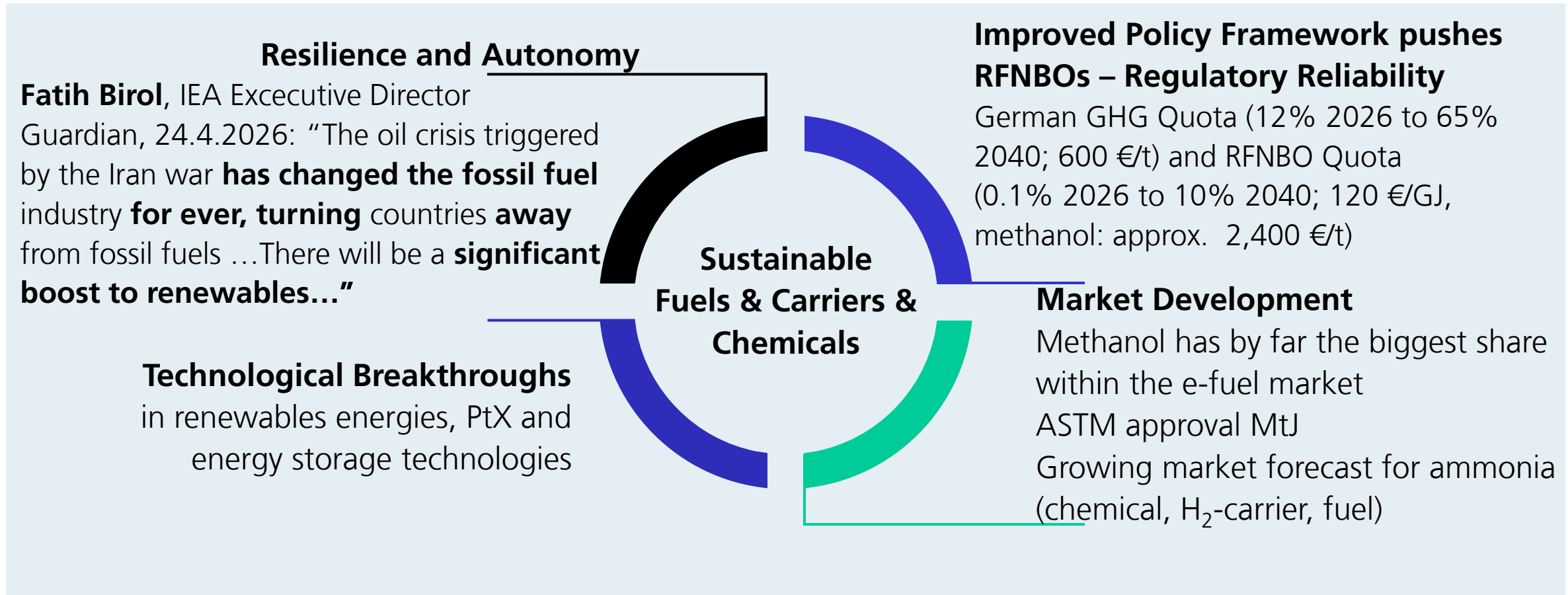


Verfügbarkeit und Bezahlbarkeit von Importenergieträgern: Dimethylether DME – Multitalent für nachhaltige Mobilität, Industrie & Energiewirtschaft

- DME – ungiftiges Gas und blendfähig mit LPG (Liquified Petroleum Gas), auch bekannt als Campinggas bzw. Autogas
- DME – wird industriell aus Methanol hergestellt: > 5 Mio t/a
- Diversifizierung der Energieimporte & Erhöhung der Resilienz durch Nutzung der vorhandenen Infrastruktur mittels DME
- Reduktion der Kosten durch Markthochlauf & Innovationen



Powerful Drivers for Sustainable Energy Fuels, Carrier & Chemicals



Global Hydrogen Flows

170 MT of hydrogen derivatives are transported over long distances by 2050 [1]

→ Energy density is key

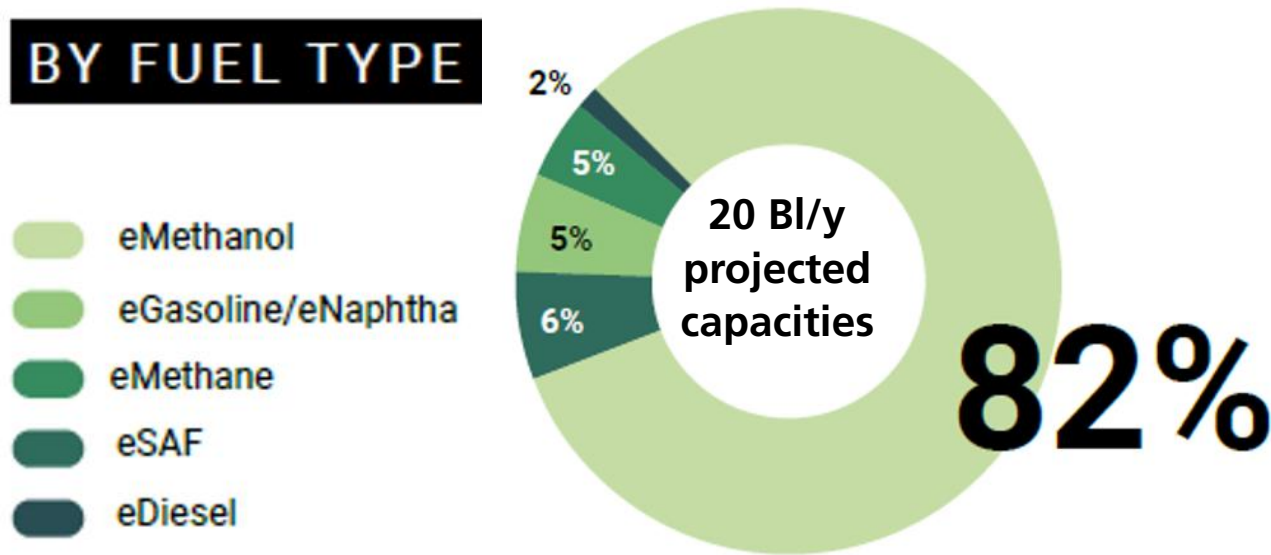
→ H₂ derivatives are relevant: NH₃, MeOH, DME

Category	Unit	LH2	NH ₃	DME
H ₂ storage density	kg _{H2} m ⁻³	70.9	121.1	172.2* (86.1)
Lower heating value	kWh kg ⁻³	33.3	5.2	8.0
Vol. energy density	kWh L ⁻¹	2.3	3.5	5.3

***technical H₂ storage density including steam reforming**
LH2 (-253°C, atm) / NH3 (-33°C, atm) / DME (25°C, 5.9 bar)

E-Fuels Market Share by 2030

Methanol is the Frontrunner and Dimethyl Ether (DME) – Made from Methanol – Could Follow



- Methanol has by far the biggest share within the e-fuel market (European Energy/Kassø, etc.)
- Be aware: IEA Oil Market Report: Fossil Fuel demand: ca. 100 Mio barrel per day [2]

E-Fuel Alliance [1]

Biomass as Carbon Source | Limited Biobased Substitution Potential

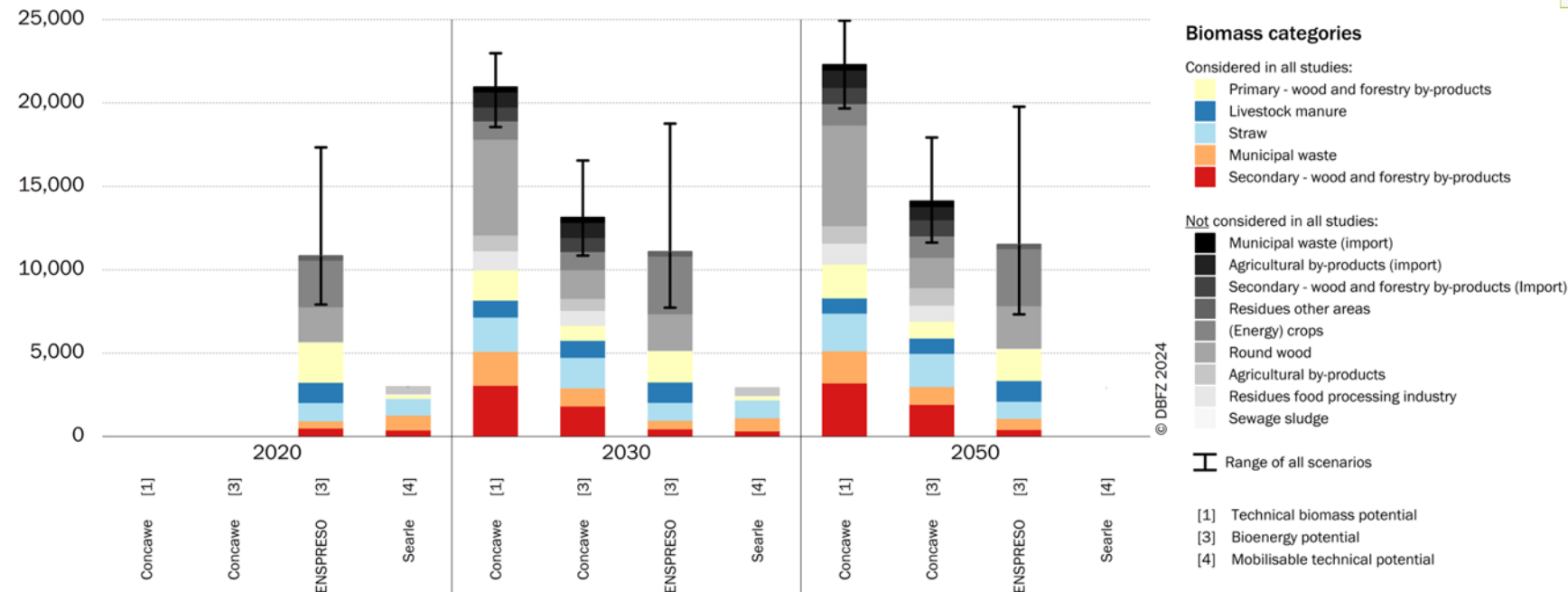


Biomass potentials [all types of biomass] in PJ

scenario = medium



Product potential and substitution



Diesel fuel	0.7 Mt	0.3%
Jet fuel	3.7 Mt	13.8%
Naphtha	1.9 Mt	5.0%

Methane	31 – 131 Mt
Methanol	9 -91 Mt
DME	6.5 – 65.5 Mt

Technical potential	34 - 49%
Bioenergy potential	10 – 45%
Mobilisable potential	8%
(substitution of current refinery output)	

Technical potential up to 25,000 PJ + about 34 Mt biobased CO₂ from ethanol, biogas and biomethane

+ up to 18 Mt DME from biobased CO₂

- Biomass mobilization of importance >> high bandwidths and uncertainties in data for future potentials
- Increasing demand for biomass by 2030 with already high utilisation rates
- Example here: biomass type specific HEFA, methane via biogas, methanol / DME via gasification plus CO₂ via direct synthesis

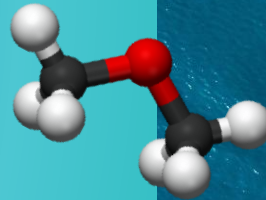
Dimethyl Ether (DME) as Hydrogen Vector and Base Chemical

DME is a commodity, made from methanol

- > 5 Mtpa global market
- Non-toxic, low environmental impact (GWP₁₀₀: 0.3), high energy density
- Stored as liquefied gas under pressure
→ Usage of LPG infrastructure (up to 20% blending)

Current/future applications: Huge market potential

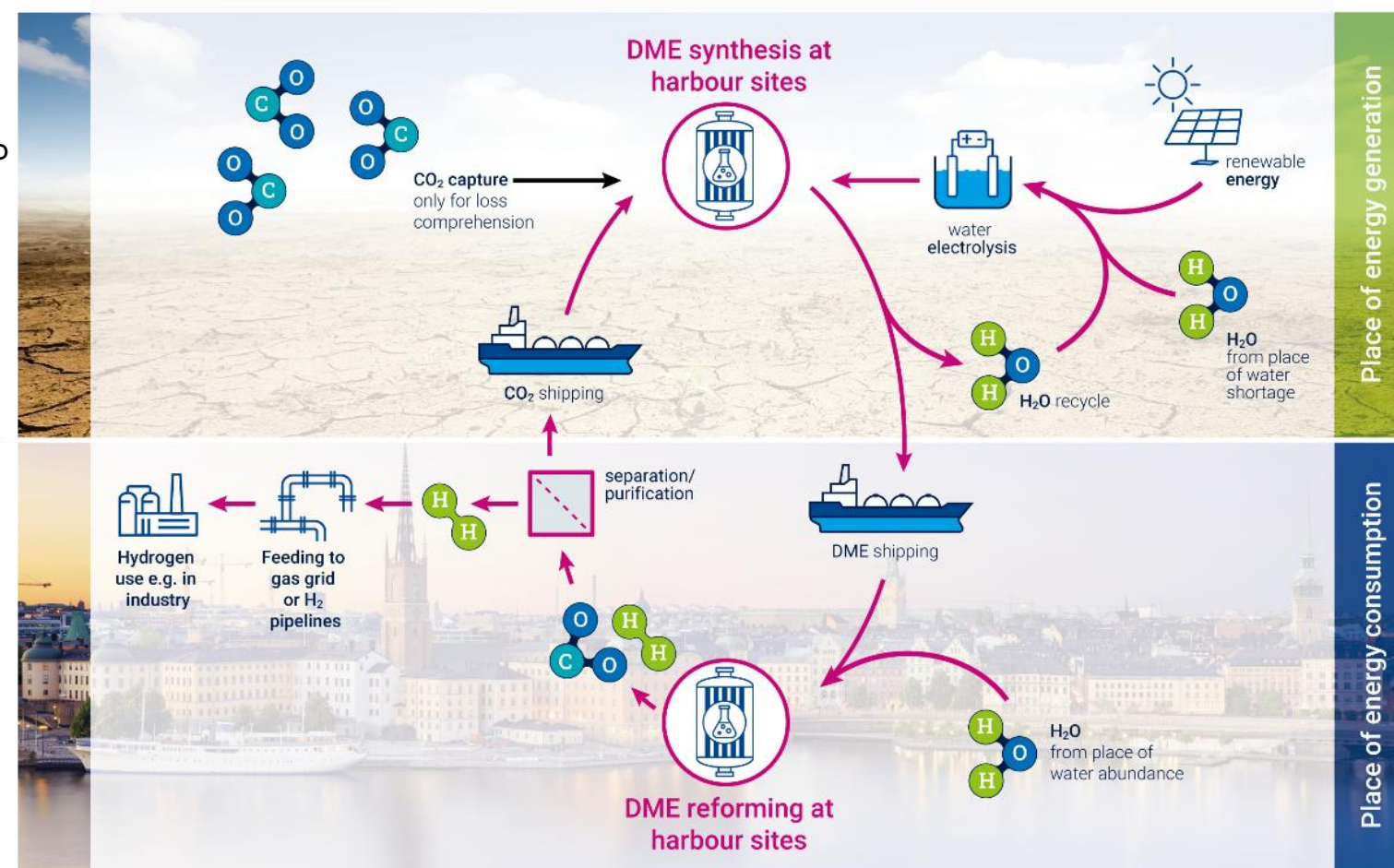
- Propellant, refrigerant, solvent
- LPG substitute & blend → global market 40 Mtpa
- 1) DME for global point-to-point hydrogen transport
- 2) Intermediate for fuels & chemicals
→ global SAF market 2050: ca. 400 Mtpa



1) Dimethyl Ether (DME) – A Global Point-to-Point H₂ Carrier

Advantages of the DME/CO₂ cycle

- DME has **48% higher theoretical hydrogen capacity** than NH₃ and is **non-toxic**, low GWP
- **Reduction of water consumption** in hydrogen production by ca. 45% compared to ammonia
- **Closed Carbon Cycle strongly reduces CO₂ demand**
- CO₂-separation after reforming process (concentrated CO₂-source)
- DME synthesis via intermediate, **highly dynamic methanol production** reduces need for H₂ storage
- **DME offers potential for cost-efficient H₂ delivery**



Schühle, P.; Stöber, R.; Semmel, M.; Schaadt, A.; Szolak, R.; Thill, S.; Alders, M.; Hebling, C.; Wasserscheid, P.; Salem, O. (2023) Dimethyl ether/CO₂ - a hitherto underestimated H₂ storage cycle; Energy & Environmental Science. [Link](#)

1) Dimethyl Ether (DME) – A Global Point-to-Point H₂ Carrier

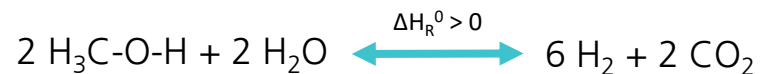
- DME reforming:
 - High temperature reforming using state of the art catalyst from industrial SMR process
 - Low- and medium temperature reforming @TRL 2

Main reactions

- DME hydrolysis

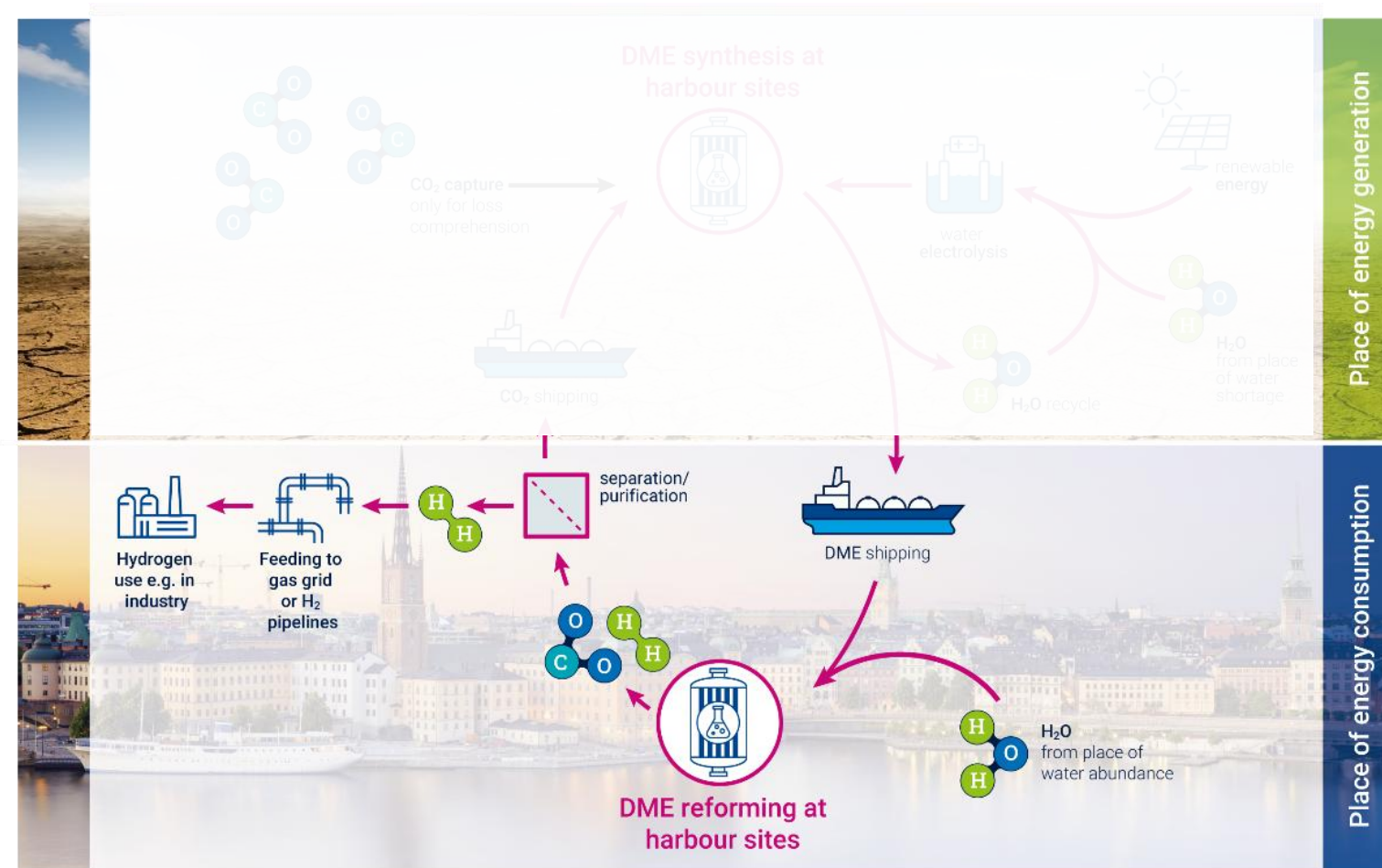


- MeOH steam reforming



Side reactions

- DME decomposition, MeOH decomposition, MeOH-to-Gasoline, methanation, Water-Gas-Shift



Schühle, P.; Stöber, R.; Semmel, M.; Schaadt, A.; Szolak, R.; Thill, S.; Alders, M.; Hebling, C.; Wasserscheid, P.; Salem, O. (2023) Dimethyl ether/CO₂ - a hitherto underestimated H₂ storage cycle; Energy & Environmental Science. [Link](#)

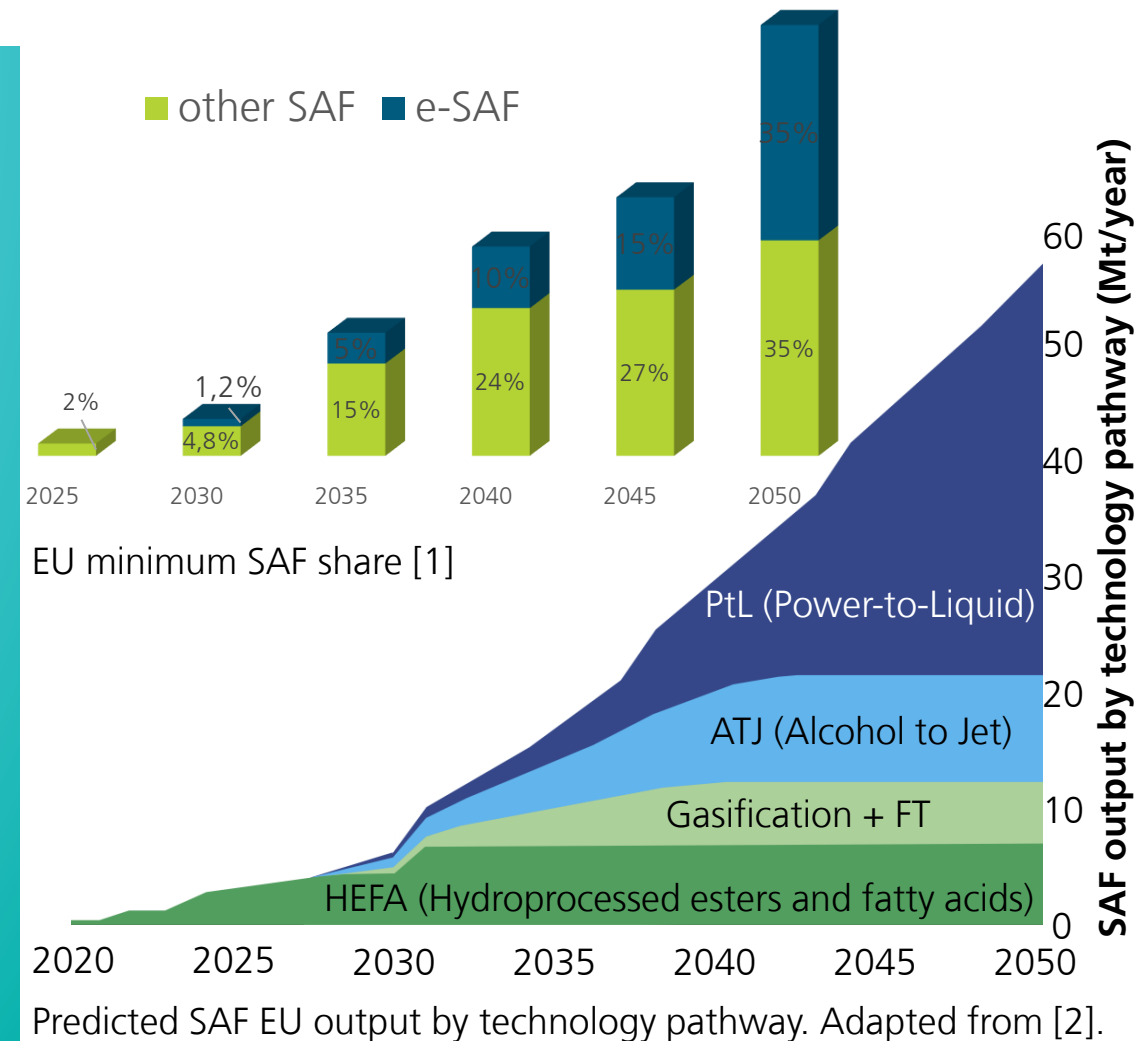
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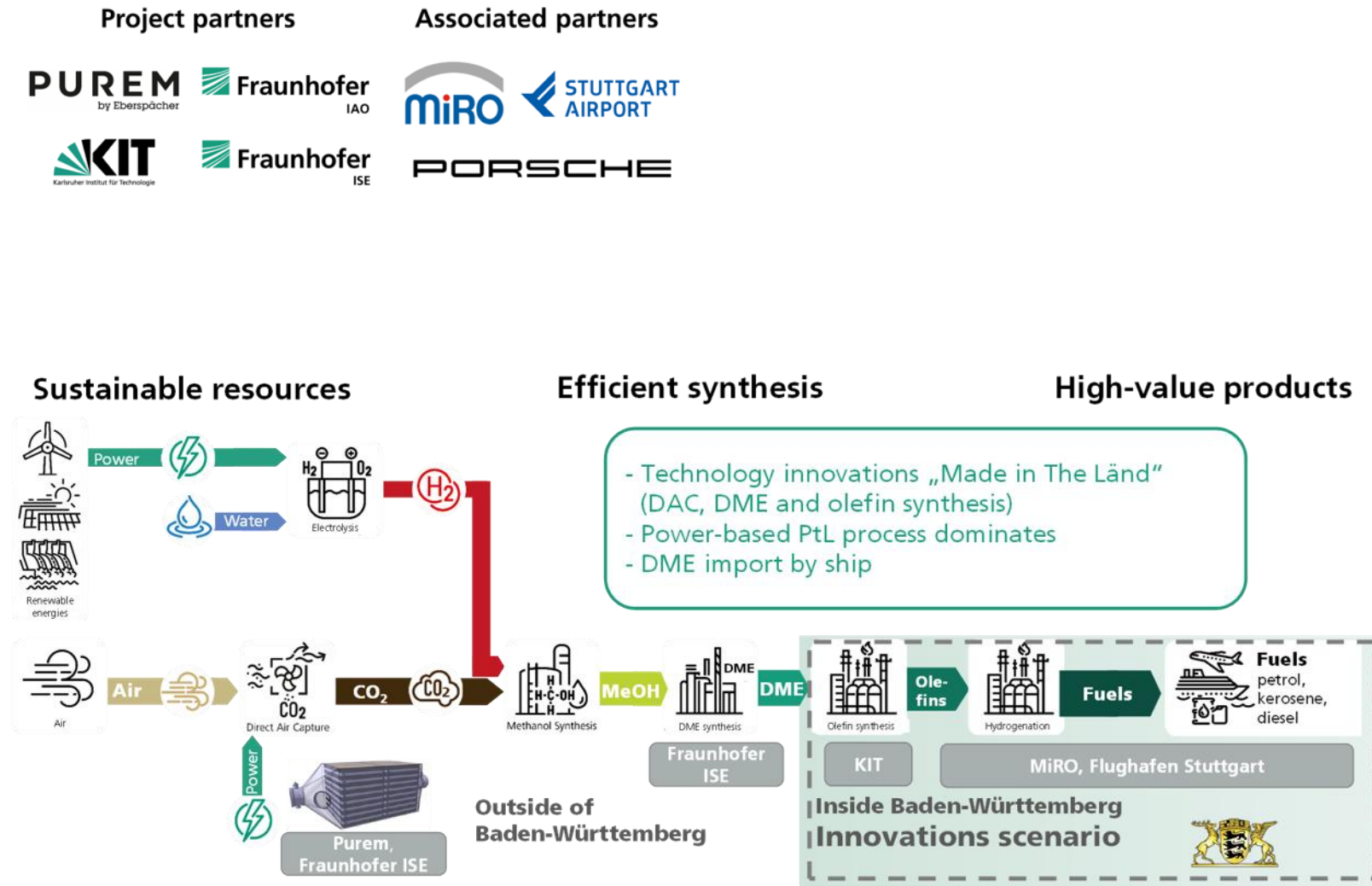


2) DME as a Platform Molecule for the Production of e-fuels

e-Fuels-fürs-Länd-Projekt

Project Goals

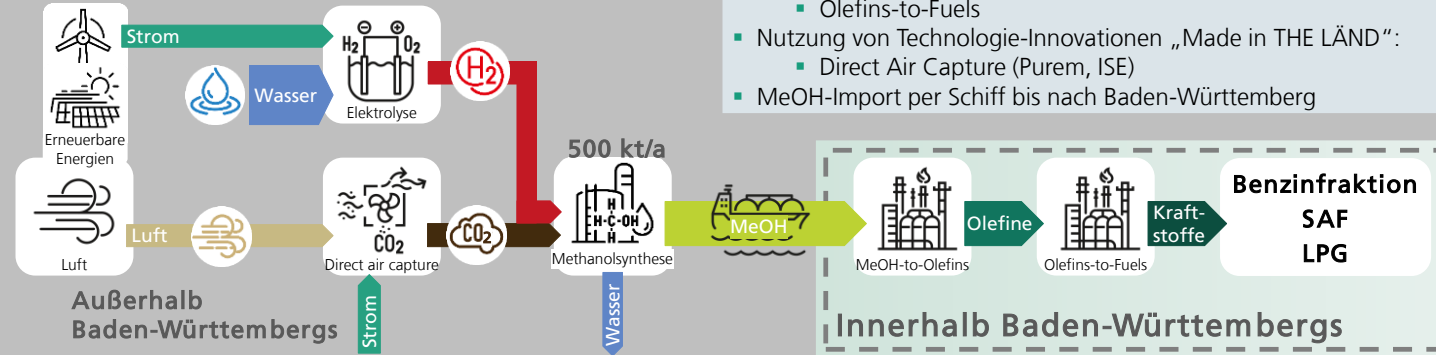
- Assessment of different scenarios for production of DME-based e-fuels regarding fuel production costs and value added in Baden-Württemberg
- Comparison of DME-based e-fuels with state-of-the-art technologies (e.g. e-methanol/reference scenario)
- Showcase a concept for an early business case for e-fuels in Baden-Württemberg based on DME



DME as a Platform Molecule for the Production of e-fuels

ii) Referenz-Szenario (2035)

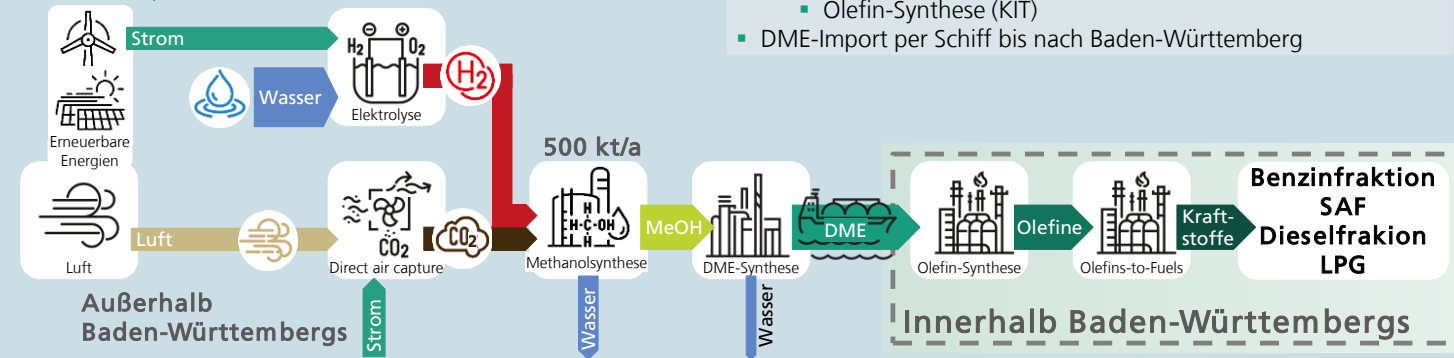
Exportregion: je ein Szenario für
Finnland, Spanien und Brasilien



e-Fuels-fürs-Länd-Projekt

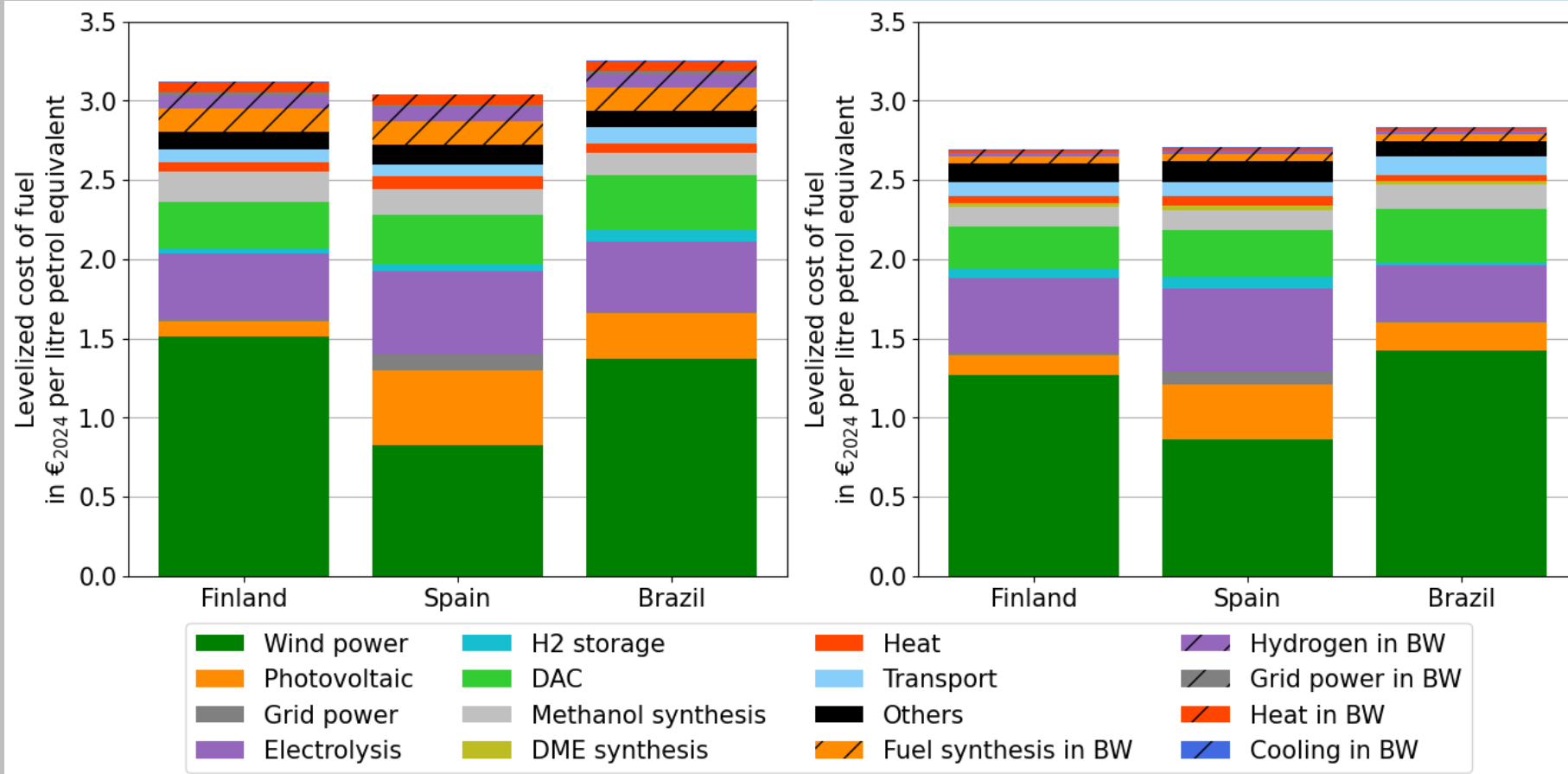
iii) Innovations-Szenario (2035)

Exportregion: je ein Szenario für
Finnland, Spanien und Brasilien



DME as a Platform Molecule for the Production of e-fuels

e-Fuels-fürs-Länd-Projekt – Report [1]



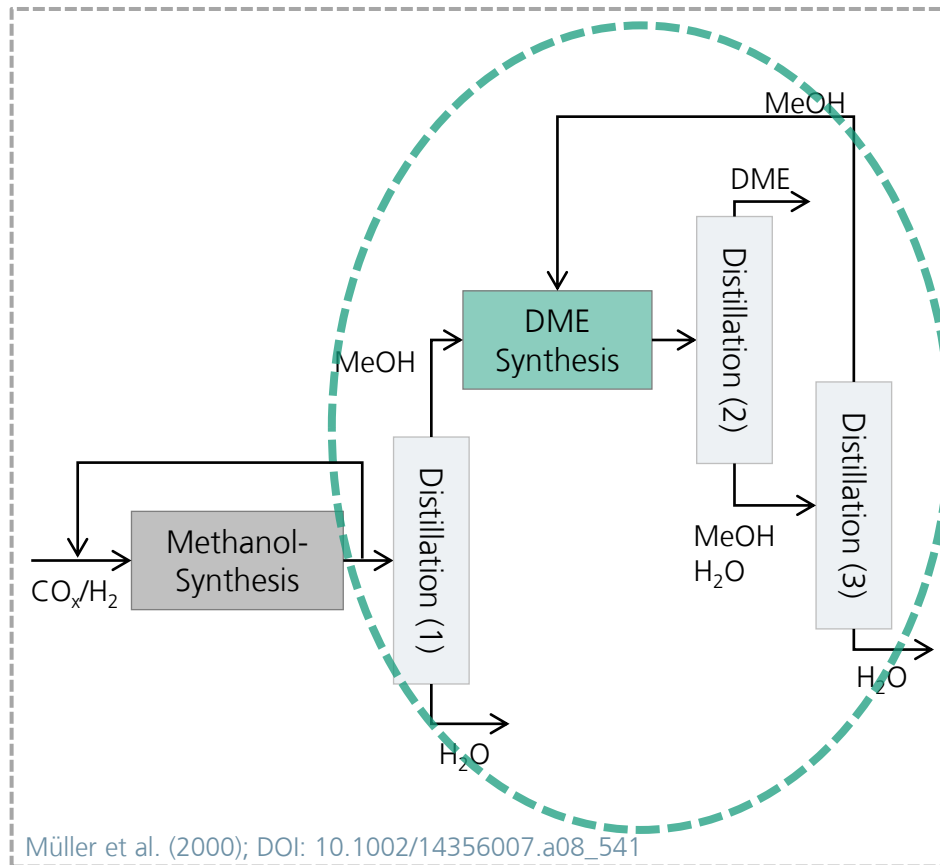
Reference scenario: Methanol transport & methanol to fuel

Innovation scenario: INDIGO & DME transport & DME to fuel

DME Synthesis: INDIGO Technology by Fraunhofer ISE

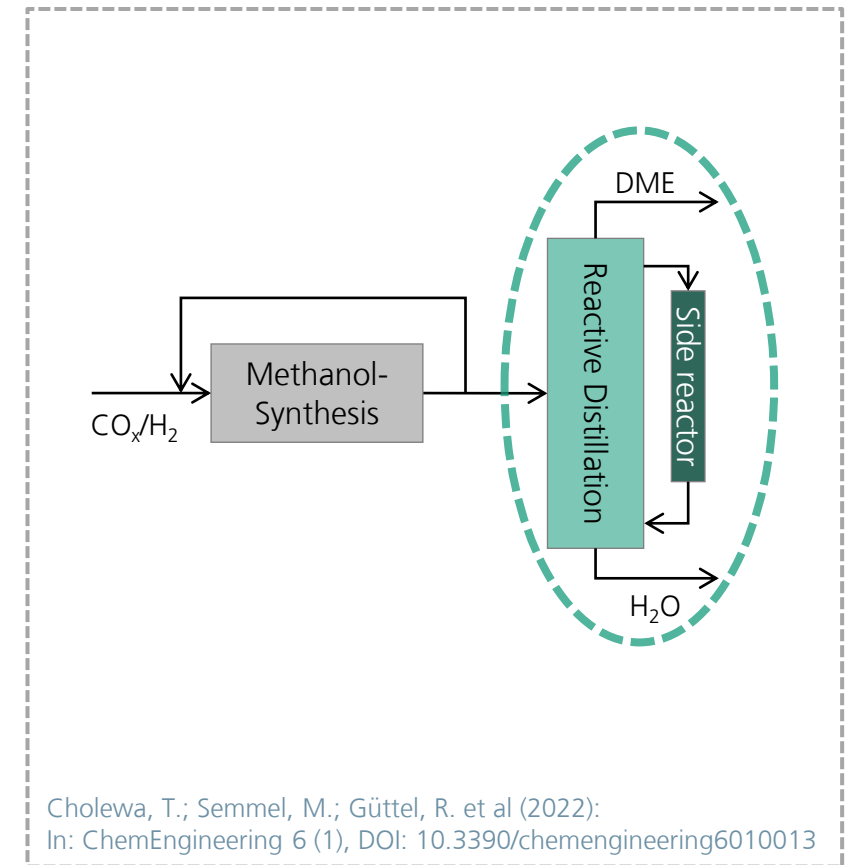
Patent Granted: DE102022114811B4

Conventional Process



Reactive distillation

INDIGO Technology



World's First DME Production Directly from Crude MeOH

Pilot Campaign with thyssenkrupp Uhde

- **Feedstock: Real crude MeOH including contaminants from side reactions** from CO₂-based methanol synthesis with commercial catalyst from Carbon2Chem Pilot plant ^[1].
- Stable day/night operation for more than **400 h** TOS with very low catalyst deactivation.
- **Fuel-grade DME product** was achieved in a single catalytic distillation unit without further purification steps.
- Successful validation of **Aspen Plus process simulation** based on piloting campaign.

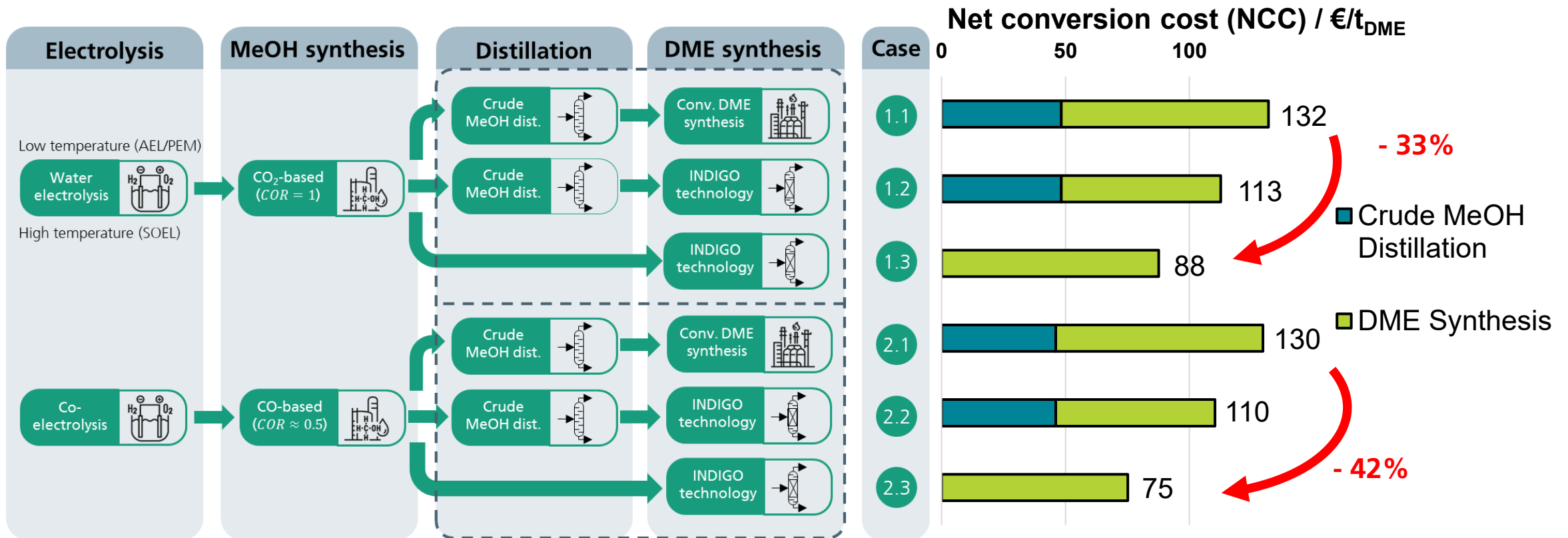
DN 50 distillation column,
commissioning & operation
since 2024



INDIGO Technology

Assumptions:
 Electricity price: 166.5 €/MWh
 Nat. gas price: 22.8 €/MWh
 Depreciation period: 20 years
 Interest rate: 5 %
 Labor cost: 54 €/h

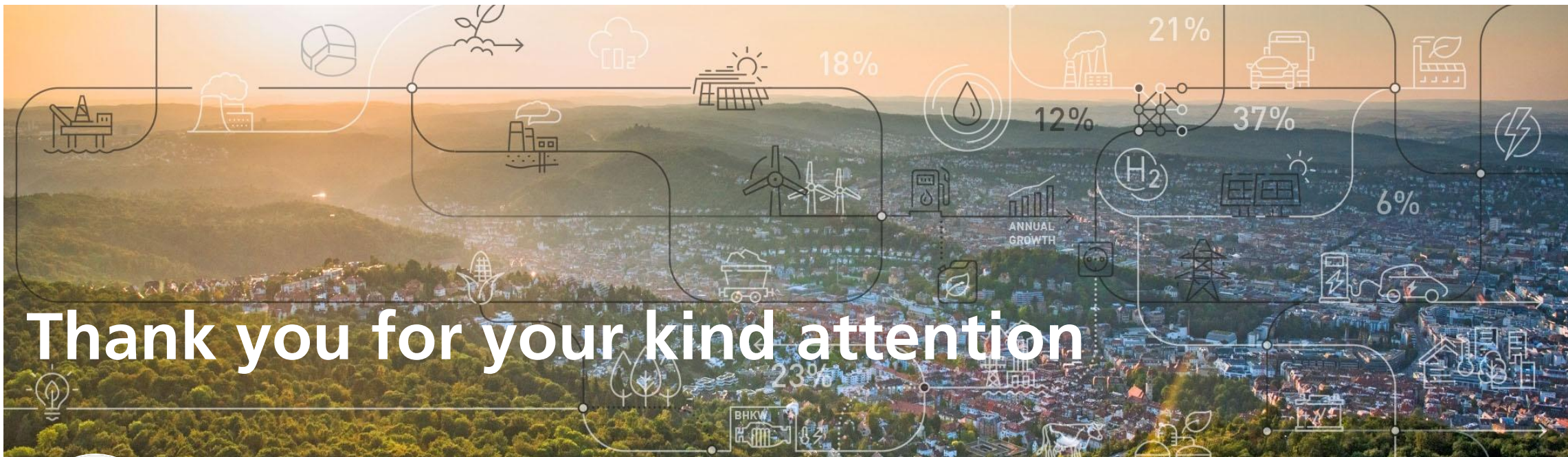
Techno-Economic Analysis [1]



Summary & Conclusions

- DME is already commodity chemical. Due to its advantageous properties, there is enormous market potential as a
 - **Global point-to-point energy carrier** and
 - **Platform molecule for fuels and chemicals.**
- **Many components of the DME value chain are already available. Biomass is an important feedstock.** This enables a **fast ramp-up and resilience.**
- **Future cost reduction** will be realized through **global scale-up** and **technological improvements** by optimization in syngas production and process intensification.
- **INDIGO technology from Fraunhofer ISE enables significant cost reductions.**





Thank you for your kind attention



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