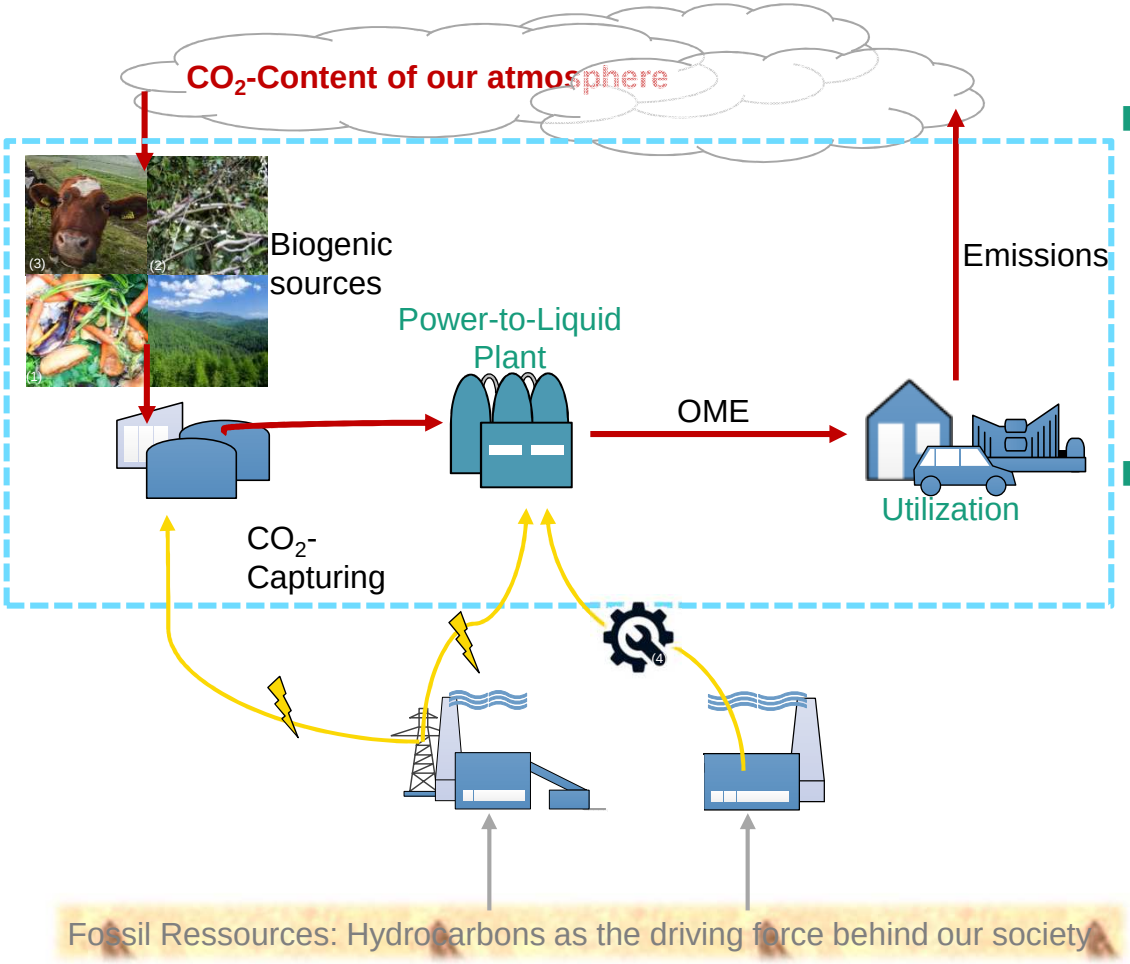

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  → Holistic Life-Cycle-Assessment necessary

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(3): http://time2relax.ch/blog/kuehe-in-roethenbach-im-emmental; Rolf Sterch 2013

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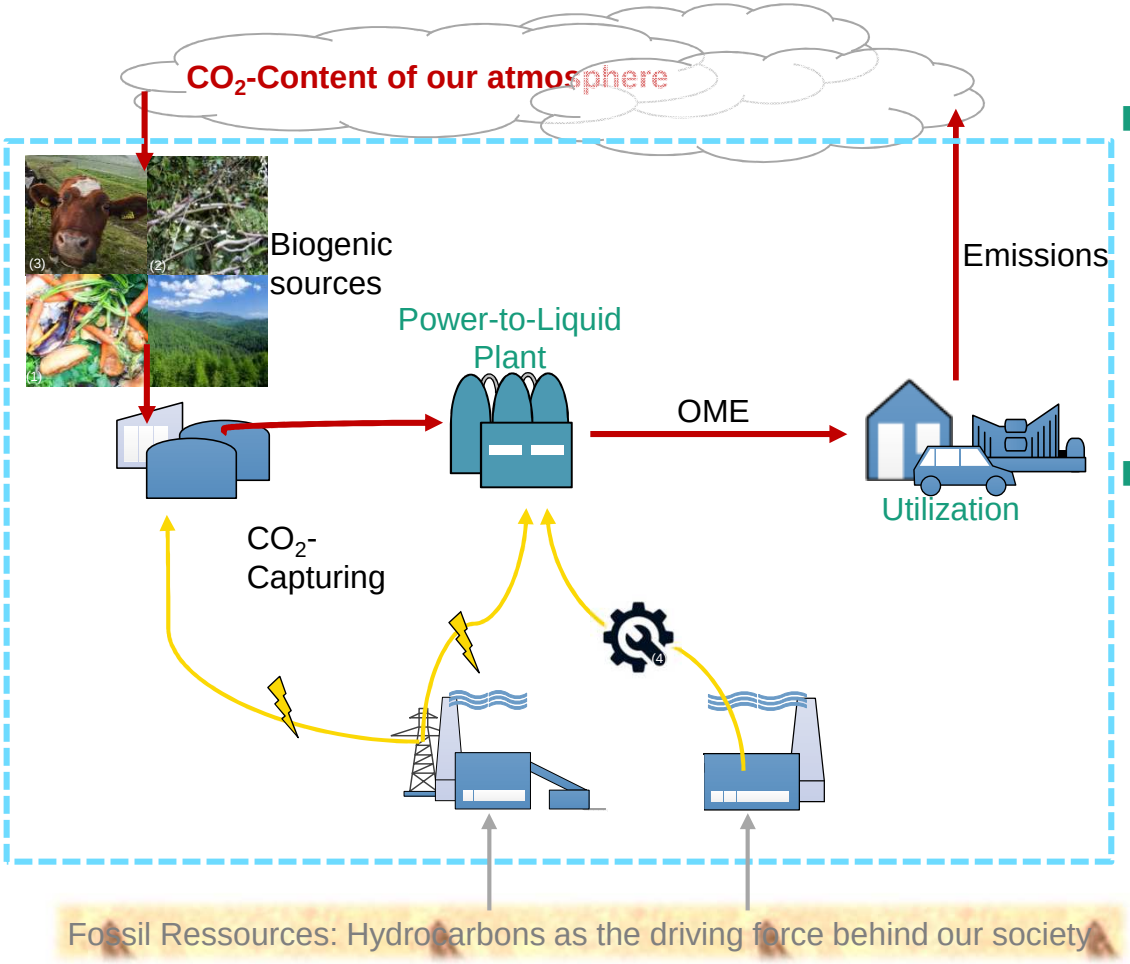

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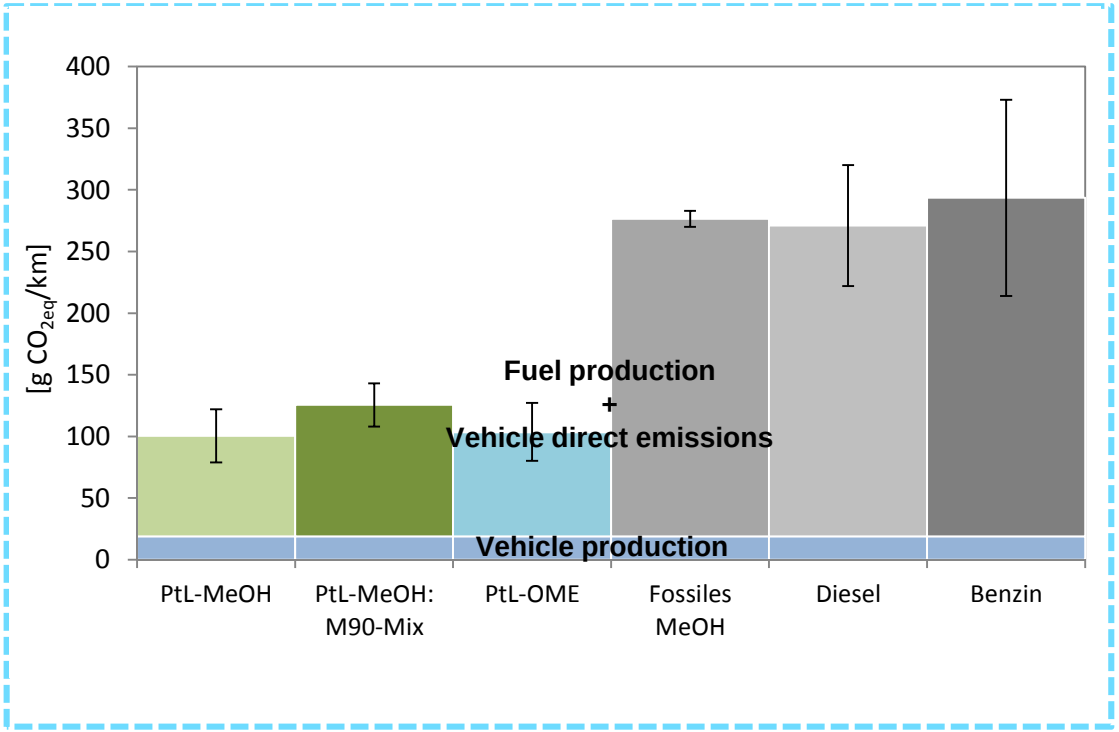

Well-to-Wheel analysis of the CO_2 equivalent emissions (Global Warming Potential) per km of driving distance.

- Significant reduction in global warming potential over complete life-cycle
- Source of energy provided with big impact
- Other impact categories (land use change, material & water consumption, etc.) important as well

CO_2-equivalent emissions per km of driving distance for PtL and conventional fuels: PtL-Methanol and –OME via Wind-/PV-electricity mix and CO_2 derived from biogas, PtL-Methanol/Petrol-Mix (90Vol% MeOH), Fossil MeOH via steam-reforming of natural gas, conventional fuels; speicified deviations originate from different production.

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Thank you for your kind attention!

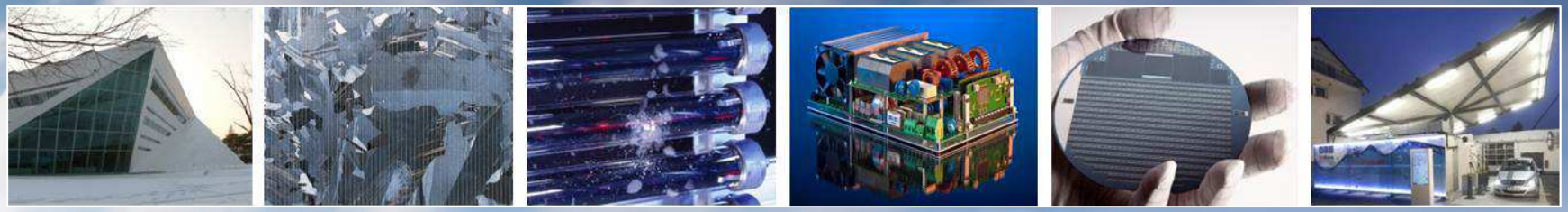

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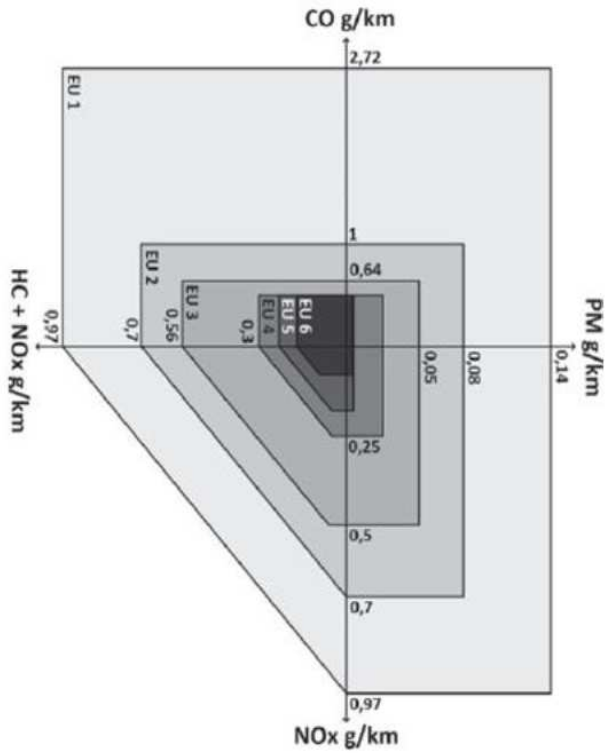
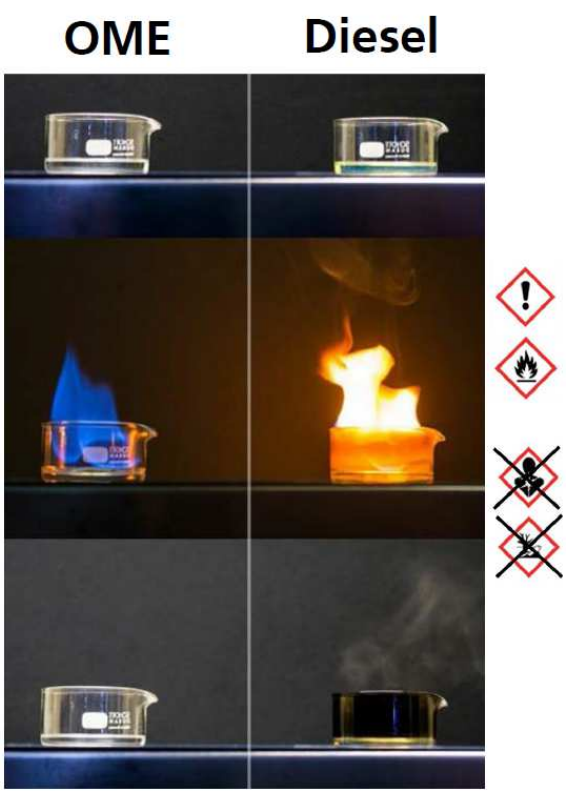
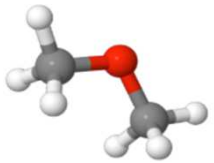
Foto Joscha Feuerstein

Mobility Sector

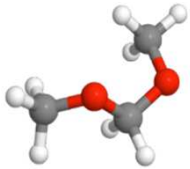
Liquid Oxymethylenethers (OME) as clean diesel substitute and drop-in solution for instant reductions in NOx, Particulate Matter and well-to-wheel CO_2eq-emissions



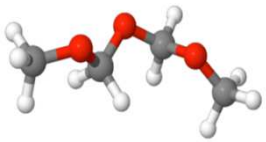




$DME_{n=0}$



$OME1_{n=1}$



$OME2_{n=2}$

G. Wachmeister (2017) *MTZ Worldw* 78 (3), pp. 52–57
R. Schlögl (Ed.) (2016): 193–264. 37. Internationales Wiener Motorensymposium. Vienna

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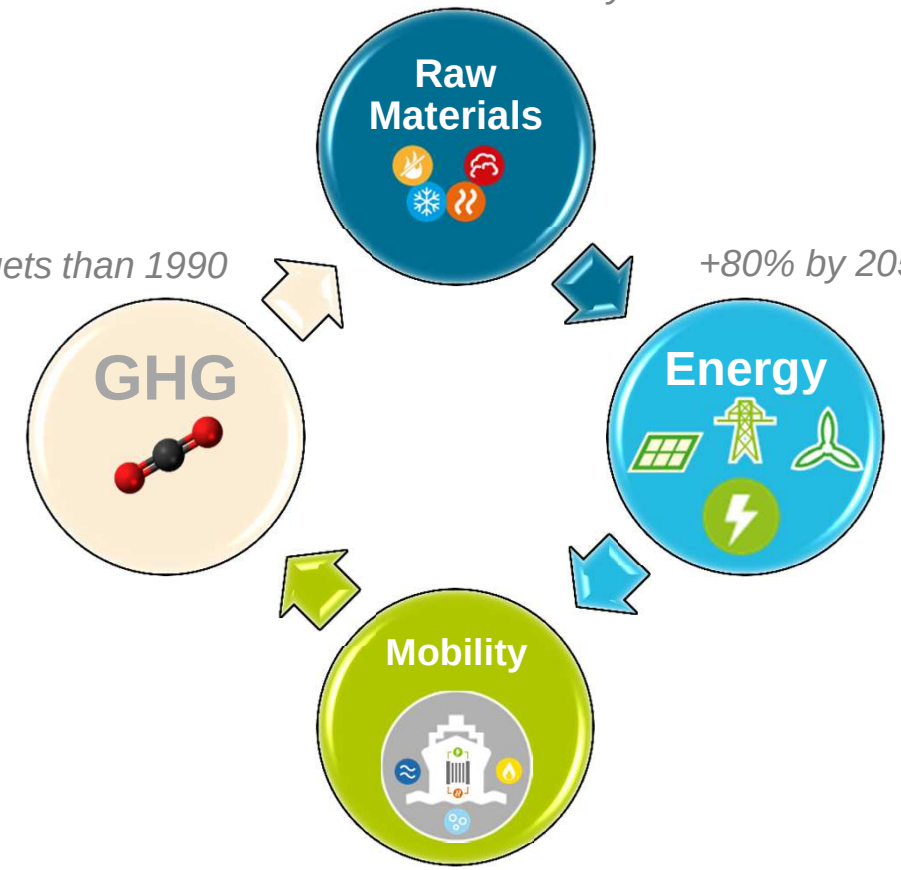
Context of PhD Thesis

+3 Earths are needed by 2050

(DE) -95% targets than 1990

+80% by 2050/Fluctuations → Storage



ca. 25% CO_2 Global Share 2015

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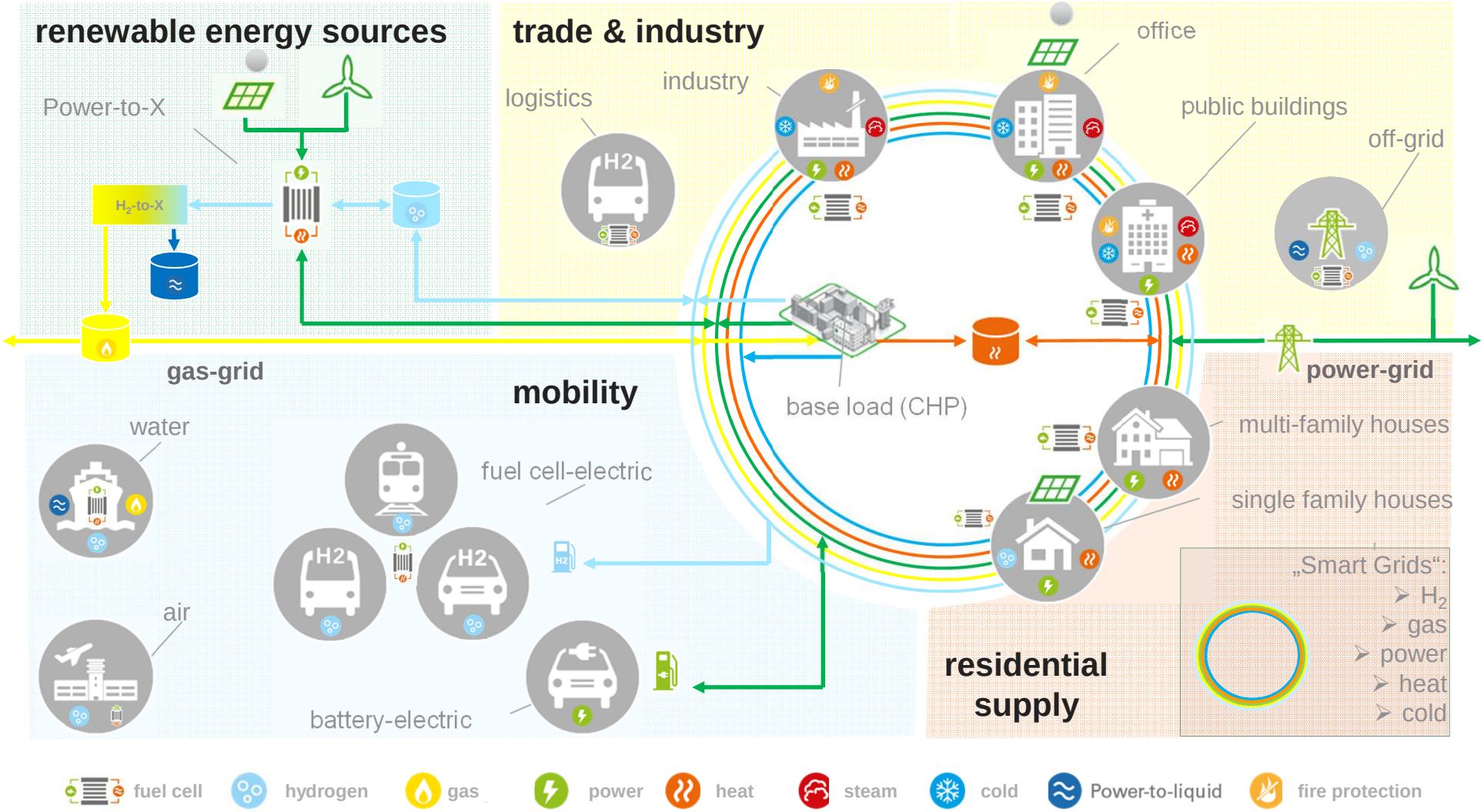
Electricity Transition

Energy – Chemistry – Mobility Sectors Coupling



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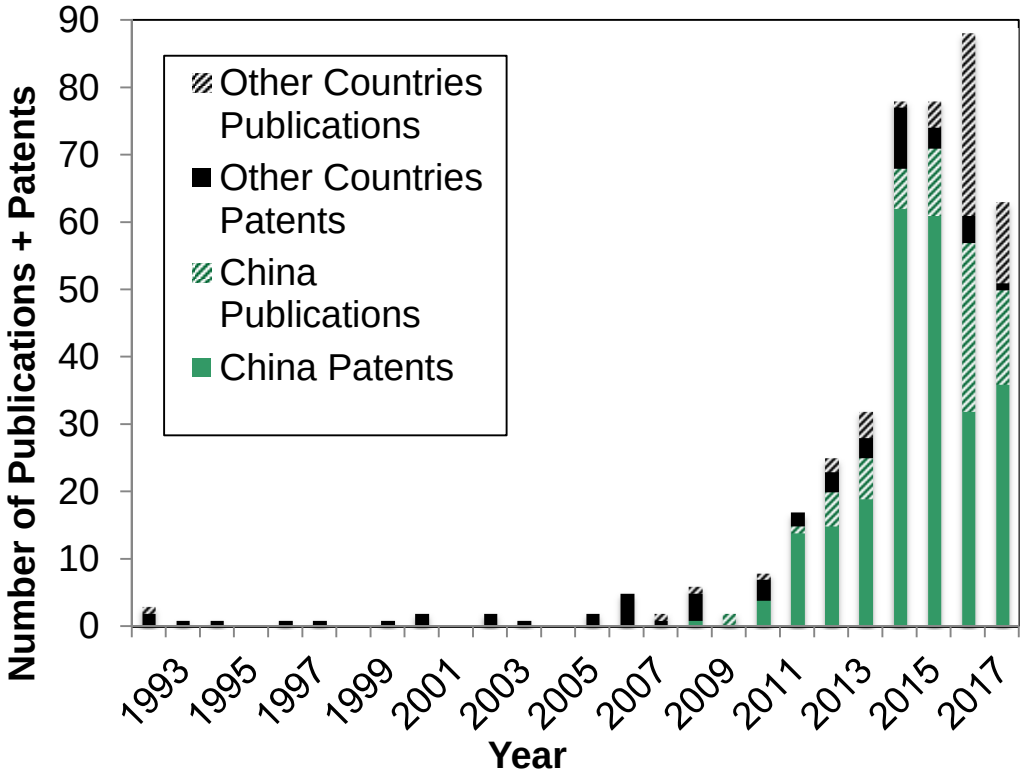
State of The Art

- Early Contributions from BP, BASF, Eni SPA, Arkema and Ford motor co.
- Most recent contributions are from China lead by SINOPEC
- Most recent research is focused on Engine tests



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