Power-to-Liquids: A new pathway to renewable jet fuel

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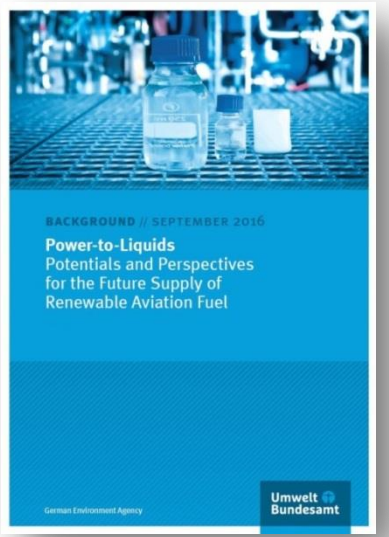
Background study: PtL for Aviation

- Commissioned by German Environment Agency (UBA)
- Joint expertise of LBST and Bauhaus Luftfahrt e.V.
- Download:
  - http://bit.ly/2cowOyf
  - https://www.umweltbundesamt.de/en/publikationen/power-to-liquids-potentials-perspectives-for-the



Umwelt Bundesamt

Expertise sponsored by the German Environment Agency

Bauhaus Luftfahrt Neue Wege.

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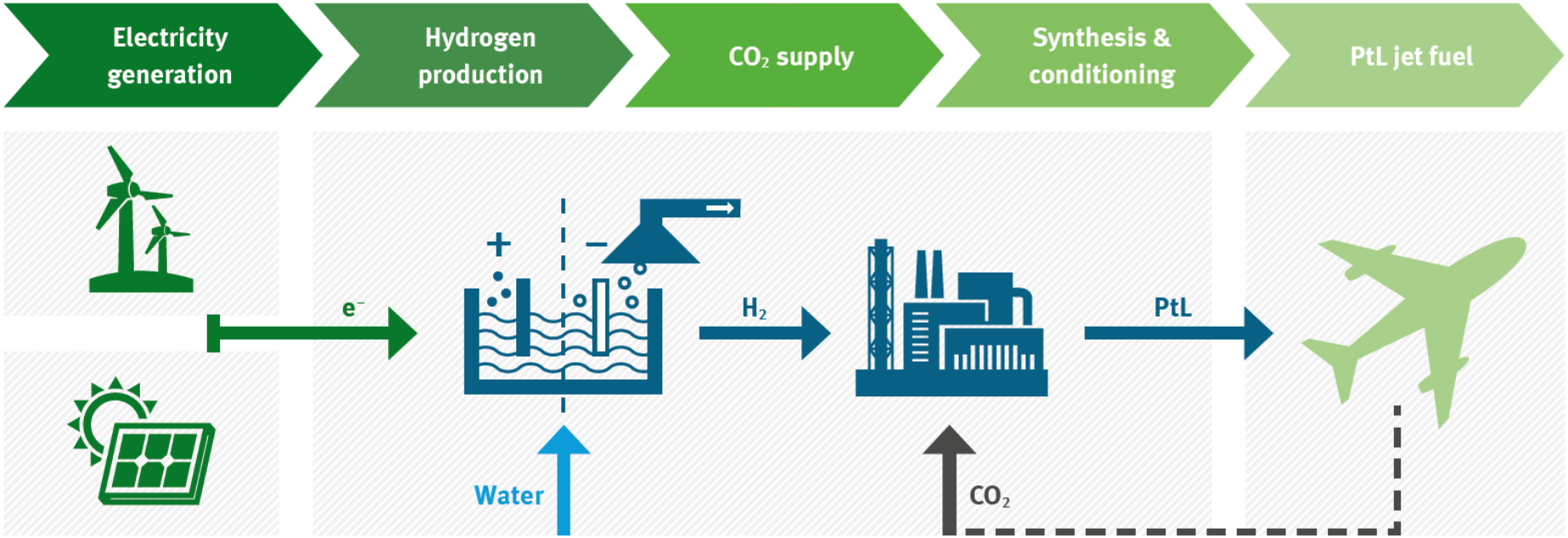
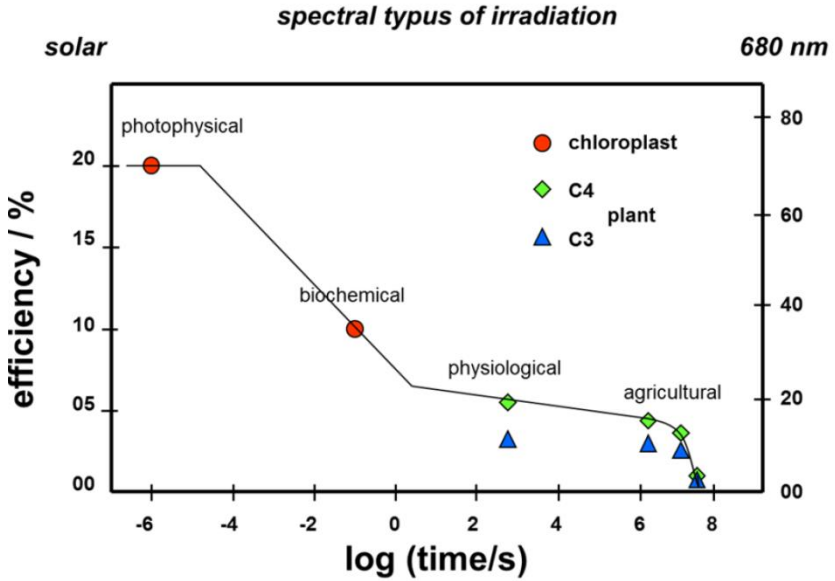
Power-to-Liquids (PtL): The pathway



Biofuels: Intrinsic efficiency limitation



- Photosynthesis: An inefficient way of harnessing solar energy for fuel production
- Less than 1% overall efficiency

Source: Wolfgang Junge, Efficiency Potentials of Photosynthetic Fuels, Bauhaus Luftfahrt Symposium „Future of Aviation“, Munich, 2013.

PtL: An efficient alternative to photosynthetic energy conversion

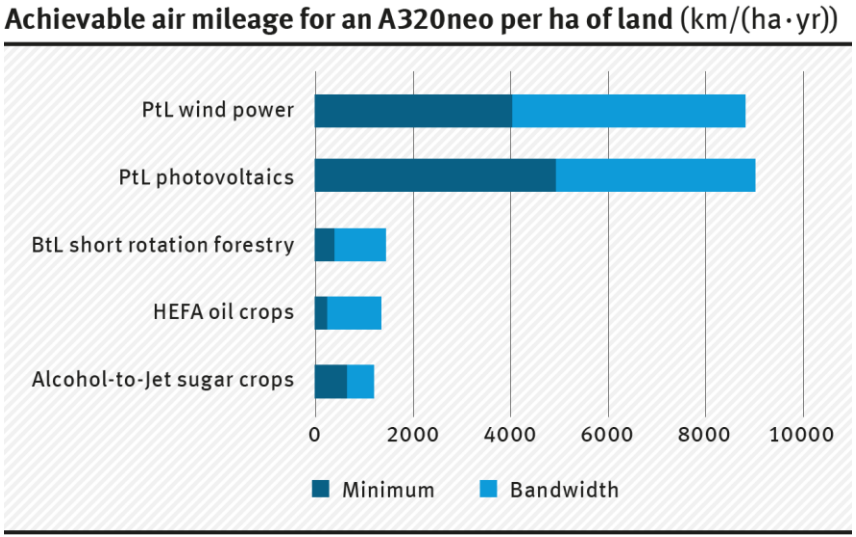
- PV: 15%
- PtL conversion: 60%
  - high-temperature electrolysis
  - concentrated CO_2 source
  - reverse water gas shift
  - Fischer-Tropsch synthesis

=>About 9% solar-to-fuel energy efficiency (6-7% for CO_2 from air)

Source: https://commons.wikimedia.org/wiki/File:Solar_Panels.jpg

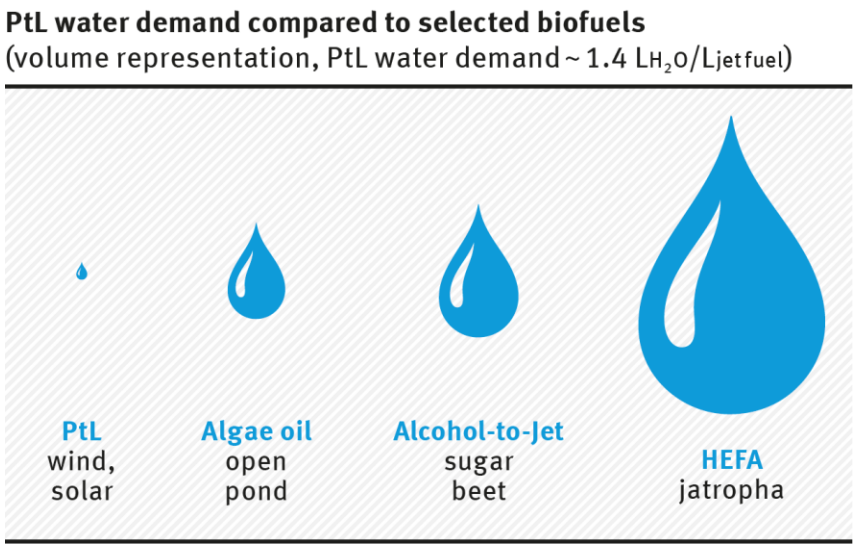
Land demand

- High efficiency of solar energy conversion translates into low land demand
- Harvesting of solar energy independent of arable land



Water demand

- Water is needed as feedstock (for hydrogen production)
- Extremely efficient use of water via PtL (compared to biofuels)



GHG emissions (WtW) in g_{CO2eq}/MJ

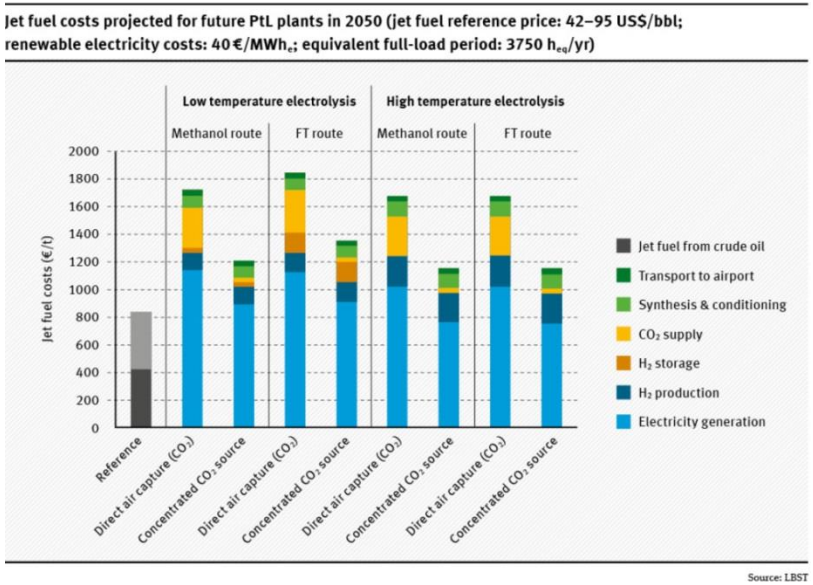
- Favorable GHG balance for PtL using renewable electricity, CO_2 and water relative to conventional jet fuel and many biogenic alternatives

Jet fuel pathway	GHG emissions without land-use change	GHG emissions including direct land-use change
Crude oil (reference)	87.5	–
Crude oil (ultra-low sulfur)	89.1	–
Oil sand (e.g. Canada)	103.4	–
Oil shale (in situ)	121.5	–
Natural gas (GtL)	101.0	–
Coal (CtL)	194.8	–
Switchgrass (BtL)	17.7	-2.0*
Soybean oil (HEFA)	37	97.8–564.2
Palm oil (HEFA)	30.1	39.8–698.0
Rapeseed oil (HEFA)	54.9	97.9
Jatropha oil (HEFA)	39.4	–
Algae oil (HEFA)	50.7	–
PtL (wind/PV in Germany)	~1	–
	11–28**	–

Source: This study (LBST & BHL) for PtL fuels; data for all other listed pathways from (Stratton 2010)
* Negative value because soil carbon from former vegetation lower compared to soil carbon for switchgrass
** Including construction of power plants and production facility (today)

Cost of production

- Fuel costs represent most serious challenge
- Improvements of renewable electricity production and of conversion process to be expected



Conclusions

- PtL: A scalable and sustainable pathway to drop-in fuels
  - Low GHG and water footprint
  - High production potentials and area-specific yield
  - Highest yields on non-arable land
- High costs are greatest challenge
- Sustainable sources of electricity and CO_2 required

Further steps

⇒ Investigate PtL on equal terms alongside bio-jet fuel.

⇒ Include PtL in CAEP's technology roadmap and R&D agenda.

⇒ Support PtL development and industrial projects.

⇒ Establish sustainability safeguards (accounting for sources of electricity and CO_2).

Thank you

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