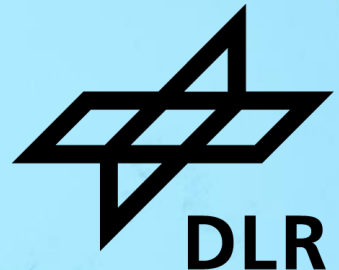


LIFE CYCLE ASSESSMENT OF SUSTAINABLE AVIATION FUEL PRODUCTION IN THE EUROPEAN CONTEXT

Julia Weyand and Ralph-Uwe Dietrich

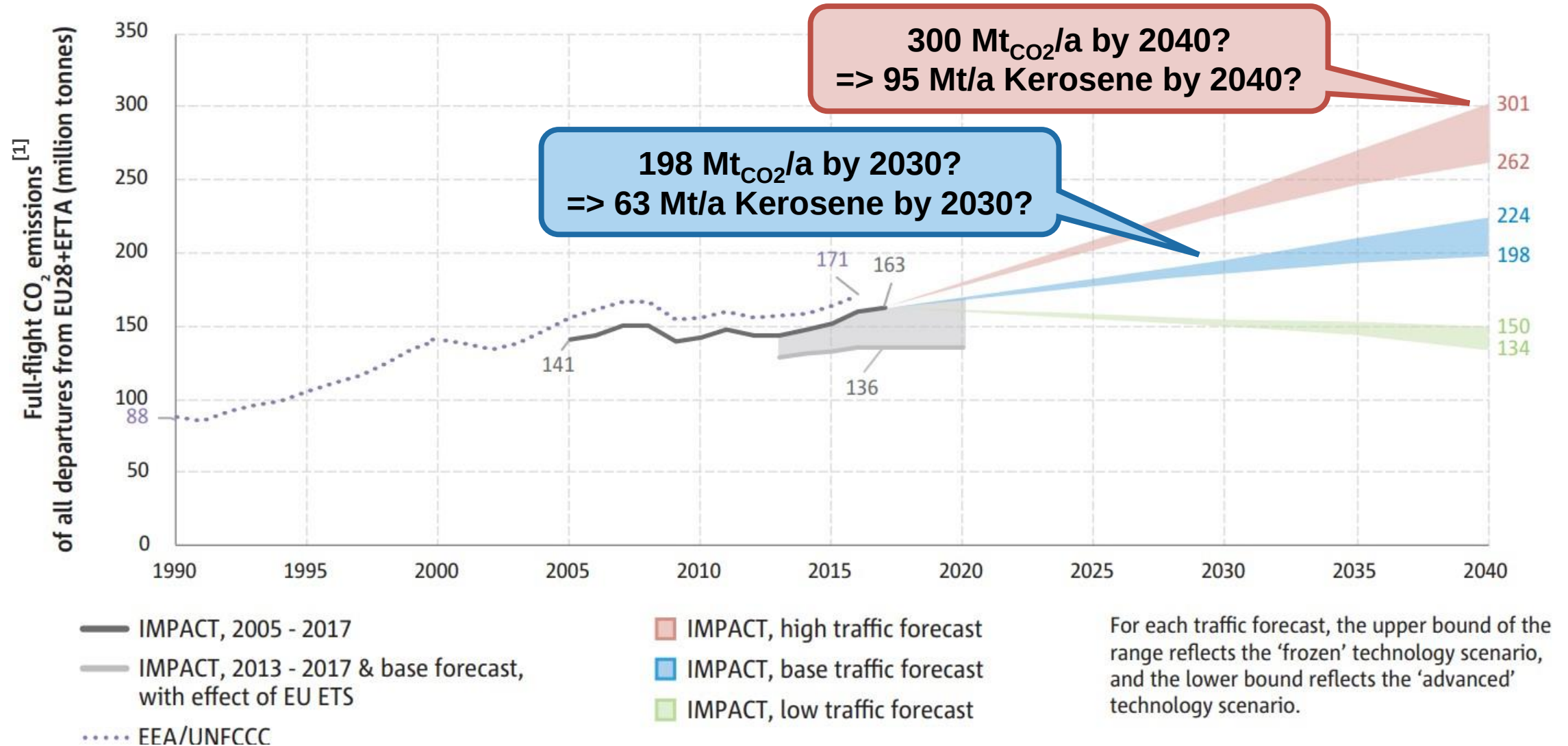
O2.19

10.07.2025



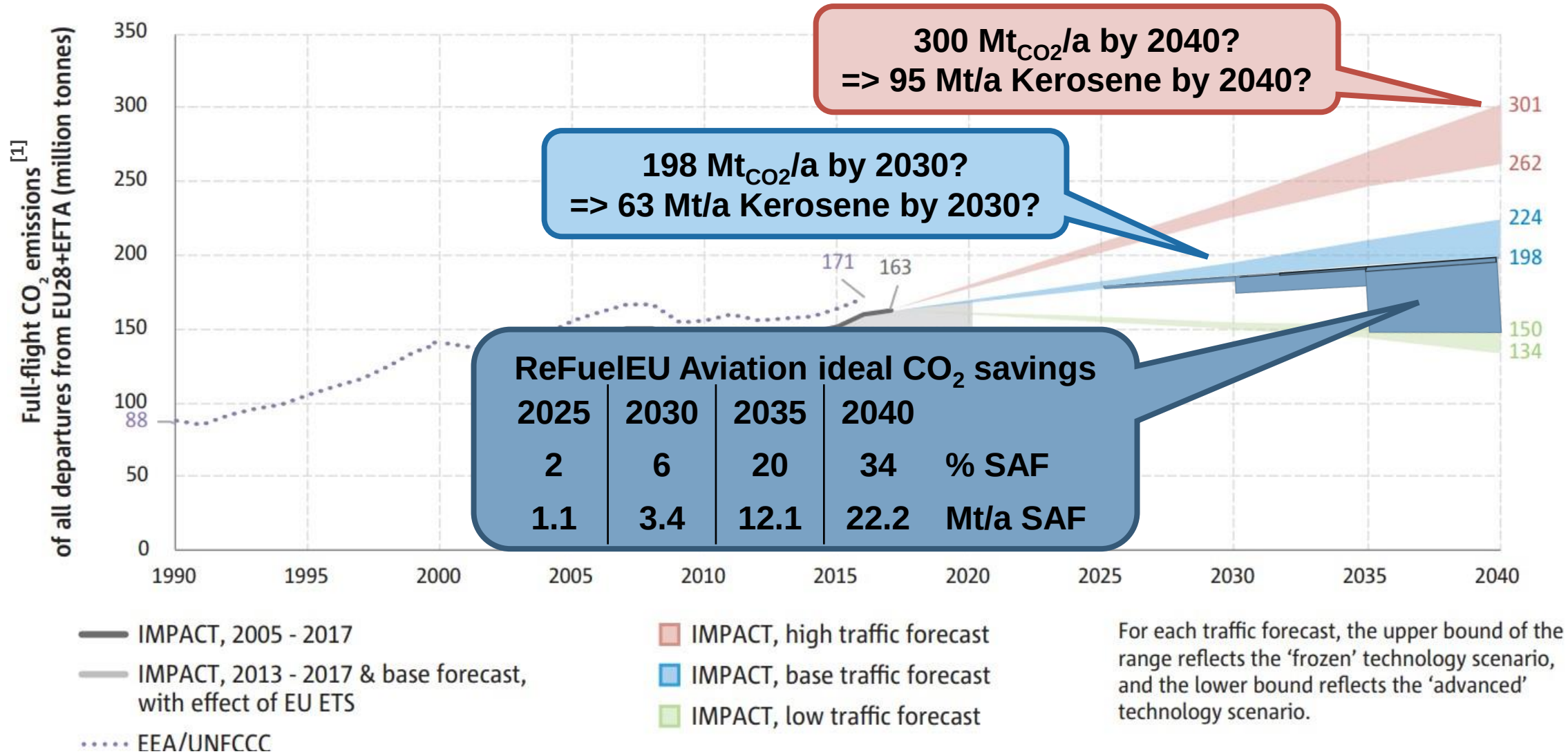
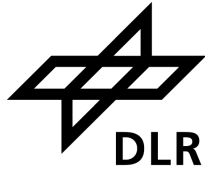
EU aviation CO₂ emissions

SAF demand and ReFuelEU Aviation



EU aviation CO₂ emissions

SAF demand and ReFuelEU Aviation



[1] European Aviation Environmental Report 2019, https://www.easa.europa.eu/eaer/system/files/usr_uploaded/219473_EASA_EAER_2019_WEB_LOW-RES.pdf

Certified Alternative Jet Fuels

ASTM D7566 – 24 [1]

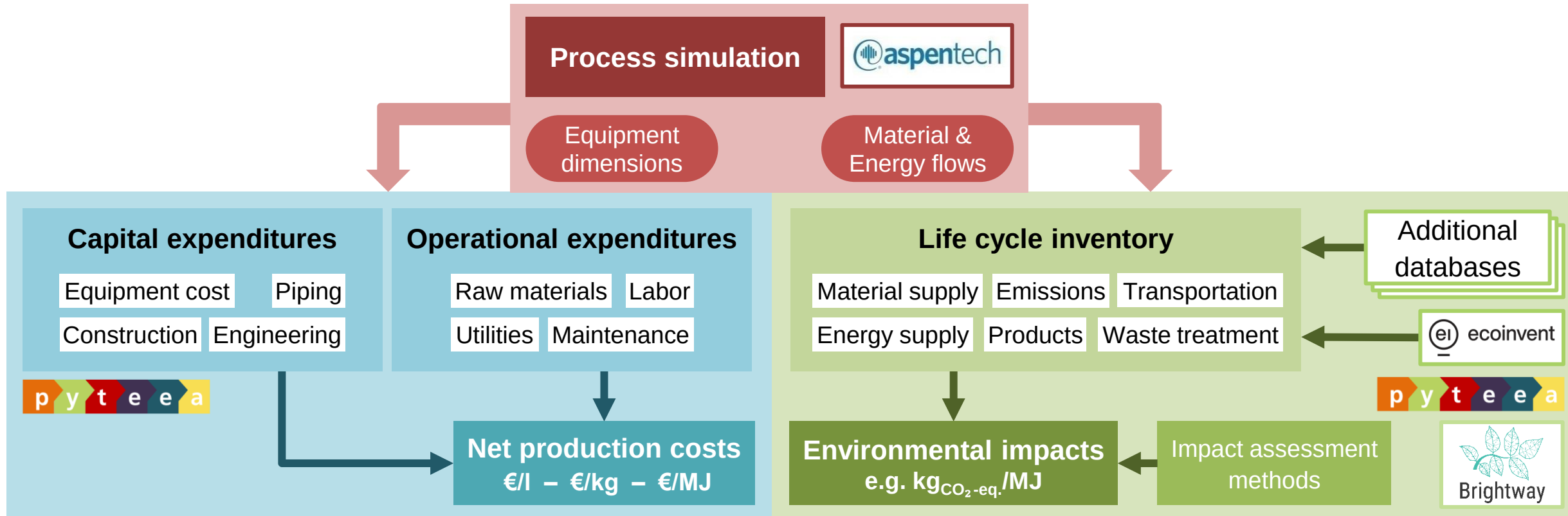
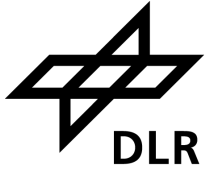


Fuel Type	Feedstock	Conversion Pathway	Blend Limit
FT-SPK (Fischer-Tropsch Synthetic Paraffinic Kerosene)	Biomass, municipal solid waste, coal, or natural gas	Fischer-Tropsch synthesis → COMSYN hydroprocessing FLEXCHX	≤ 50%
HEFA-SPK (Hydroprocessed Esters and Fatty Acids)	Vegetable oils, used cooking oils, animal fats, algae oil	Hydroprocessing of lipids	≤ 50%
SIP (Synthesized Iso-Paraffins)	Sugars (e.g., from corn stover, sugarcane)	Fermentation → catalytic upgrading	≤ 10%
FT-SPK/A (Fischer-Tropsch SPK with Aromatics)	Same as FT-SPK (biomass, waste, coal, gas)	Fischer-Tropsch synthesis → aromatic recovery	≤ 50%
ATJ-SPK (Alcohol-to-Jet SPK)	Ethanol or isobutanol (from biomass or industrial waste gases)	Alcohol fermentation → dehydration → oligomerization → hydroprocessing	≤ 50%
CHJ (Catalytic Hydrothermolysis Jet)	Lipids (e.g., from oilseeds, algae)	Hydrothermal liquefaction → hydroprocessing ABC-Salt	≤ 50%
HC-HEFA-SPK (High Freezing Point HEFA)	Camelina oil or other lipid feedstocks	HEFA (modified for high freezing point)	≤ 50%
CHJ-AR (CHJ with Aromatics)	Lipids (as in CHJ)	Hydrothermal liquefaction → catalytic reforming (to increase aromatics)	≤ 50%

[1] ASTM International, „ASTM D7566-24 Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons“, 2024

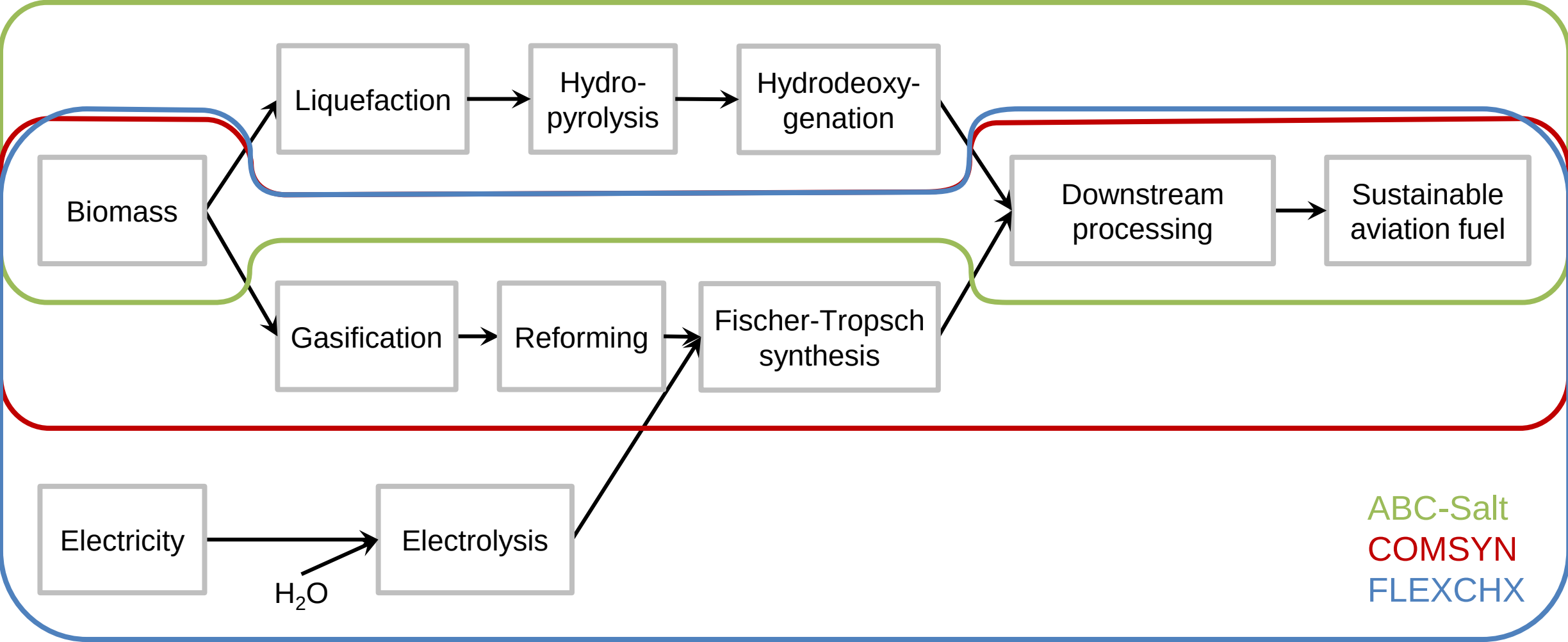
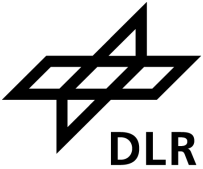
Methodology

Technical, economic and environmental evaluation at DLR



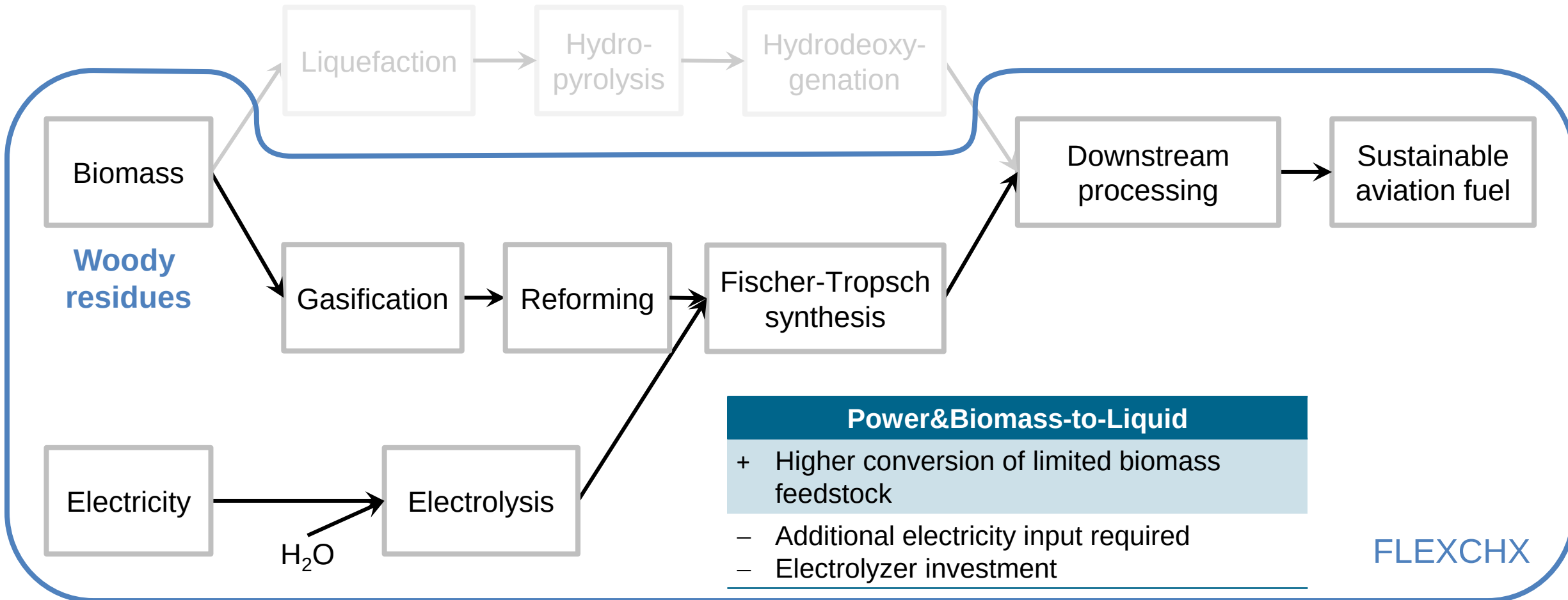
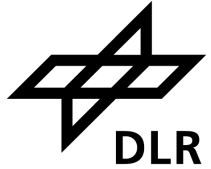
➤ Inhouse tool for automated standardized economic and environmental assessment

SAF production routes



SAF production routes

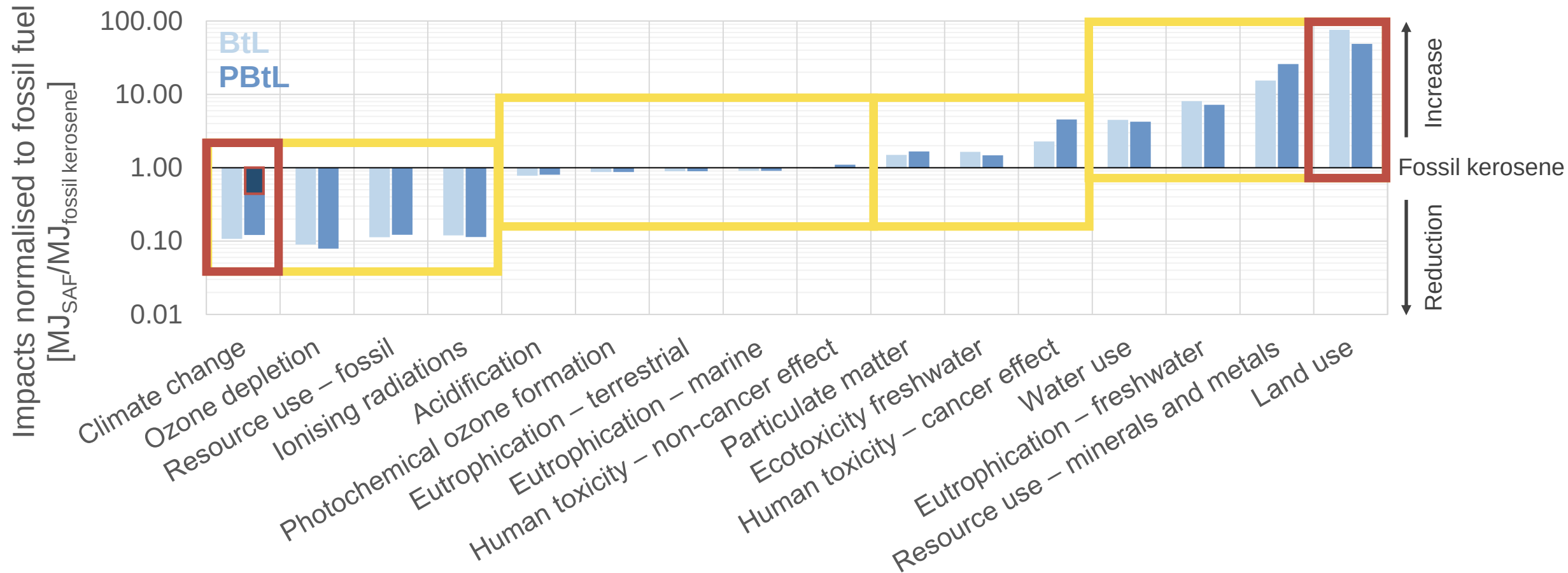
FLEXCHX project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 763919



FLEXCHX

Hydrogen addition for increased SAF production volumes ^[1]

Environmental impacts compared to fossil kerosene (Finland)

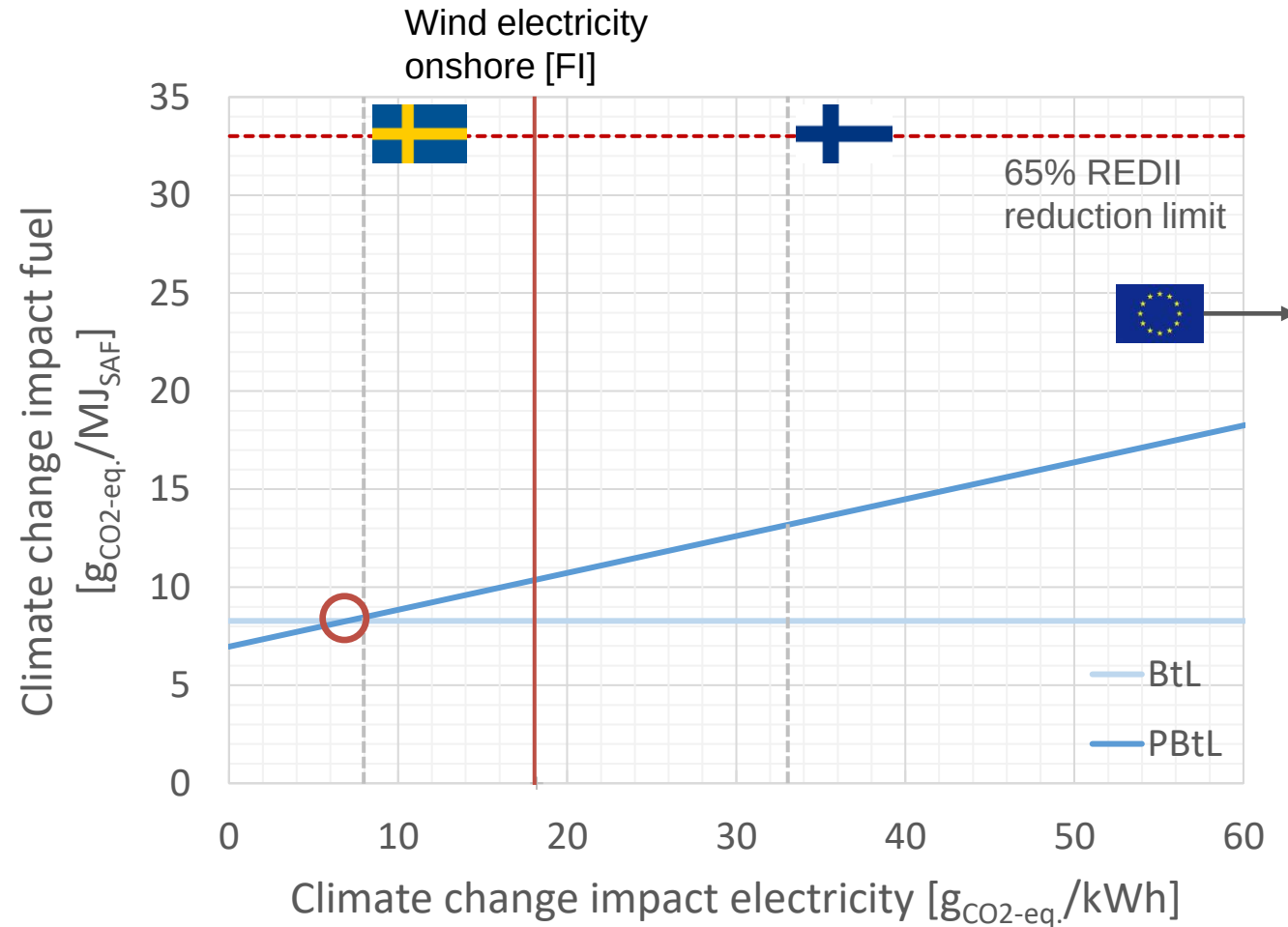


➤ Trade-offs with other impact categories need to be considered

Hydrogen addition for increased SAF production volumes ^[1]

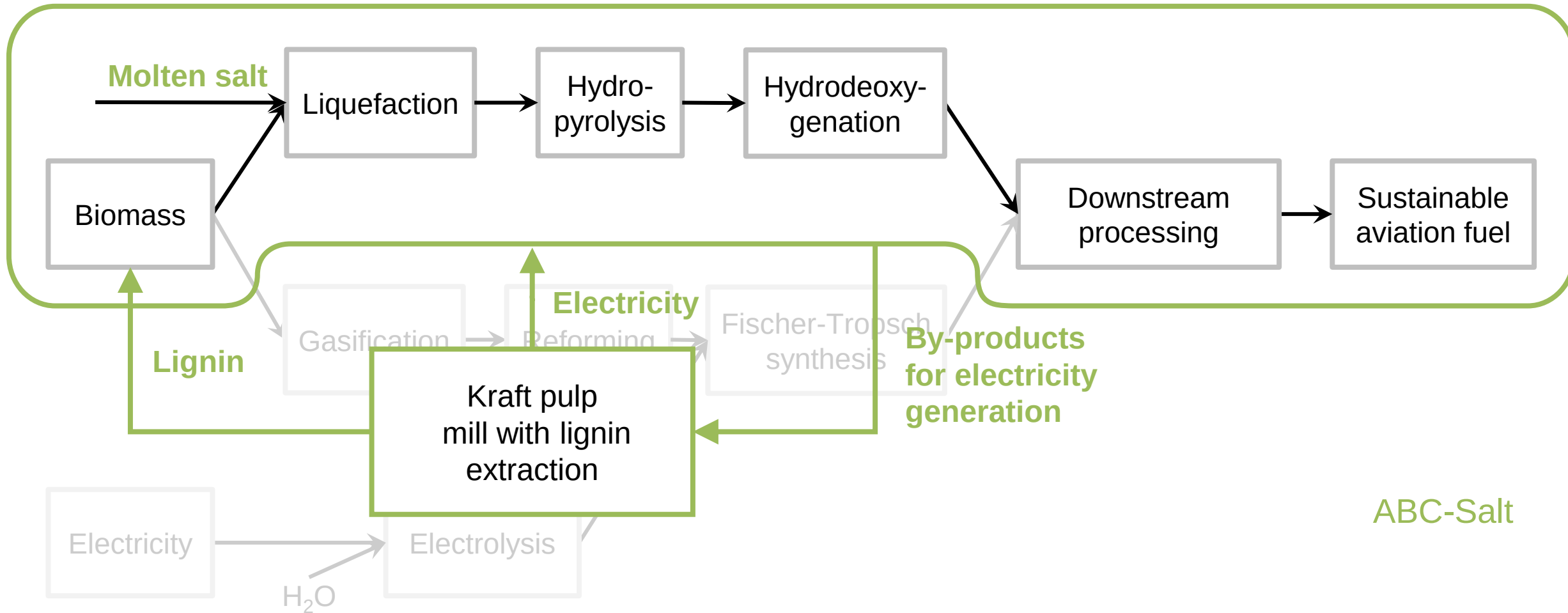
Electricity climate change impact sensitivity

- PBtL product output ~1.8x BtL
- CC impact < 7 g_{CO₂-eq.}/kWh
→ PBtL > BtL
- European electricity CC average in 2023 ^[2]: 207 g_{CO₂-eq.}/kWh
→ 49 g_{CO₂-eq.}/MJ_{SAF}
(> REDII Limit: 33 g_{CO₂-eq.}/MJ_{SAF})



SAF production routes

ABC-Salt project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 764089

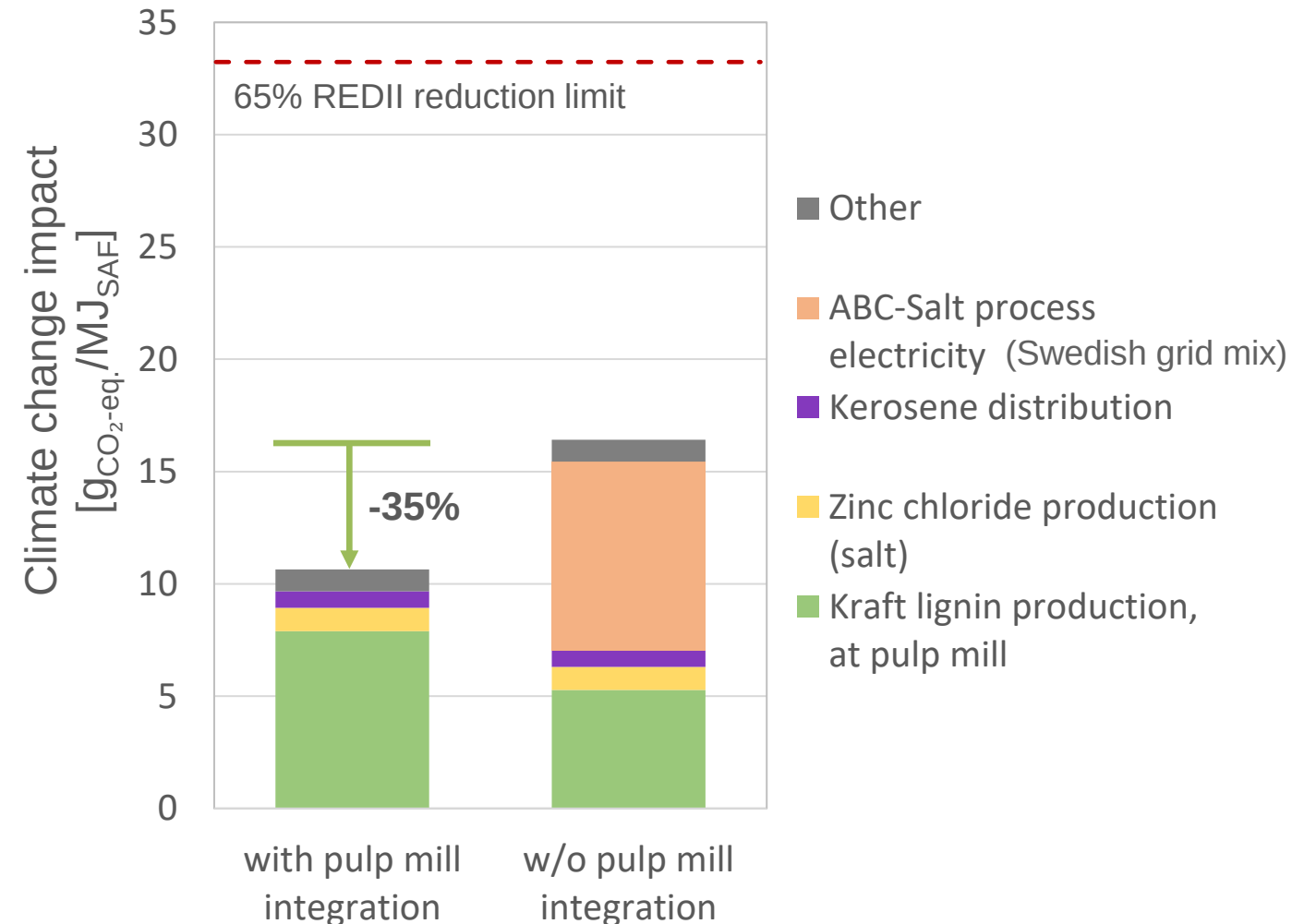


ABC-Salt

Energetic integration with existing industry ^[1]

SAF from lignin with pulp mill integration (Sweden)

- SAF from by-product of pulp and paper industry (Kraft lignin)
- Efficiencies: $\eta_c = 78 \%$
 $\eta_e = 52.5 \%_{LHV}$
- CC impact reduction through integration: up to -35%

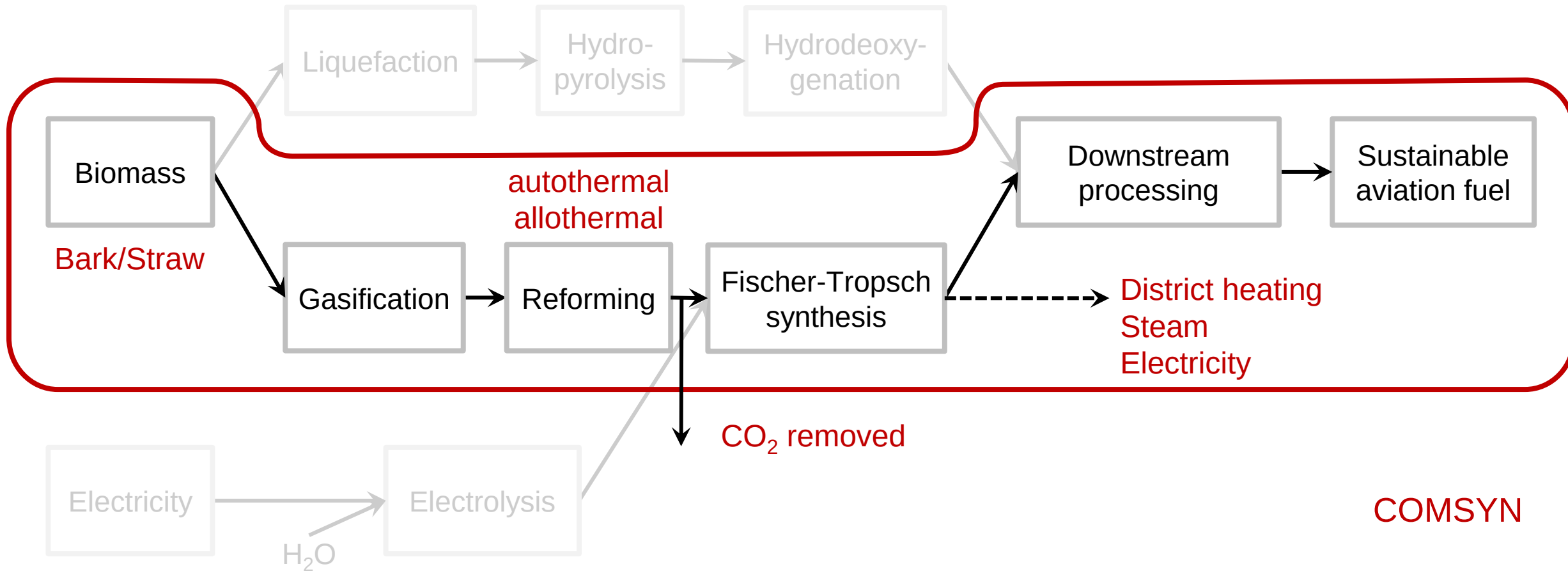
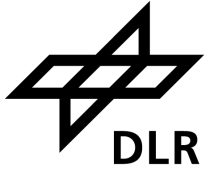


SAF production routes

COMSYN project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727476



COMSYN



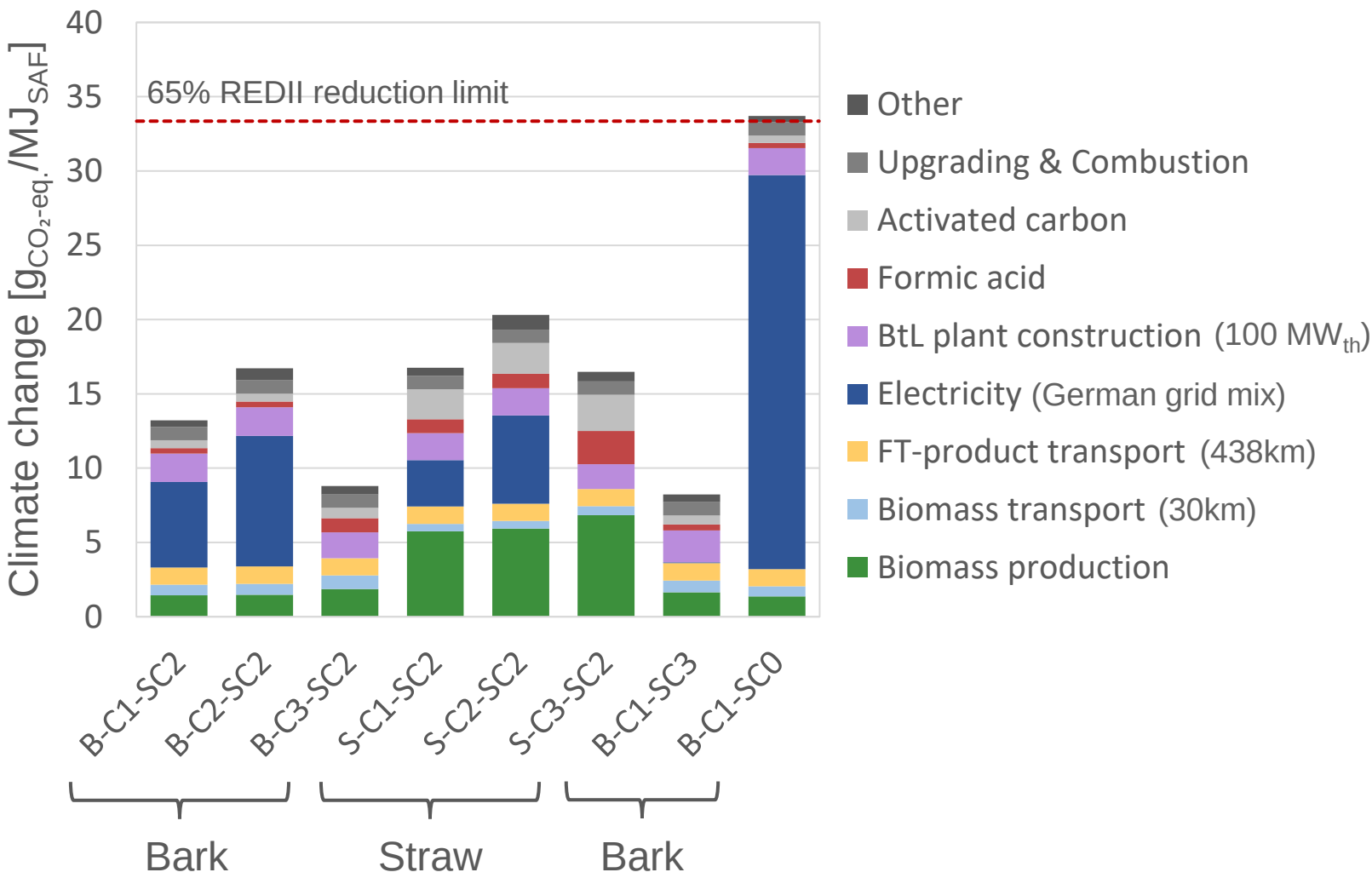
COMSYN

Location dependent process design for SAF [1]

Design options example (Germany)



	Description
C1	Autothermal reformer
C2	Autothermal reformer + CO ₂ removal
C3	Allothermal reformer
SC2	Electricity + District heating
SC3	Electricity
SC0	District heating + Steam



[1] Weyand, J. et al. (2025): Location dependent process design for biomass-to-liquid fuel from a technical, economic and environmental perspective – A Central European case study, to be submitted

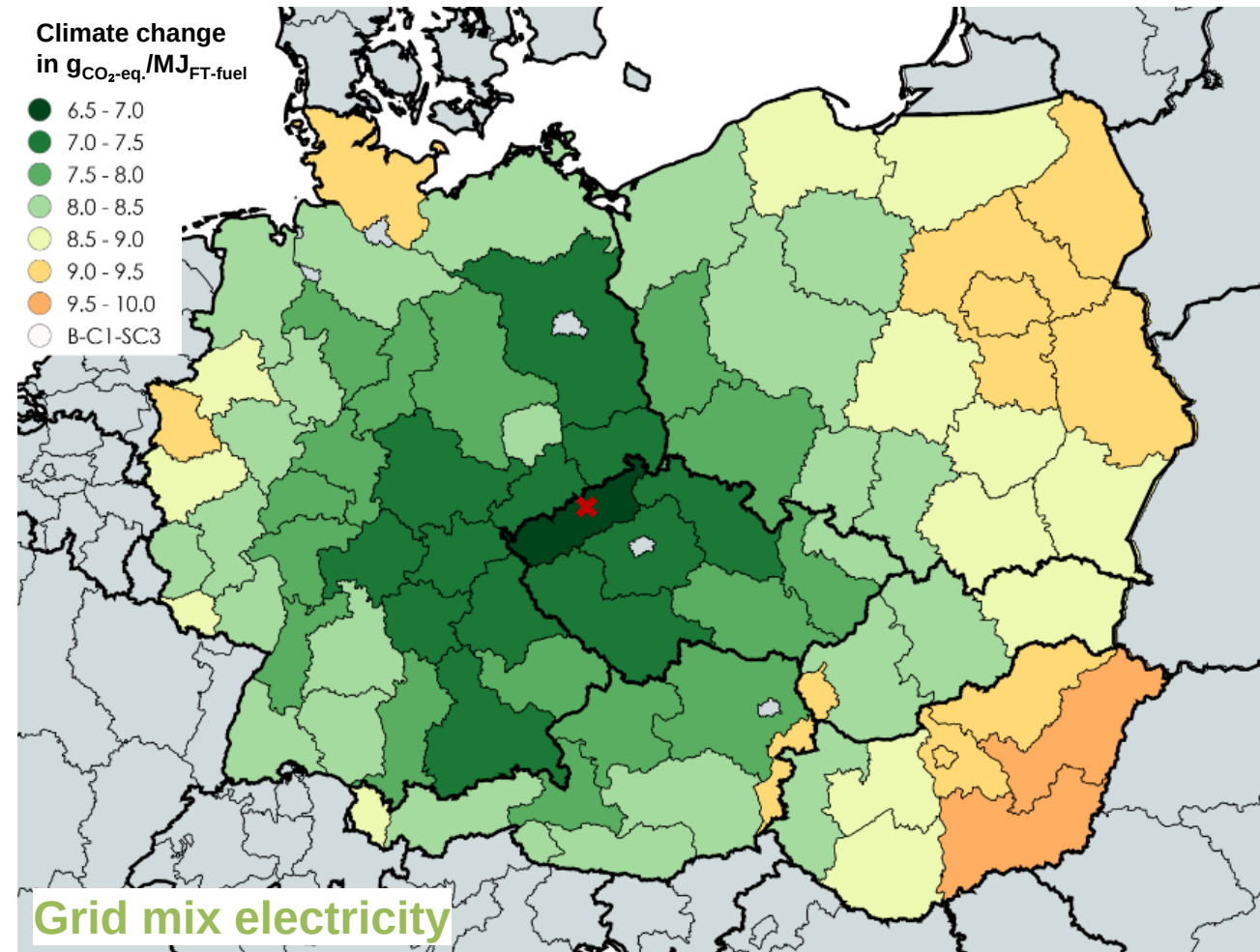
Location dependent process design for SAF^[1]

Central Europe

82 NUTS2 regions

(Nomenclature of Territorial Units for Statistics in Cat. 2)

- Biomass feedstock potential
- Biomass composition
- Biomass transport distances
- Grid mix composition
- Transport distance to refinery
- Plant size



x Refinery location in Litvinov

- Automated LCA based on process simulation enables standardized assessment of various production routes, designs, feedstocks, locations, ...
- Take-aways for large scale deployment:
 - FLEXCHX: Hydrogen addition can enhance SAF production volumes but also reduces CC reduction potential
 - ABC-Salt: Energetic integration with existing industry processes is beneficial
 - COMSYN: Location dependent process design can reduce environmental impacts (balance between cost and environment)
- All routes: CC reduction potential of 75-90% for SAF
- Certification should be simplified

FLEXCHX:

J. Weyand et al. (2023): Process design analysis of a hybrid Power-and-Biomass-to-Liquid process – An approach combining life cycle and techno-economic assessment, Fuel 342

<https://doi.org/10.1016/j.fuel.2023.127763>

ABC-Salt:

J. Weyand et al. (2025): Sustainable aviation fuel from Kraft lignin – Technical, economic and ecological process analysis, Journal of Cleaner Production 500

<https://doi.org/10.1016/j.jclepro.2024.144559>

COMSYN:

J. Weyand et al. (2025): Location dependent process design for biomass-to-liquid fuel from a technical, economic and environmental perspective – A Central European case study, to be submitted

Thank You!

Julia Weyand

julia.weyand@dlr.de

German Aerospace Center (DLR)

Institute of Engineering Thermodynamics



INTERNATIONAL CONFERENCE ON
SUSTAINABLE AVIATION RESEARCH

ICSAR

9th-11th July 2025, Dublin, Ireland



**1st International
Conference on Sustainable
Aviation Research**

9th-11th July 2025, Dublin, Ireland

*Net-Zero Skies: Advancing Sustainable Aviation
through Collaborative Research*

