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· Webinar on Power-to-Liquids · 2 July 2020

EsadeGeo-Center
for Global Economy
and Geopolitics

Power-to-Liquid Technologies

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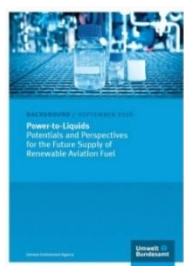
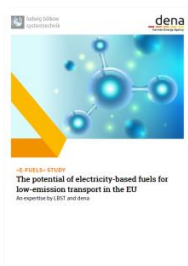


Profile

- Independent expert for sustainable energy and mobility for over 30 years
- Bridging technology, markets, and policy
- Renewable energies, fuels, infrastructure
- Technology-based strategy consulting, System and technology studies, Sustainability assessment
- Global and long term perspective
- Rigorous system approach – thinking outside the box
- Serving international clients in industry, finance, politics, NGOs

References

- EC –  CertifHy – *Green H₂ guarantee of origin scheme*
- EC Joint Research Centre – *Well-to-Wheels Studies*
- German Environmental Agency – *Power-to-Liquids for Aviation*
- German Car Manufacturers Association (VDA) – *E-Fuels Study*
- German Transport Ministry – *Mobility & Fuels Strategy* ²



Contents



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- PtL drivers – Why just now?
- Technology bricks
- Technology readiness levels
- Efficiencies
- GHG
- Pilots
- Summary

It's nothing totally new – so why just now?



Sense of urgency for need to mitigate climate change



There are hard-to-electrify / hard-to-abate fuel uses



Limitations and collateral damages with bio-based fuels



Renewable electricity generation almost 'cheap like dirt'

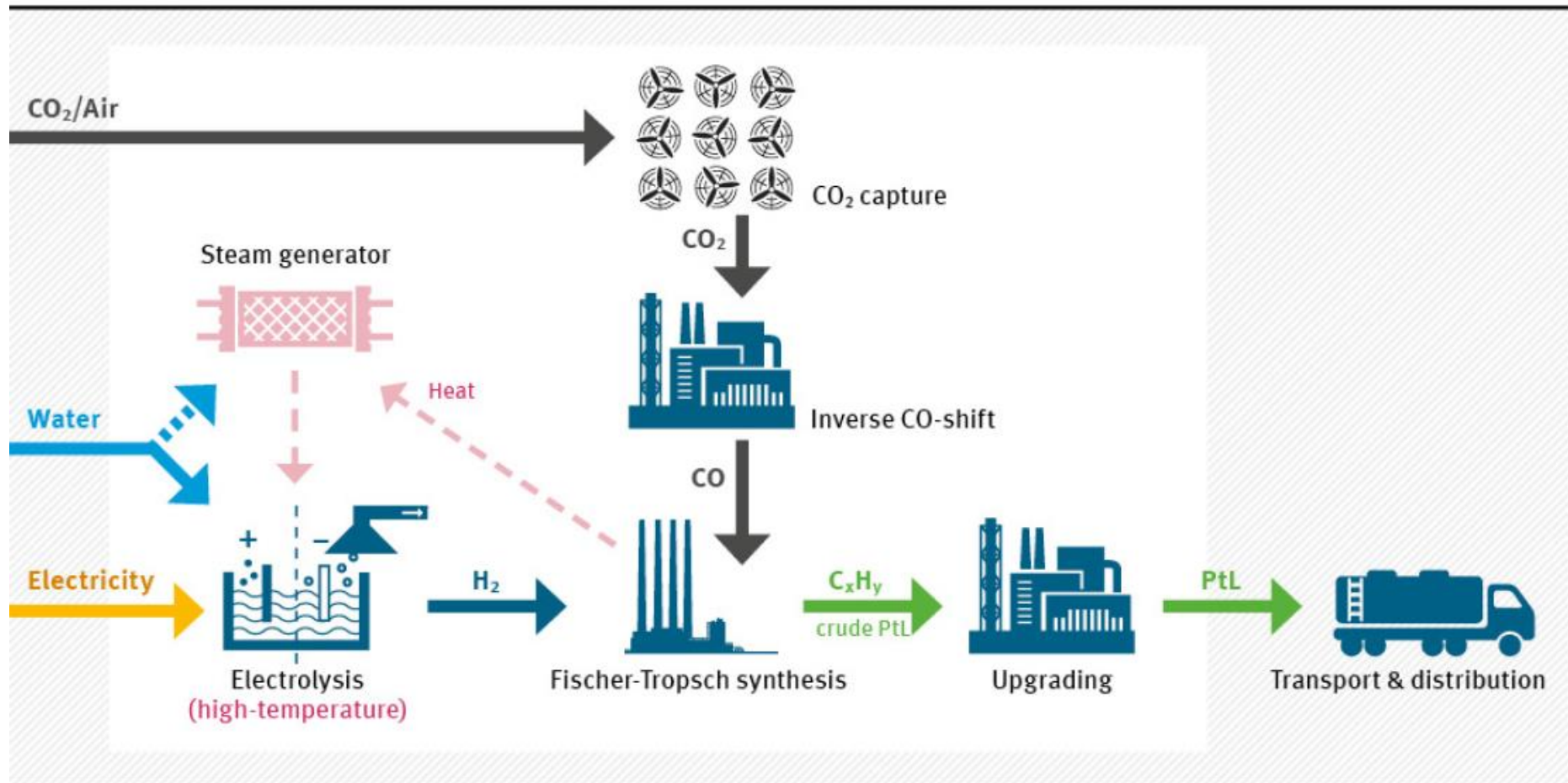
Power-to-liquids via Fischer-Tropsch route



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PtL production via Fischer-Tropsch pathway (high-temperature electrolysis optional)



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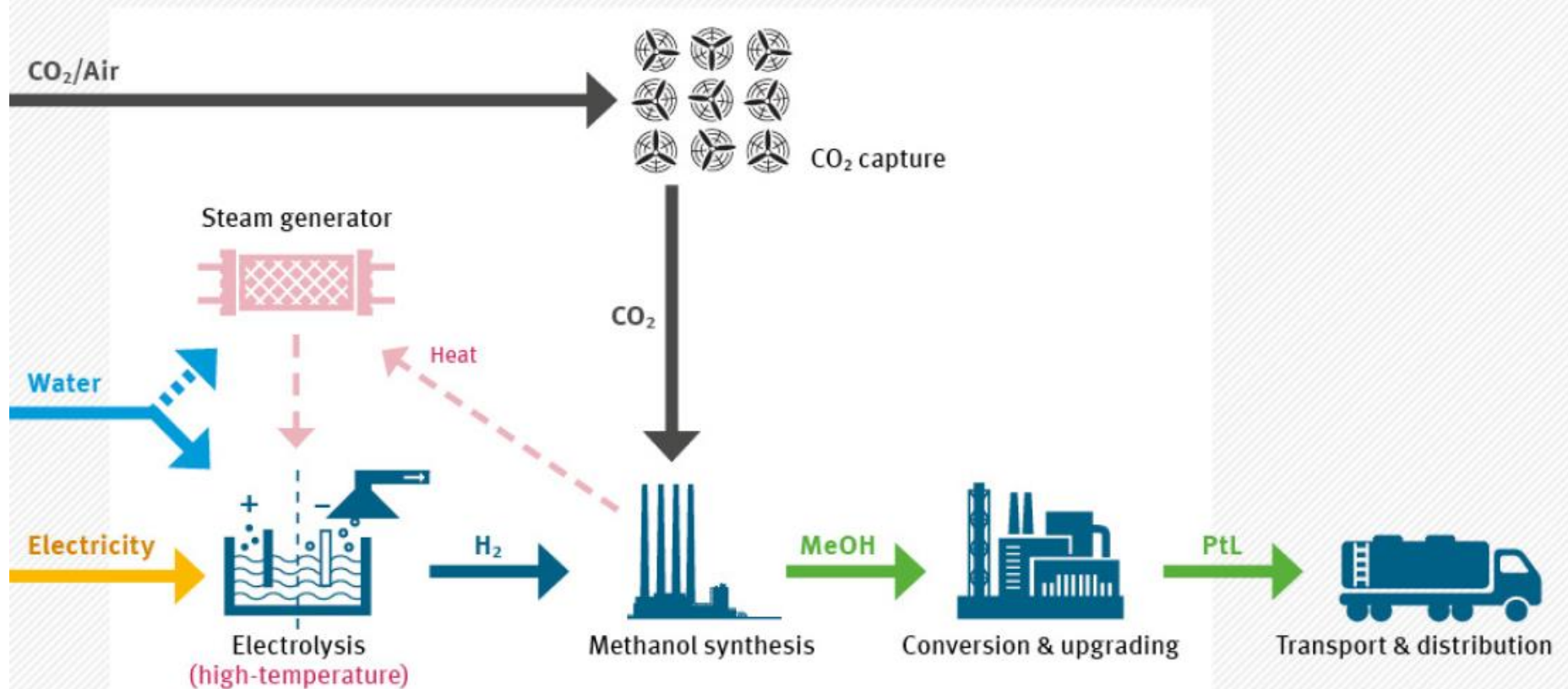
Source: LBST

Power-to-liquids via Methanol route



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PtL production via methanol pathway (high-temperature electrolysis optional)



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Source: LBST

Technology readiness level (TRL)



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PtX fuel pathway	TRL*
E-Hydrogen (H ₂) via low-temp. water electrolysis	9
E-Methane (CH ₄) via Sabatier route	8 – 9 (DAC)
E-Gasoline via methanol route – PEM/ALK	8 – 9 (DAC)
... – SOEC	7 – 8 (SOEC)
E-Diesel via Fischer-Tropsch route – PEM/ALK	6 – 7 (RWGS)
... – SOEC	6 – 8 (RWGS, SOEC)
... – SOEC co-electrolysis	6 (co-SOEC)

LBST, 2020-06

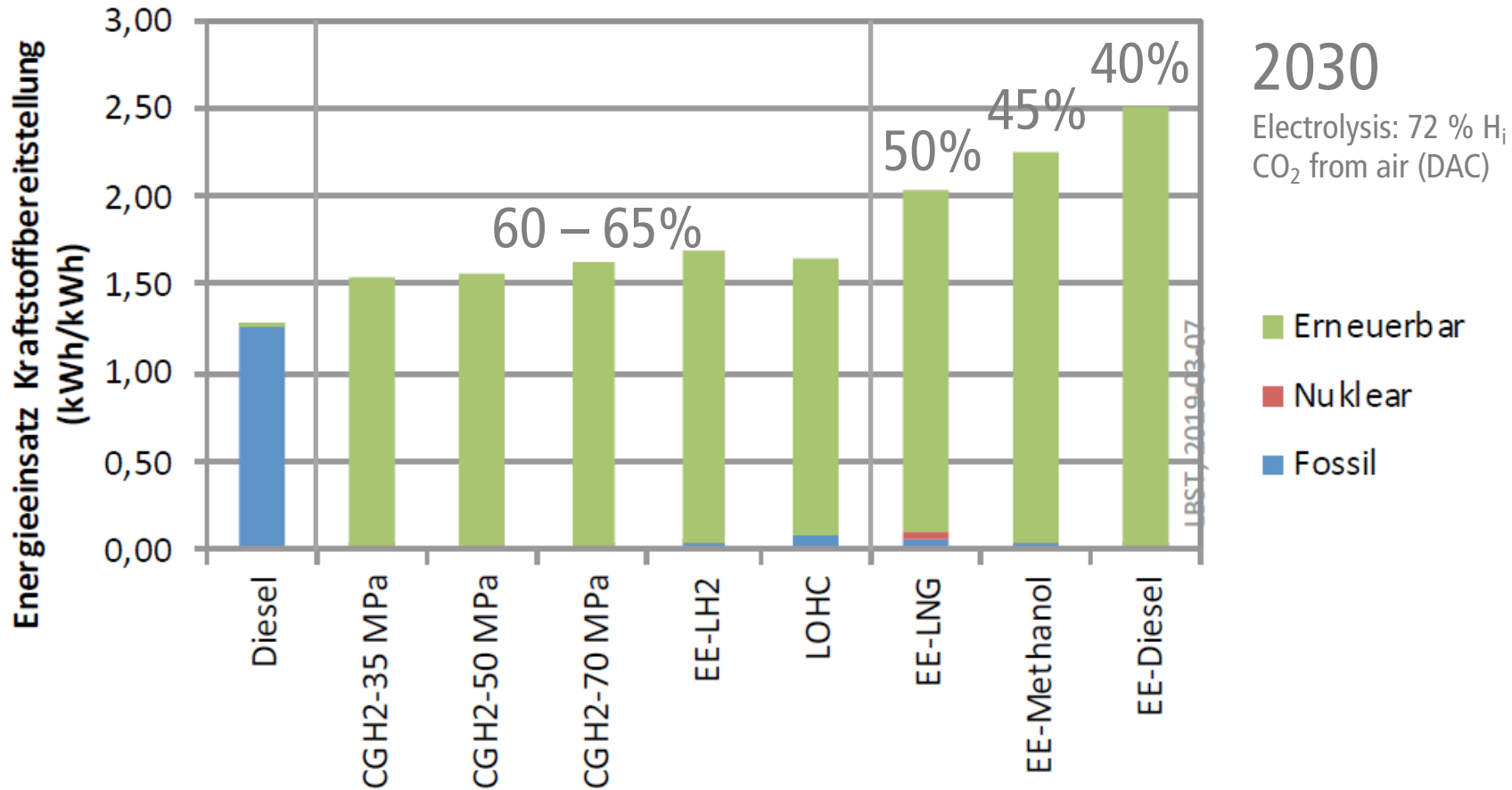
⇒ PtX has generally high technological maturity – the devil's in the detail

⇒ Innovative approaches (DAC, (co-)SOEC) have been developing fast

Fuel production efficiency 'well-to-tank'



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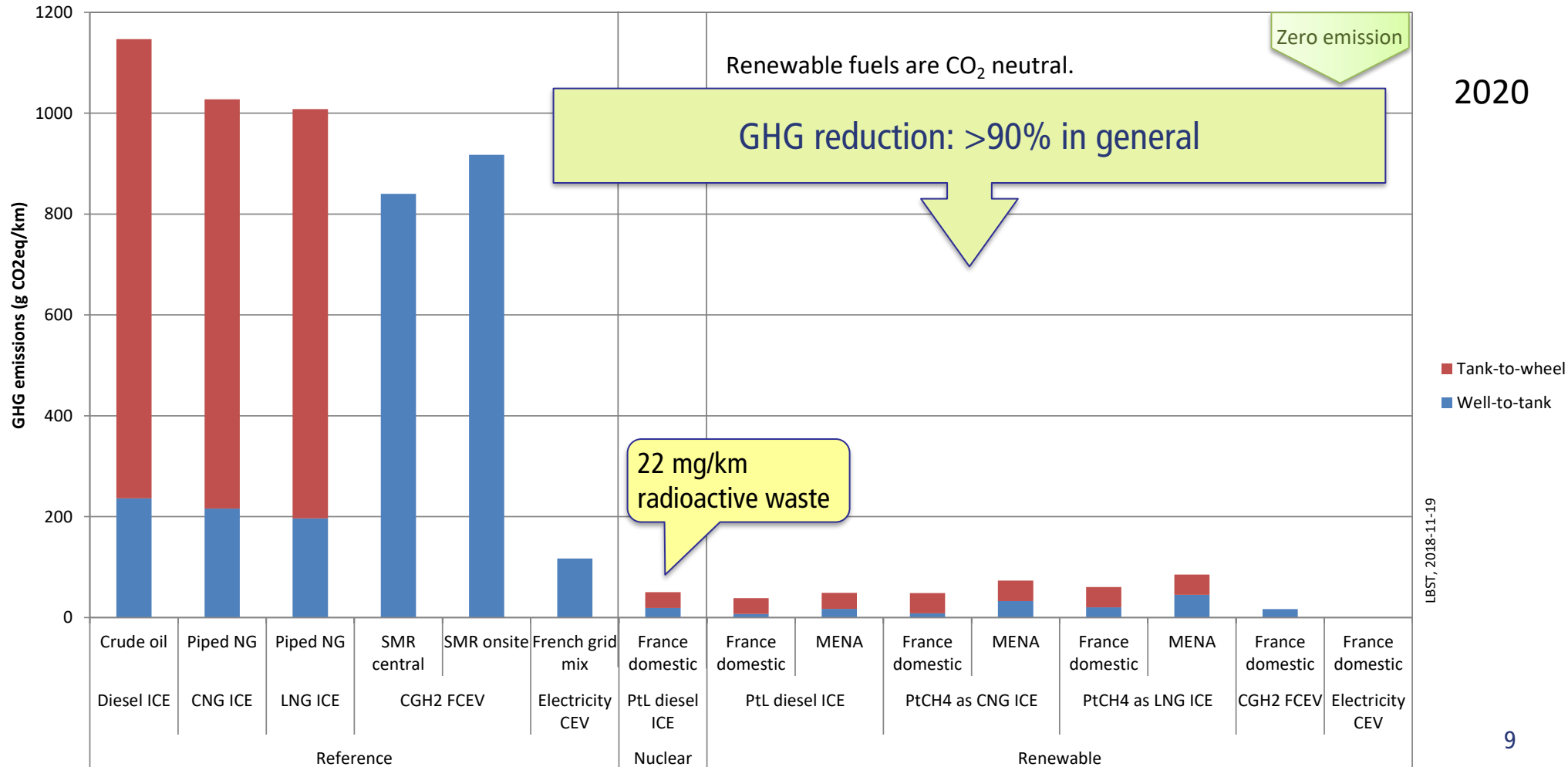
- Rule-of-thumb: The longer the H-C-chain, the higher the energy effort
- Use in fuel cells increases efficiency advantage of direct PtH₂ over more complex fuels



Truck well-to-wheel greenhouse gas emissions



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Recent PtL project announcements (from PtX database)



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Green Power 2 Jet (DE)

- DOW/Stade, BP/Lingen, Airbus, ...
- Fischer-Tropsch



ReWest100 (DE)

- EDF, OGE, Ørsted, ThyssenKrupp, Heide Refinery, ...
- Methanol-to-jetfuel



Delfzijl DSL-01 (Groningen, NL)

- KLM, SHV Energy, SkyNRG, ...
- Wastes/residues + power-to-hydrogen (40 MW)



Norsk E-Fuel (Heroya, NO)

- Sunfire, Climeworks, Paul Wurth, ...
- 20 MW co-SOEC (10 Mio. L/a), Fischer-Tropsch



Copenhagen PtX

- Ørsted, Maersk, SAS, ...
- up to 1.3 GW wind, PtH₂ / PtMeOH

Key messages for take-away



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- PtL is notably an option for hard-to-electrify / hard-to-abate uses.
- Key technology components for PtL production are there. Further technology improvements and industrialisation needs deployment.
- First large-scale projects with 2-3+ MW-digits have been announced.
- Initially very high production costs (albeit for a small fuel share).
- PtL sustainability performance can be outstanding, but needs safeguards.
- Production ventures require long-term off-take contracts for bankability.

⇒ Tangible regulatory/support framework required for introduction

Questions?



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