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DEFOSSILIZING AVIATION WITH SUSTAINABLE AVIATION FUEL (SAF)

NEW DEVELOPMENTS FOR INDUSTRIAL APPLICATIONS

INSPIRING TECHNOLOGY

ÖGEW-DGMK Herbstveranstaltung
23. - 24. November 2023

Dr. Michael Haid

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DEFOSSILIZING AVIATION | HAID | 23.11.2023



INTRODUCTION

EDL Anlagenbau Gesellschaft mbH

Leading technology-driven engineering company for the process industries looking back on a history of over 100 years. Since 2003 EDL is part of the Austrian Pörner group after many years as part of DEA/RWE and Texaco under the name Edeleanu GmbH.

- Design, engineering and supply of PtX, refining and chemical plants.
- Technology licensor for PtX plants and residue processes.
- Integrator of own and third party technologies for complete plant solutions.

XFuels GmbH

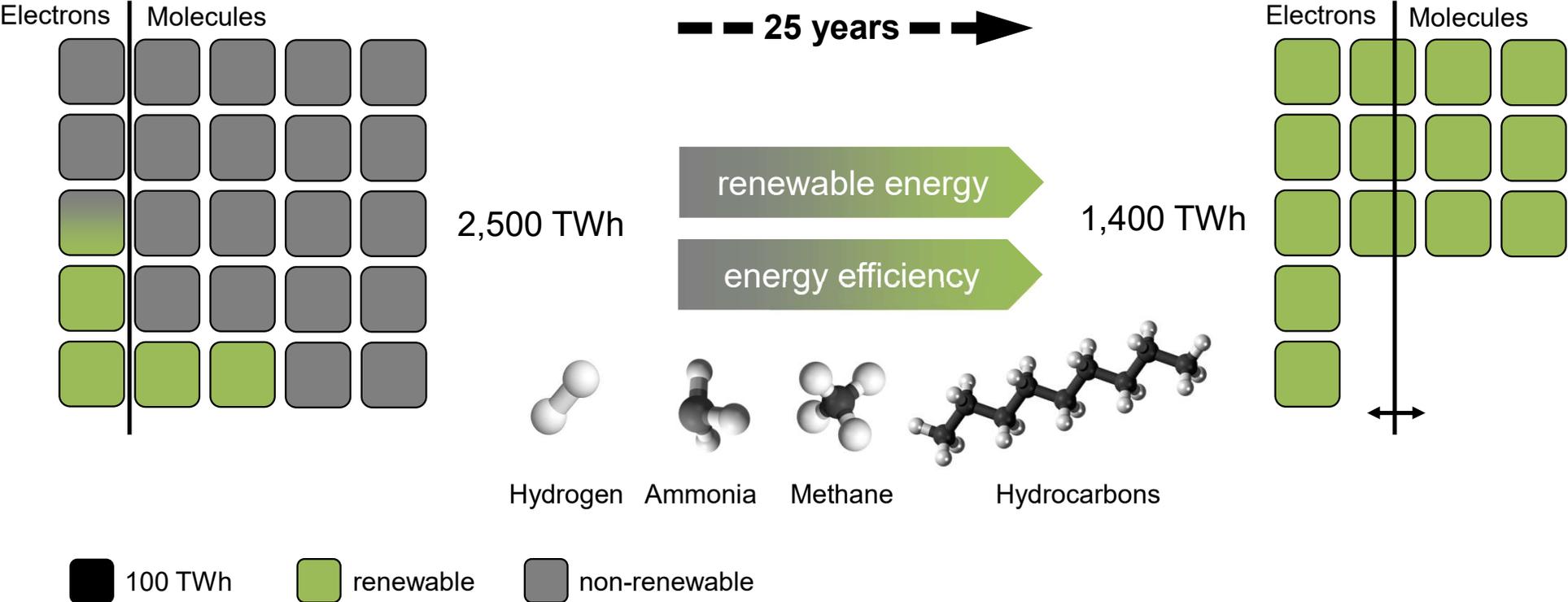
EDL has implemented XFuels GmbH as vehicle for PtX project development and PtX plant operations.



ENERGY TRANSITION NEEDS MOLECULES

Final energy consumption 2020

Final energy consumption 2045



Sources: Fernleitungsnetzbetreiber, terranets bw, Wasserstoff für BW; Energieeffizienzgesetz (EnEfG), 17.11.2023



HYDROGEN CORE NETWORK IN GERMANY

Natural gas network

- Length 41,600 km long-distance, 554,500 km distribution
- Consumers >1.8 mio. industrial, 19 mio. households

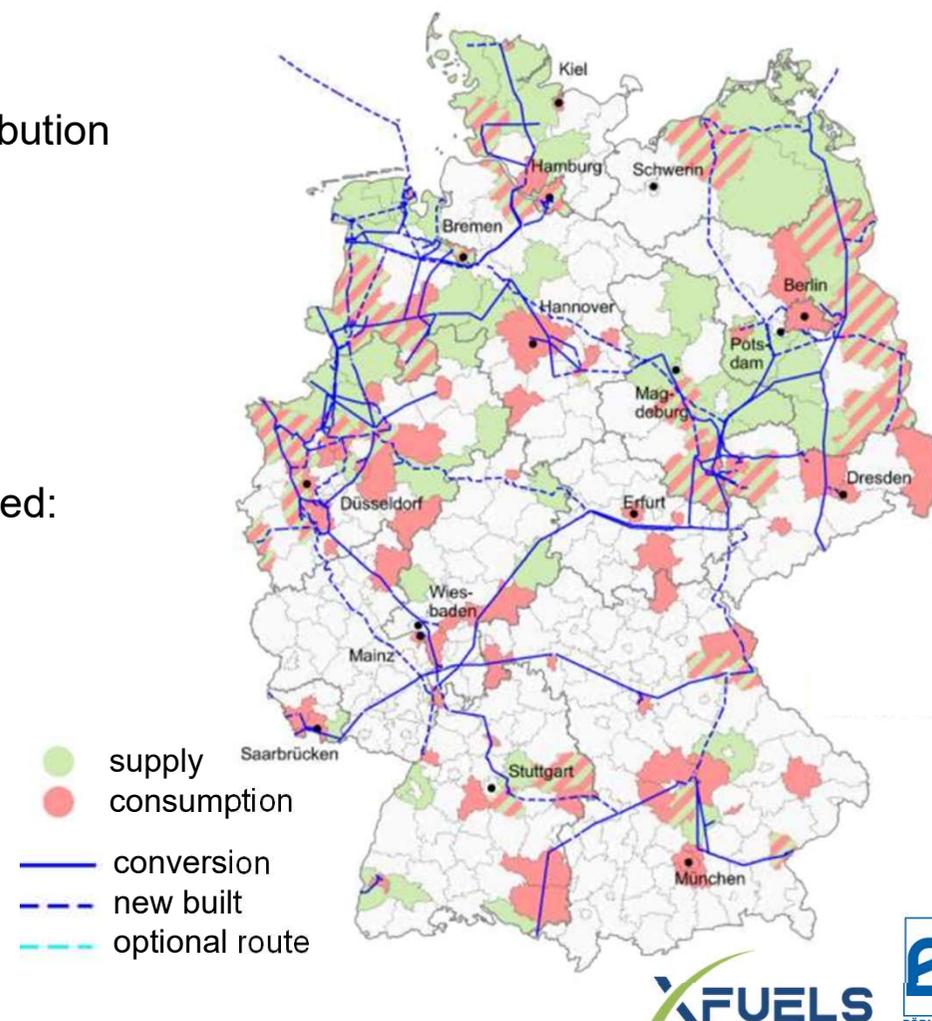
Hydrogen core network until 2032

- Length 5,630 km conversion, 4,090 km new built
- CAPEX € 19.8 billion
- Supply and consumption figures of 309 known projects used:

Supply	GW _{th}	Consumption*	GW _{th}
Cross border	58	IPCEI, PCI, real-world lab projects	11
Electrolysis	15	Industry (steel, chemical, ...)	18
Storage	8	Storage	8
Import by ships	19	Cogen power plants	62
Total	101	Total	87

* Double counting possible

Source: Fernleitungsnetzbetreiber, Antragsentwurf Wasserstoff-Kernnetz, 15.11.2023



EXISTING INFRASTRUCTURE IN EASTERN GERMANY

Hydrogen pipelines

- 150 km existing hydrogen pipelines
- Gas pipelines for expansion of hydrogen network
- Existing connections to consumers and producers

Cavern storage

- Large storage potential in cavern storages
- Cavern (440 mill. m³) in close distance to hydrogen pipelines

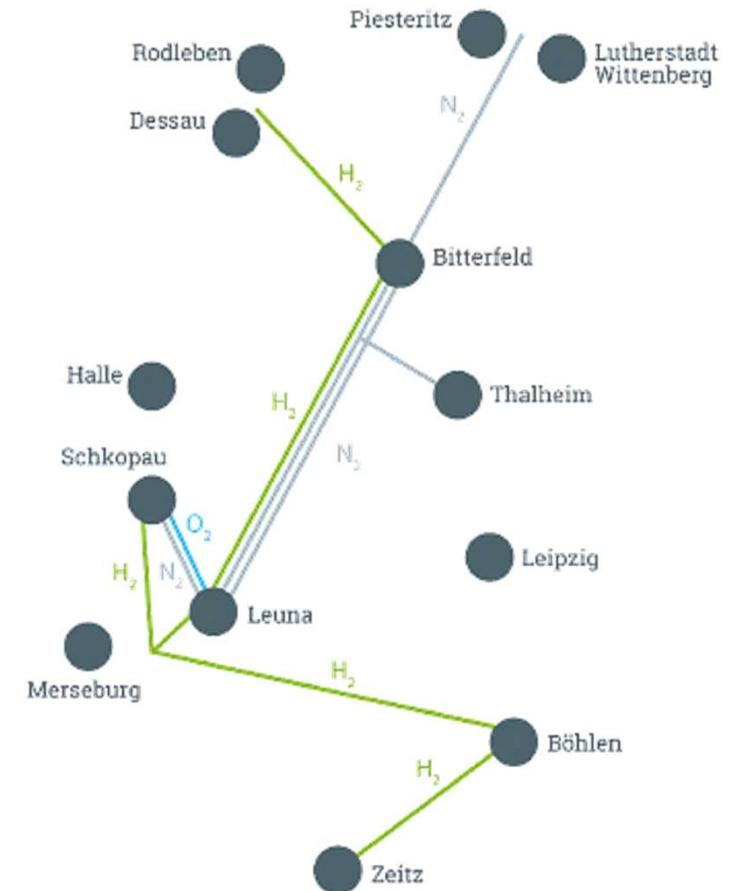
Hydrogen demand

- Consumption of 3.6 bill. m³/h in regional chemical triangle

High potential of renewable energy production

- 105 TWh/a wind
- 33 TWh/a PV

Sources: Hypos



LHYVE JOINT PROJECT (EU IPCEI H₂)



- PtL SAF
- green naphtha
- green hydrogen
- heat

HYKERO KEY FACTS

- Industrial production of 50,000 tpa PtL SAF, 14,000 tpa green naphtha, 1,000 tpa green hydrogen.
- Sustainable products save 350,000 tpa GHG emissions compared to emissions from fossil products.
- Fully integrated industrial PtL plant design developed and patented by EDL based on TRL 9 technologies of leading partners.
- Complete reutilization of by-products for GHG emission free production.
- Renewable electricity, water, carbon dioxide and bio methane are used as the only feedstock.
- High flexibility on carbon dioxide to bio methane feedstock ratio.
- Start of operation end 2027.

Fact sheet

Carbon efficiency*	> 98 %
TRL	9
PtL SAF acc. to	ASTM D7566
GHG savings**	> 80 %

* C in products vs. C in feed

** without RED II bonus



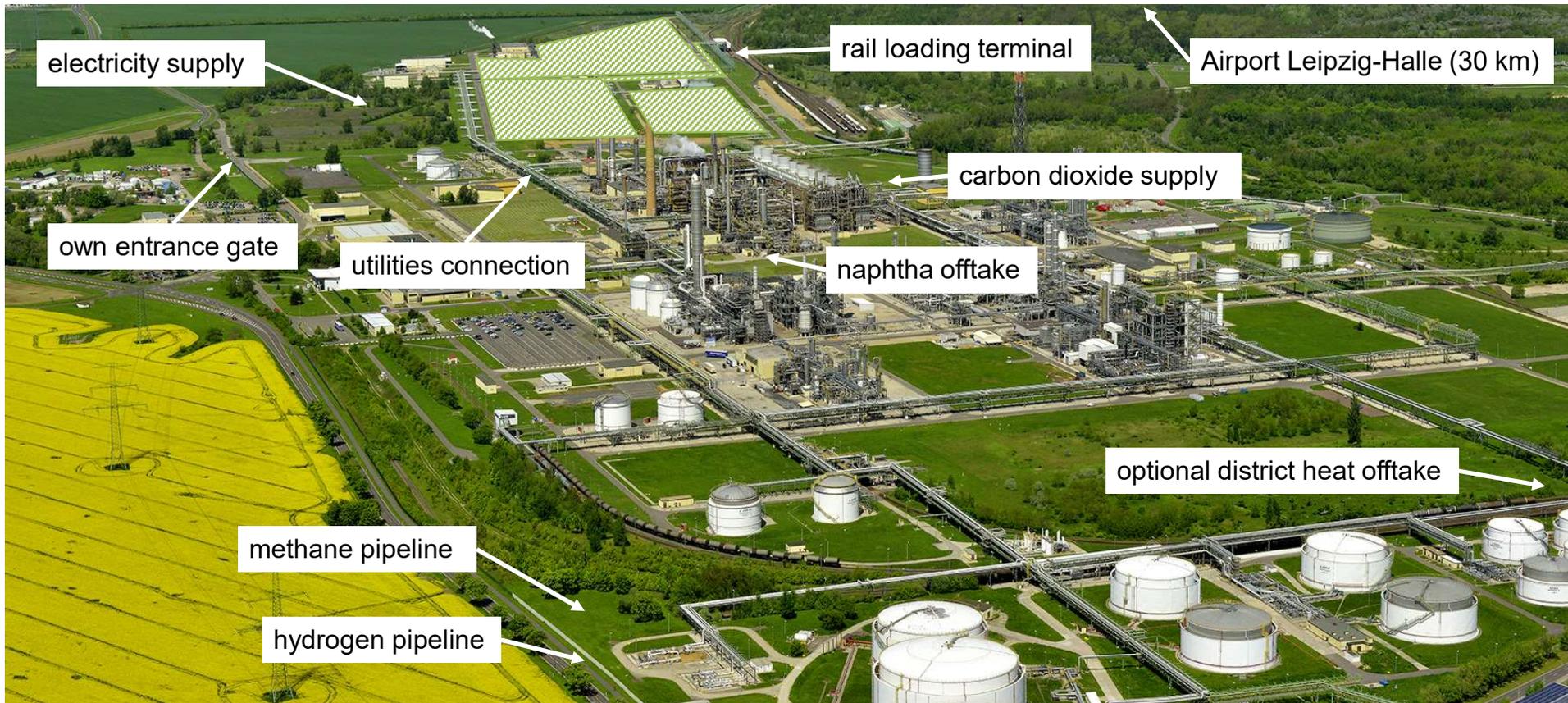
HYKERO PLANT LOCATION

Located in a region with unique synergy potential

- Sufficient plot space for plant, for blending & storage hub and for future expansion.
- Existing rail and road connection to near airport Leipzig-Halle with Europe's largest DHL hub.
- Supply of green naphtha to Dow cracker.
- Integration with existing infrastructure, utility and auxiliary systems.
- Optional heat export to existing district heating.
- Connection to existing hydrogen pipeline grid and to cavern storage in Bad Lauchstädt.
- Potential to install direct power connections to upcoming regional wind and PV parks with a total capacity of over 1.2 GW.

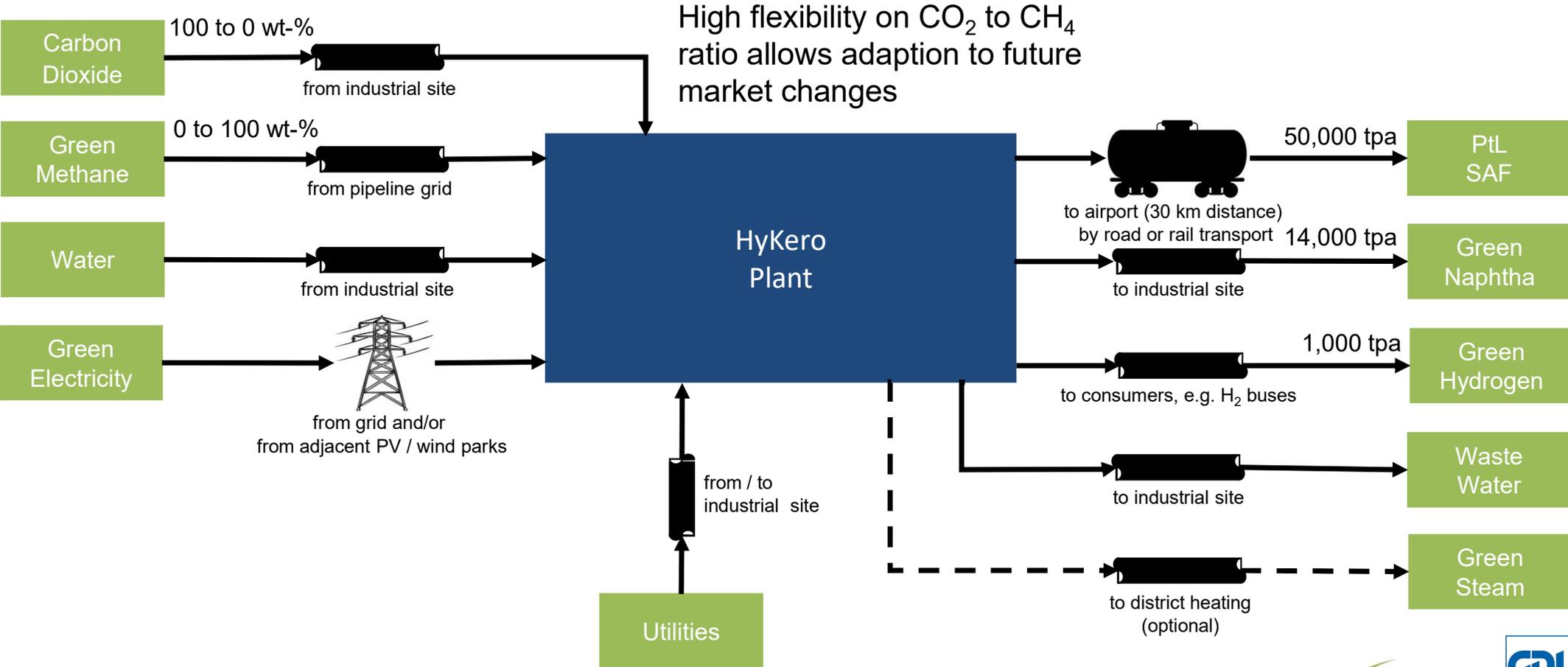


VALUEPARK

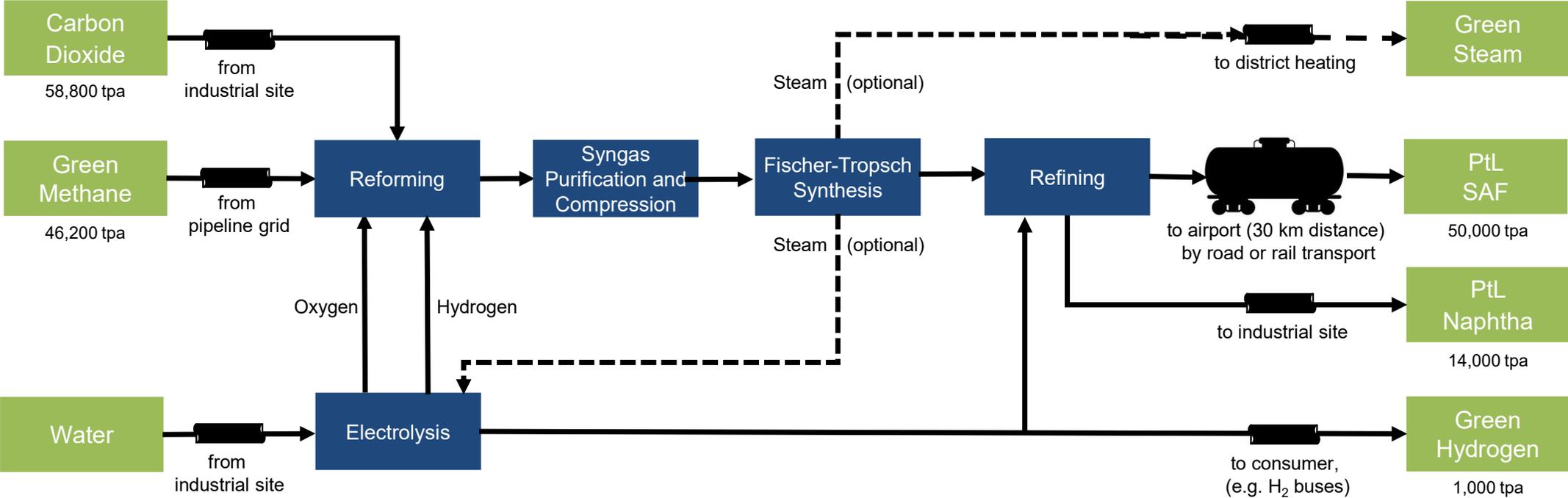


Source: Dow Olefinverbund

FEED AND PRODUCT STREAMS



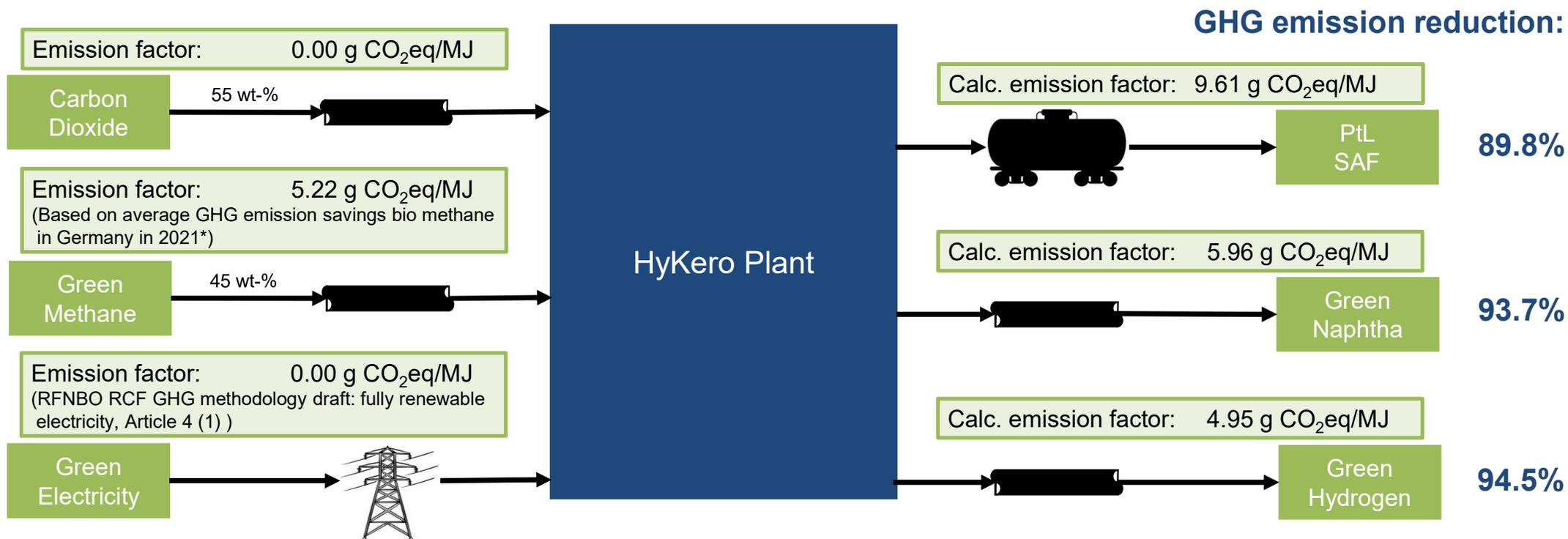
PROCESS CONFIGURATION



Figures for 55 wt-% carbon dioxide and 45 wt-% green methane. All numbers rounded and based on 8,400 annual operating hours.

GHG EMISSION FACTORS

Approved GHG emission calculator for HyKero plant in line with ISCC.



* RED II manure bonus of -20 to -103 g CO₂eq/MJ (Annex VI D) would improve GHG emission reduction.

Sources: EDL calculation, emission values of fossil products: kerosene 94 g CO₂eq/MJ, naphtha 89 g CO₂eq/MJ, hydrogen 90 g CO₂eq/MJ

SAF BLENDING & STORAGE HUB AT HYKERO PLANT

Annual capacity of 2.0 Mio. m³ SAF blend.

- Most infrastructure needed is already available at the ValuePark.
- Loading and unloading terminal for block trains with max. 22 tank rail cars with a total capacity of 1,900 m³.
- Blending tank farm:
 - 2 fossil Jet A1 tanks for 2 different densities
 - 3 neat SAF tanks for 3 different types (PtL plus AtJ, HEFA, ...)
 - 3 SAF blend tanks
- Allows expansion of limited existing storage capacity at airport Leipzig-Halle.

About 17 % of German Jet A1 consumption can be blended, i.e. 100 % of LEJ and BER plus 50 % of MUC.



SAF BLENDING

Physical properties of neat SAF and fossil Jet A1 are different.

Neat SAF	
ASTM	D7566
Density, kg/m ³	710 - 750
Aromatics, vol-%	0

Fossil Jet A1	
ASTM	D1655
Density, kg/m ³	775 - 840
Aromatics, vol-%	≤ 25

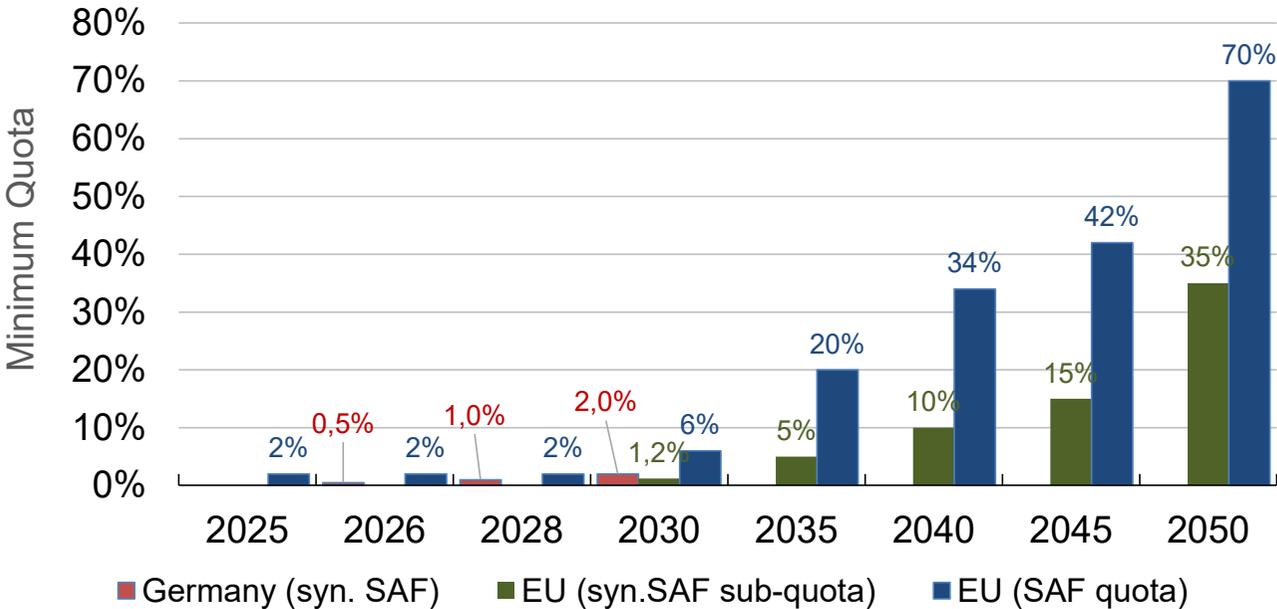


SAF Blend	Low	Med.	High
Neat SAF, kg/m ³	710	730	750
Fossil Jet A1, kg/m ³	775	800	840
SAF Blend, kg/m³	775	775	795
Blending ratio, max.	0 %	36 %	50 %

SAF blends with max. 50 % neat SAF (FT-SPK) allowed, but minimum density requirements often limit blending ratio. Typically, not more than 30 % can be achieved (since Jet A1 is sold in m³).

LEGAL FRAMEWORK

Minimum quota for SAF and sub-quota for synthetic SAF in EU (ReFuelEU Aviation) / Germany (BImSchG)



 Council of the European Union
 Brussels, 19 June 2023
 (OR. en)

10794/23

Interinstitutional File:
 2021/0218(COD)

ENER 372
 CLIMA 312
 CONSOM 242
 TRANS 267
 AGRI 331
 IND 329
 ENV 712
 COMPET 642
 FORETS 71
 CODEC 1160

OUTCOME OF PROCEEDINGS

From: General Secretariat of the Council
 To: Delegations
 No. Cion doc.: 10746/21 + ADD 1

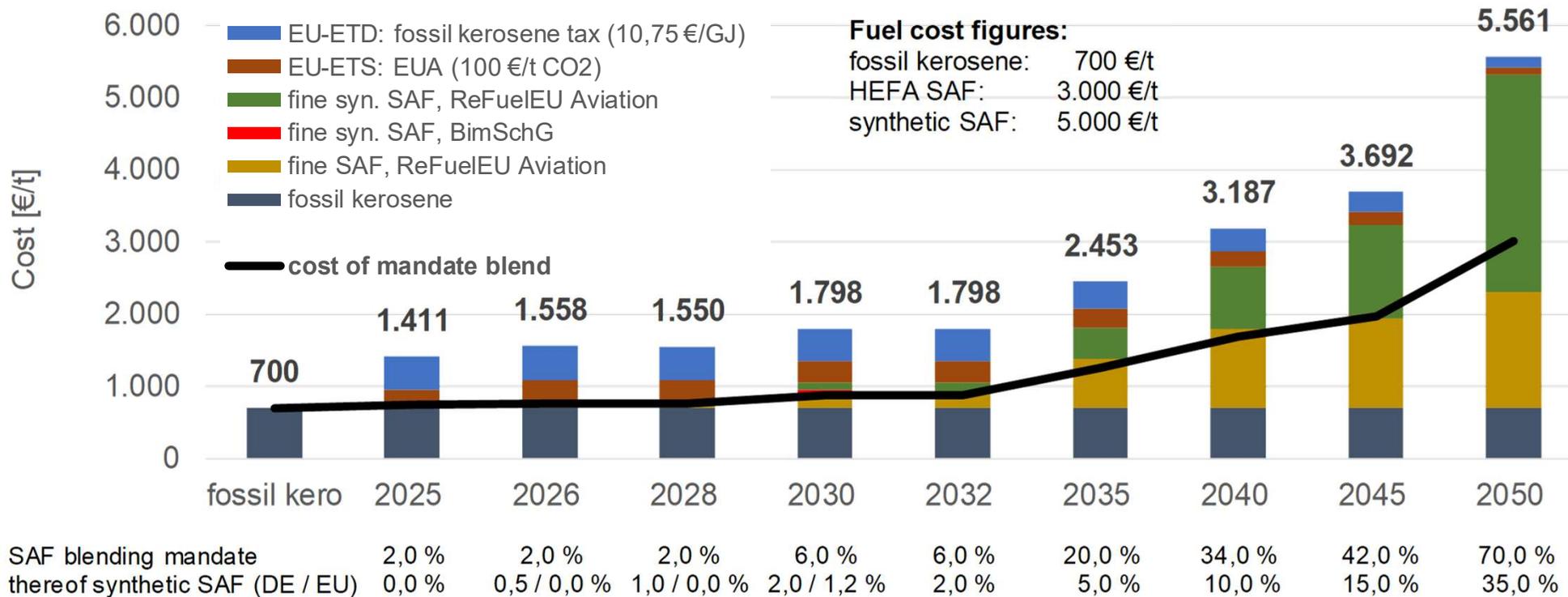
Subject: Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 and Proposal for a Directive the European Parliament and of the Council amending Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources, Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency
 - Letter sent to the Chair of the European Parliament Committee on Industry, Research and Energy (ITRE)

Following the Permanent Representatives Committee meeting of 16 June 2023 which endorsed the final compromise texts on the abovementioned proposals with a view to agreement, delegations are informed that the Presidency sent the attached letter, together with its Annexes, to the Chair of the European Parliament Committee on Industry, Research and Energy (ITRE).

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SAF BLEND IS CHEAPER THAN PURE FOSSIL KERO

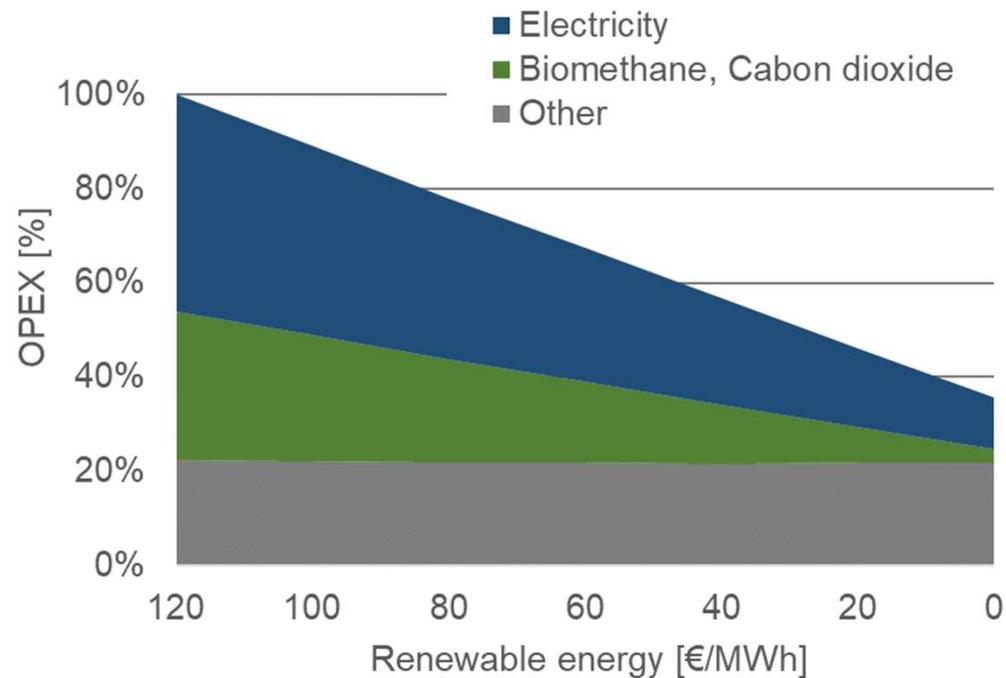


Additional fines on top of above cost figures for

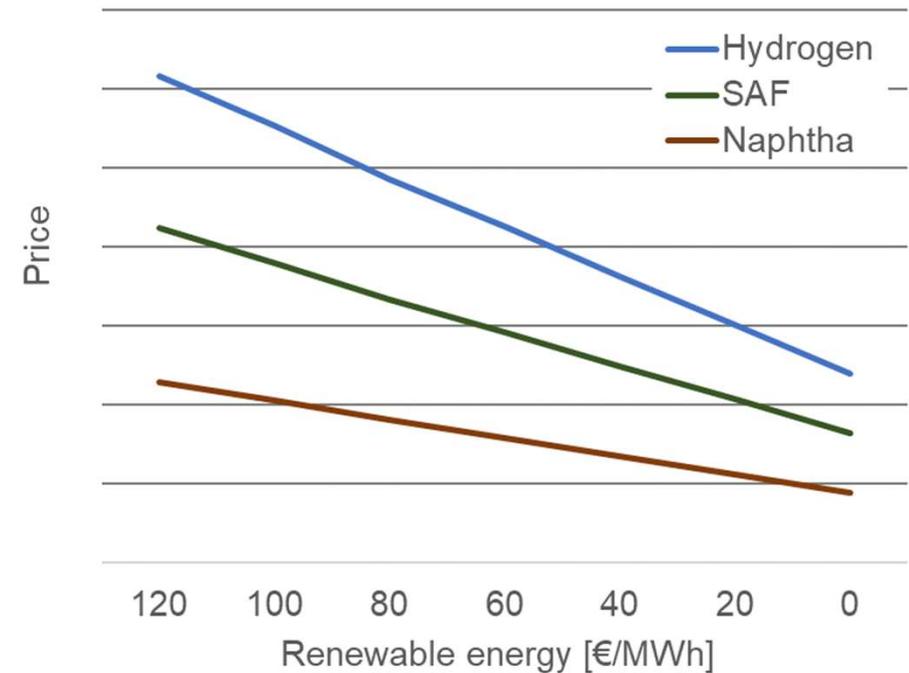
- non-delivery of shortfall quantity in next reporting period,
- missed refueling obligation by aircraft operators.

IMPACT OF ENERGY COST ON PRODUCT PRICES

OPEX



Product prices



High energy cost in Germany require suitable framework to allow quick SAF market ramp-up.

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