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The Aviation Think Tank

Sustainable jet fuel production: Technologies and scaling

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IMPACT Aviation Stocktake Forum,
London, 27.05.2026

Aviation’s continued reliance on liquid fuels

LH_2 Regional Aircraft

Liquid hydrogen
Fuel cells / propellers

CENTRELINE:

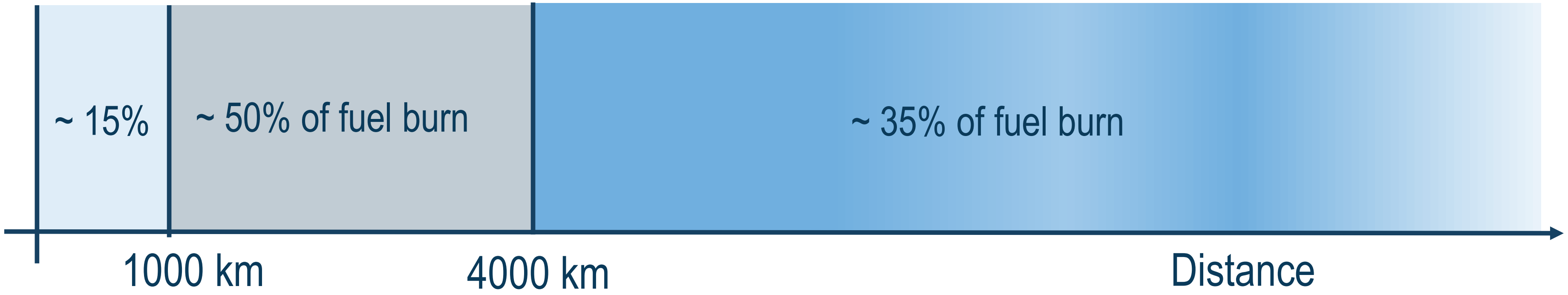
Highly efficient
kerosene-powered
wide-body aircraft

CoCoRe Projekt

Hybrid-electric commuter
High battery utilization

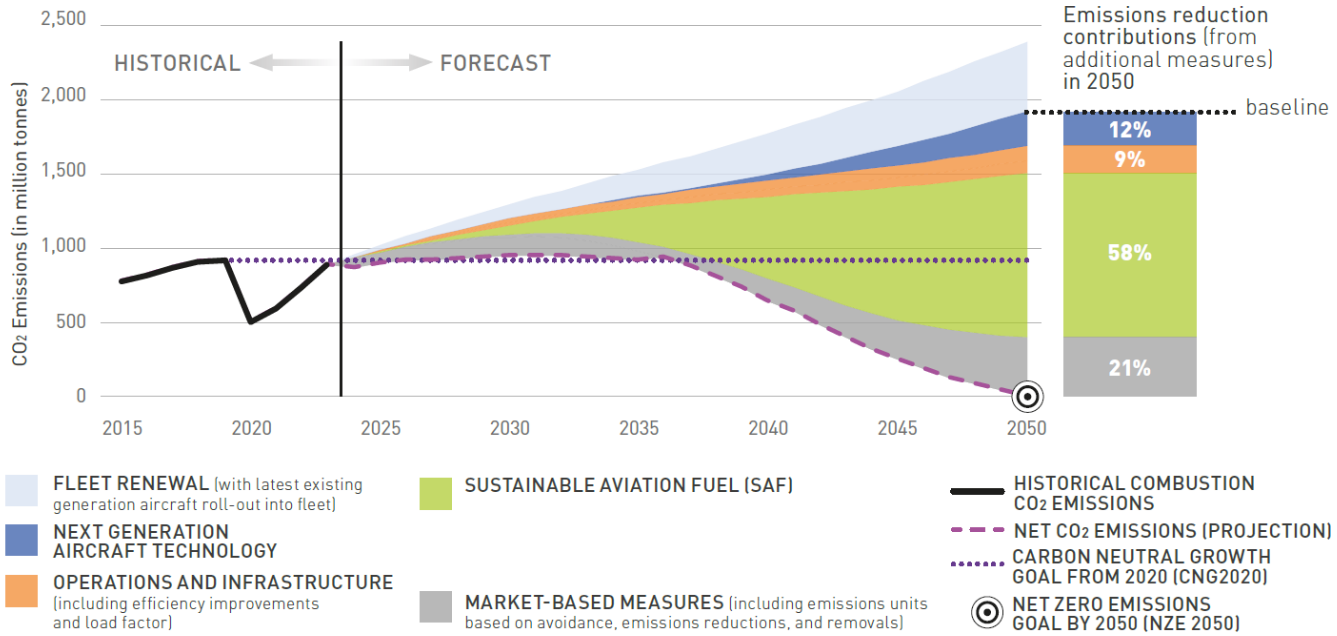
LH_2 wide-body aircraft

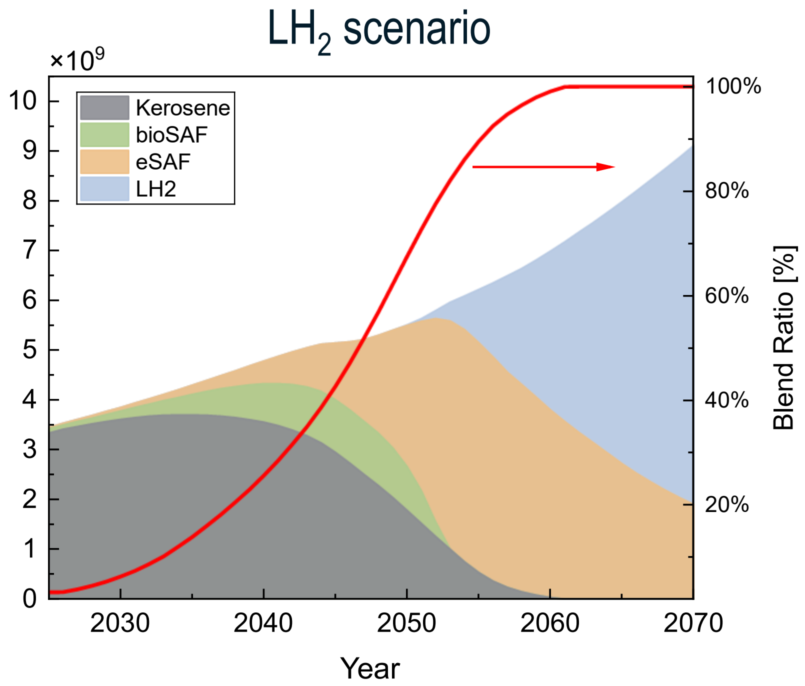
Liquid hydrogen
Gas turbines,
fuel cell hybrid options



Climate targets in aviation: Transition scenarios

- **Large volumes of sustainable kerosene are required for decades**
  - Hydrogen aviation (entry into service, fleet renewal): Impact will come late, if it is coming…

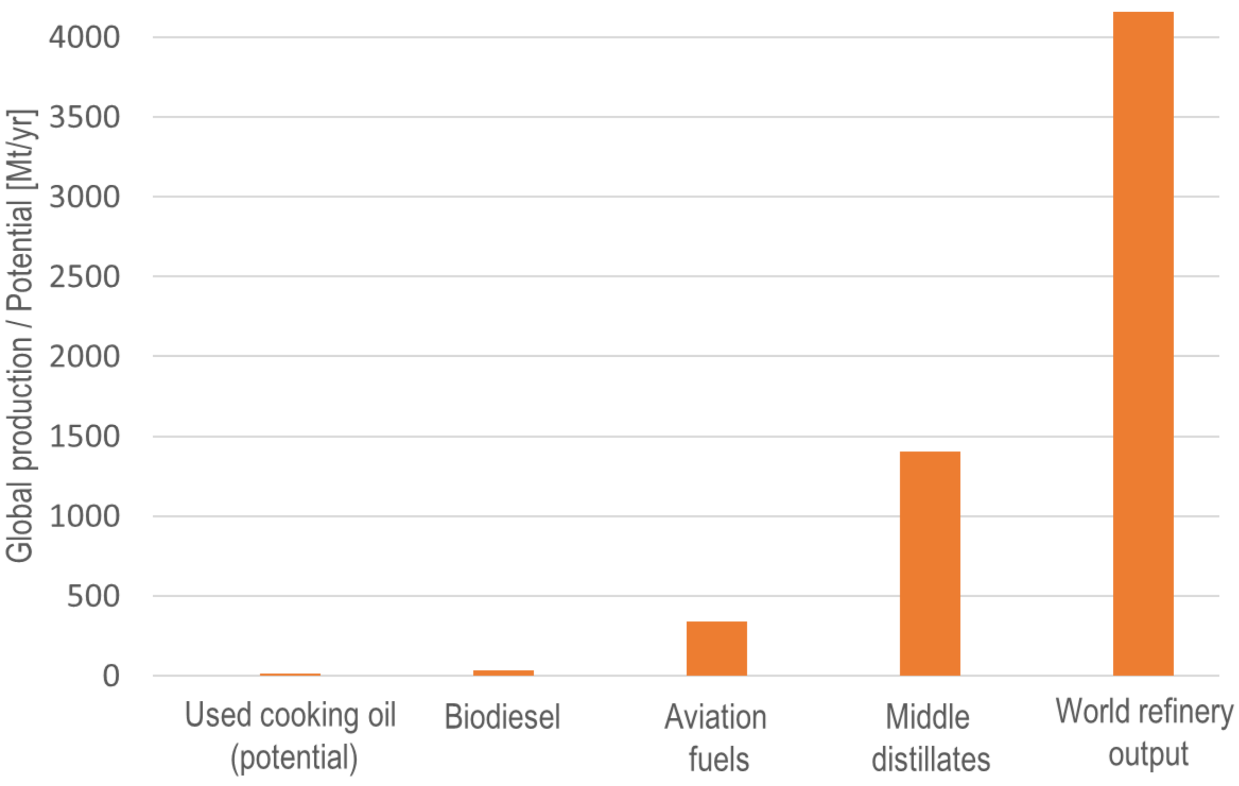




Sources: Air Transport Action Group: Waypoint 2050, 3rd Edition January 2026; The Economics towards Climate Neutrality in Aviation, BHL 2025/26

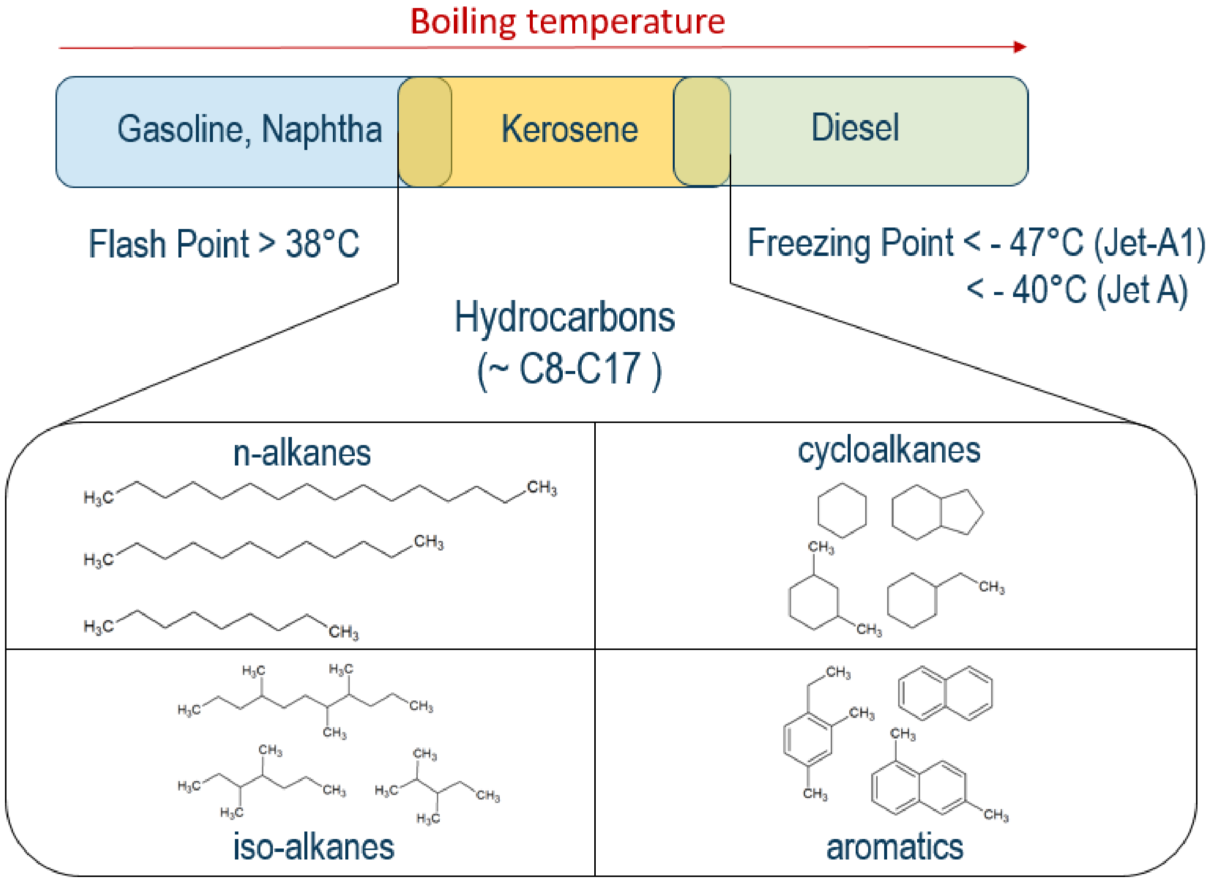
Scales & competition in middle distillate markets

- **Jet fuel: About 8% of global refinery output**
- **Significant feedstock composition in middle distillate markets**
  - Diesel, marine, aviation
  - In particular: Waste fats, oils & greases
- **Need for large additional potentials**
  - Advanced biofuels
  - Fuels from H_2O & CO_2



Kerosene as turbine fuel for aviation

- **Almost all civil aircraft and helicopters are driven by gas turbines**
- **Kerosene range fuels chosen due to**
  - Availability considerations
  - Global ground operation under various climatic conditions
  - Harsh ambient conditions at cruise altitude
- **Most relevant jet fuel specifications**
  - Jet A / Jet A-1 according to ASTM D1655



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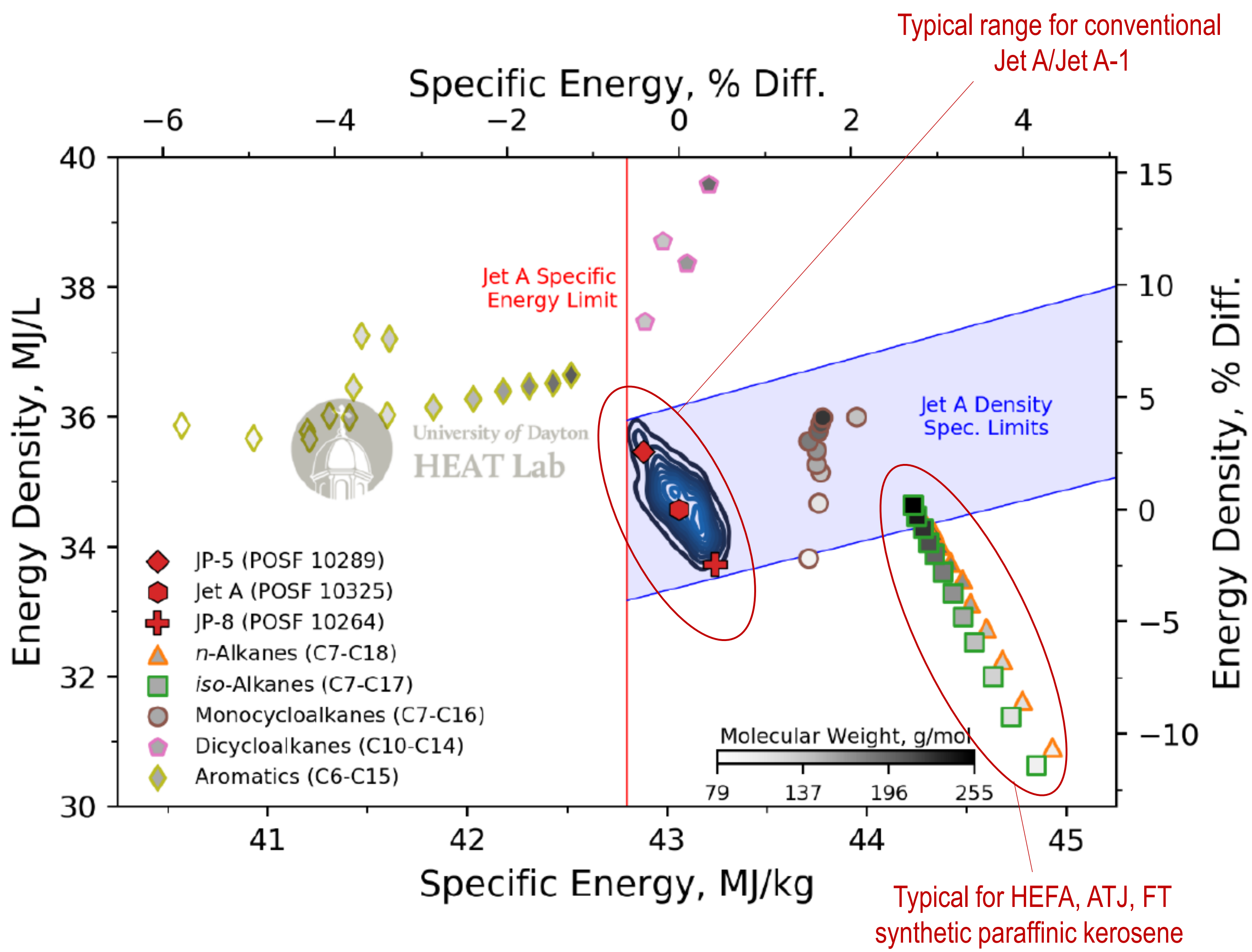
Philosophy behind ‘drop-in’ fuels (ASTM D7566)

- **Synthetic aviation fuels have different composition**
- **Drop-in fuel philosophy:**
  - ASTM D7655 defines batch specifications for synthetic blend components (Annexes)
  - Basic specifications for final blend almost identical to Jet A/Jet A-1
  - Final blend can be used in existing aircrafts & infrastructures



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Fuel approval and qualification: Current and future pathways

- **Eight pathways approved up to 50% blend ratio (ASTM D7566)**
  - Synthetic paraffinic kerosene: **FT, HEFA, ATJ**; with aromatics: FT-SPK/A, ATJ-SKA
- **Co-processing of lipids (fats, oil, greases) and FT syncrude**
  - Up to 5% (ASTM D1655), or up to 15% (Def Stan 91-091)
- **Relevant future perspectives:**
  - Fully synthetic drop-in fuel (fully fleet compatible)
  - “Jet X”: Fully synthetic fuel with low aromatic content (requires new specification)
  - “General Annex”: General specification for new pathways at low blend ratio
  - Removal of sulphur and aromatics by hydroprocessing of conventional jet fuel

Technological readiness and main bottlenecks

Biofuel pathways	10 years ago	Today	Main bottleneck
HEFA	TRL 7-9 (feed dependent)	TRL 9	Sustainable feedstock availability
ATJ	TRL 7	TRL 9	Sustainable feedstock availability
Biomass gasification (BTL)	TRL 4-7	TRL 5-8	Feedstock logistics, complexity & cost
Pyrolysis, HTL, etc.	TRL 3-4	TRL 5-7	Maturity, fuel approval
Biogas reforming (bGTL)	TRL 8	TRL 8	Feedstock logistics & cost

E-fuel pathways	10 years ago	Today	Main bottleneck
Subsystems	TRL 8-9	TRL 9	Optimized plant integration
Fischer-Tropsch (pathway)	Conceptual	Early pilot plants	Production cost
Methanol-to-Jet (pathway)	Conceptual	Fuel approval in sight	Production cost
CO_2 air capture (DAC)	TRL 4-5	TRL 6-7	Affordability

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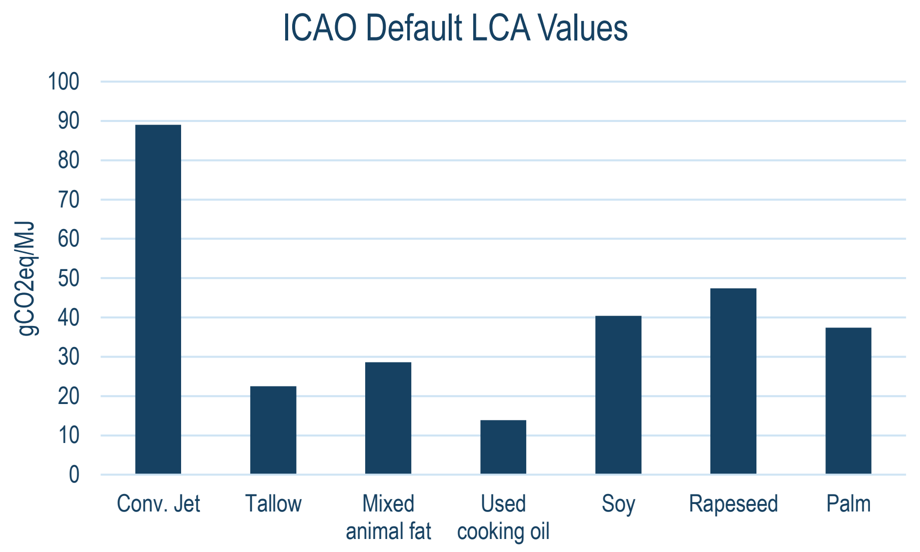
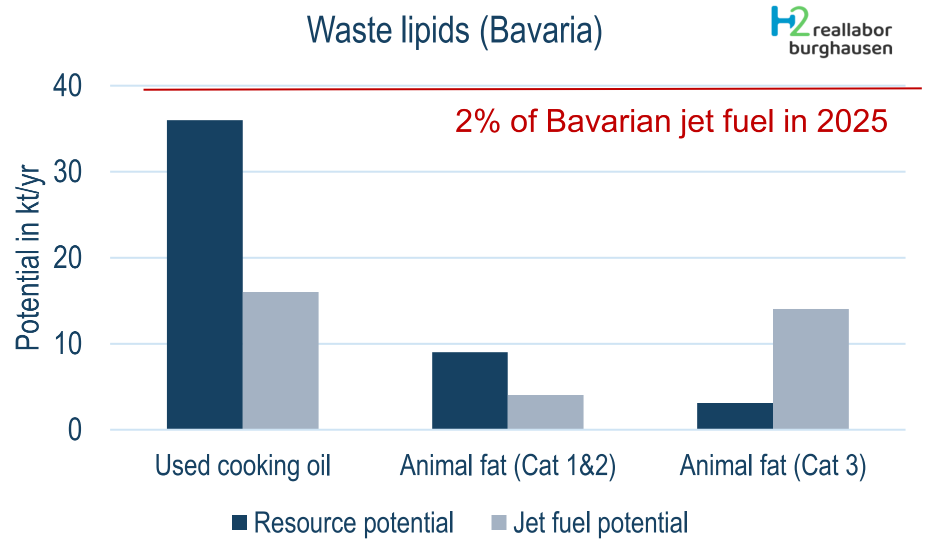
HEFA and co-processing of lipids

- **Key benefits**
  - Existing capacity: Mature, well-trusted technology
  - Established feedstock supply chains (biodiesel)
- **Challenges (plant oils)**
  - Cost vs. crude oil, feedstock eligibility
  - Sustainability concerns, limited GHG reduction
  - Competing pathways usually more area-efficient
- **Challenges (waste fats, oils & greases)**
  - Limited feedstock availability, fraud, protectionism





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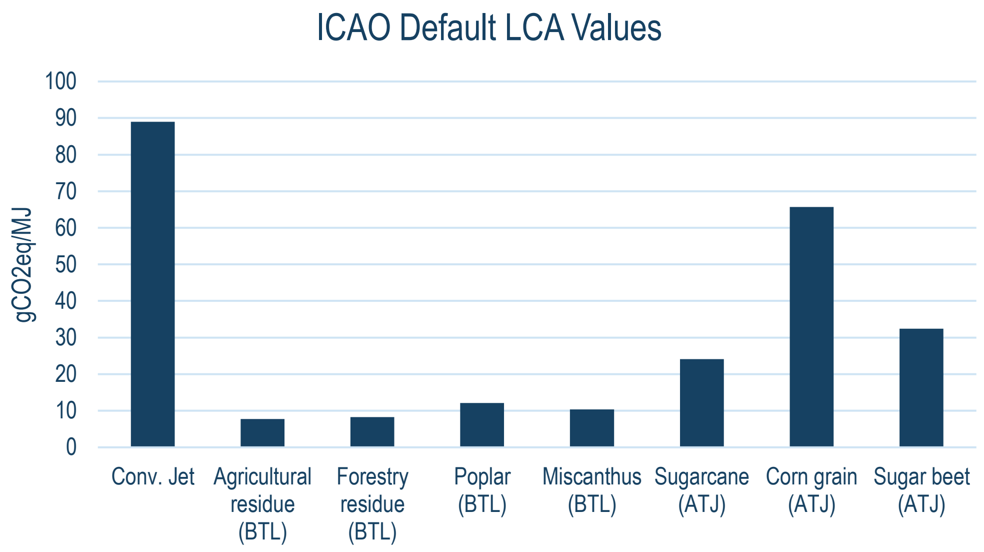
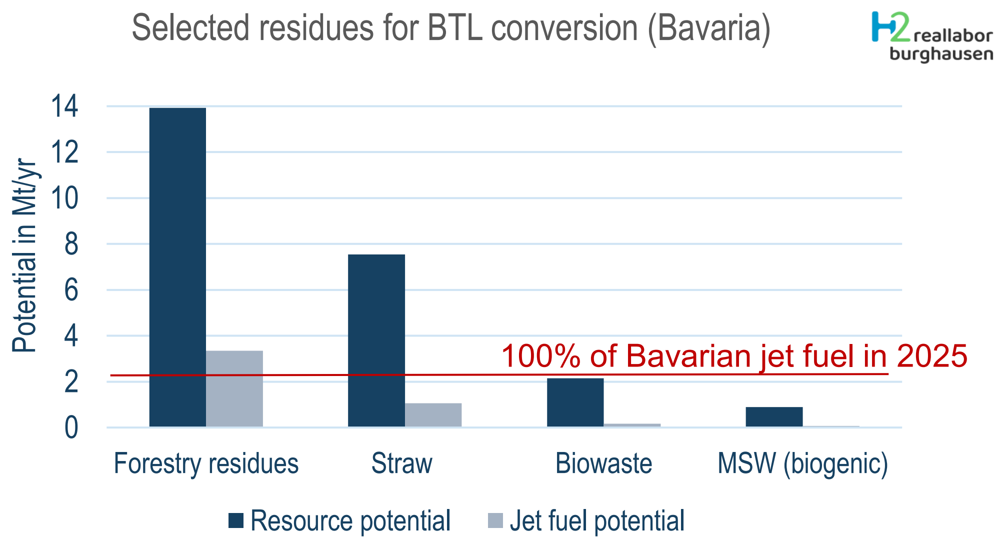
ATJ, BTL, Biogas Reforming

- **Alcohol-to-Jet (ATJ)**
  - Technologically mature pathway
  - Main challenges: Feedstock eligibility & cost
- **Biomass gasification & fuel synthesis (BTL)**
  - Large feedstock potential, low carbon intensity
  - Feedstock logistics, technical maturity, complexity
- **Biogas reforming & fuel synthesis (bGTL)**
  - Robust pathway for broad range of feedstock
  - Competitiveness with more direct options?

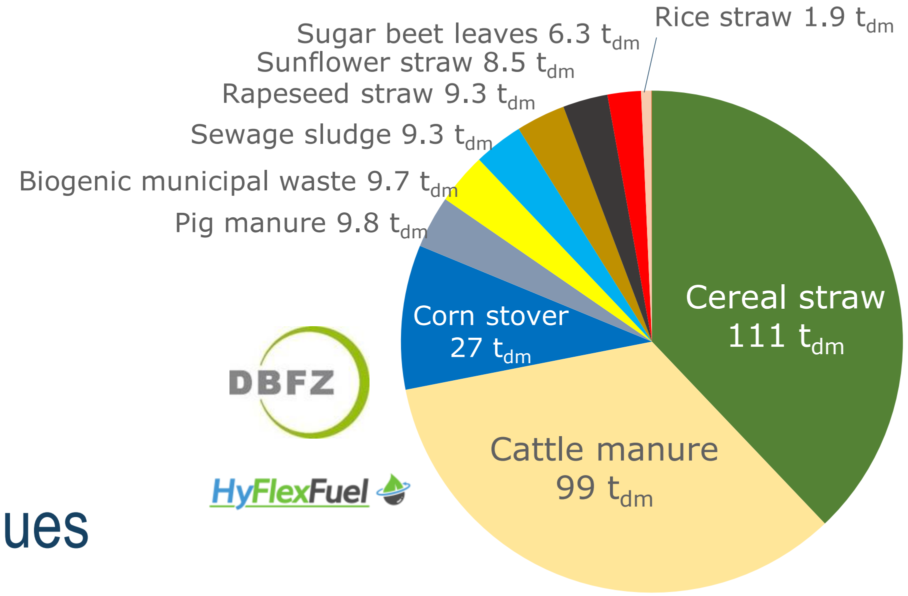


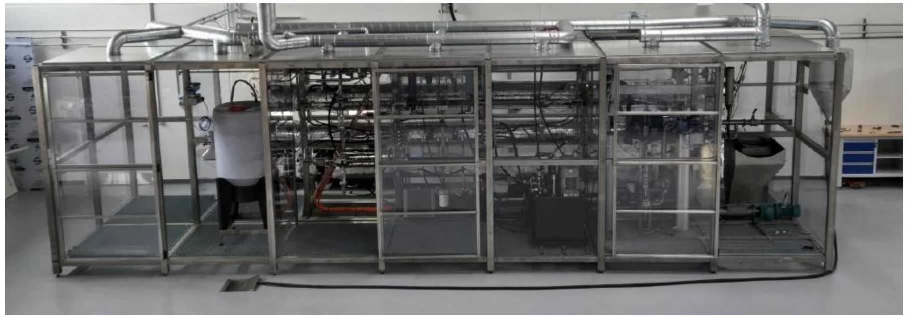


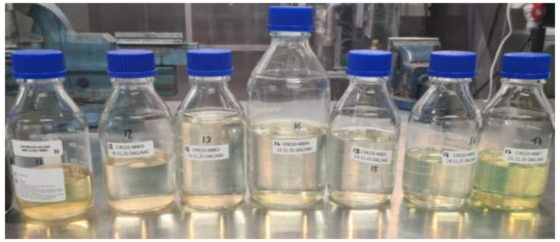
Advanced biofuels: Direct liquefaction pathways

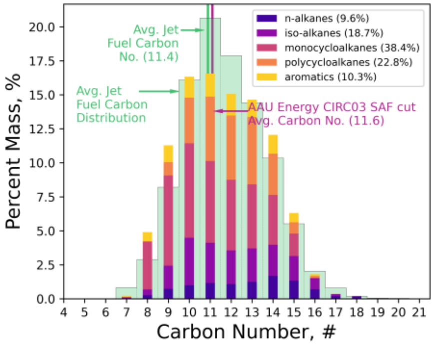
- **Pyrolysis and hydrothermal liquefaction**
  - Potentially cost effective & feedstock flexible
  - Maturity: R&D, upscale and fuel approval still required
- **Example EU-Horizon Europe project CIRCULAIR**
  - Hydrothermal liquefaction of abundant agricultural residues

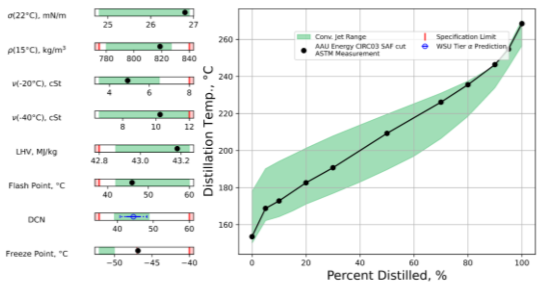
Feedstock potentials, agricultural and urban residues (EU-27 & UK)




HTL-WO pilot plant (Aarhus University)


Upgraded HTL fuel products (Aalborg University), kerosene samples characterized (N < 2 ppm).





Prescreening of CIRCULAIR jet fuel sample (Credit: Washington State University)

CIRCULAIR Funded by the European Union www.project-circulair.eu

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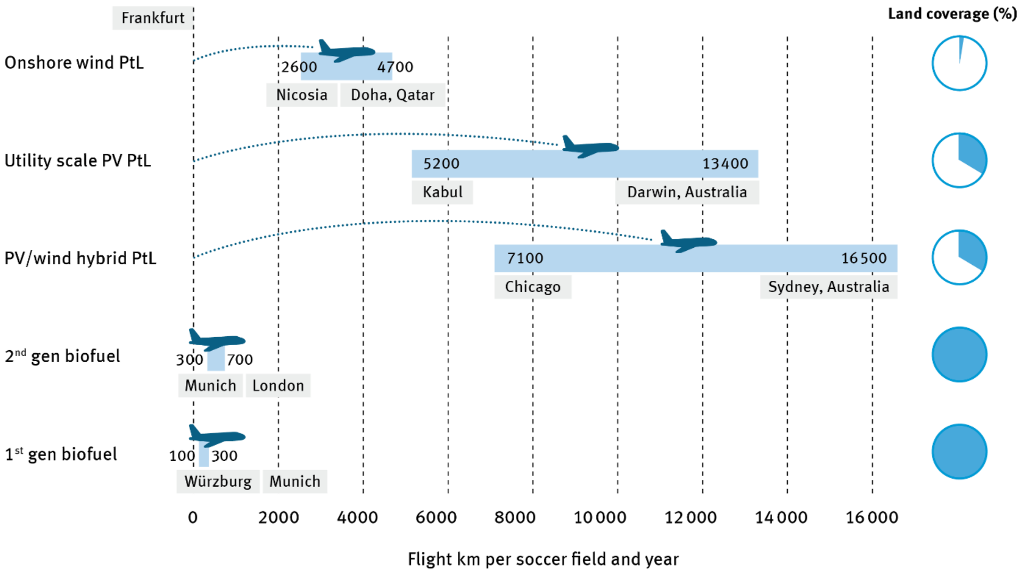
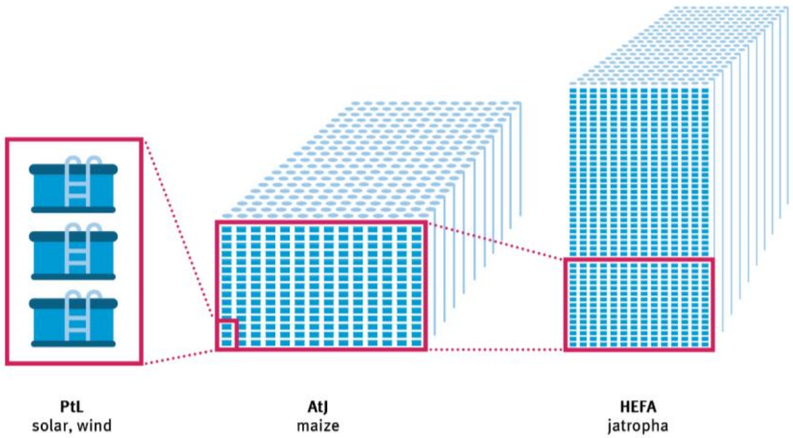
E-Fuels: Benefits & challenges



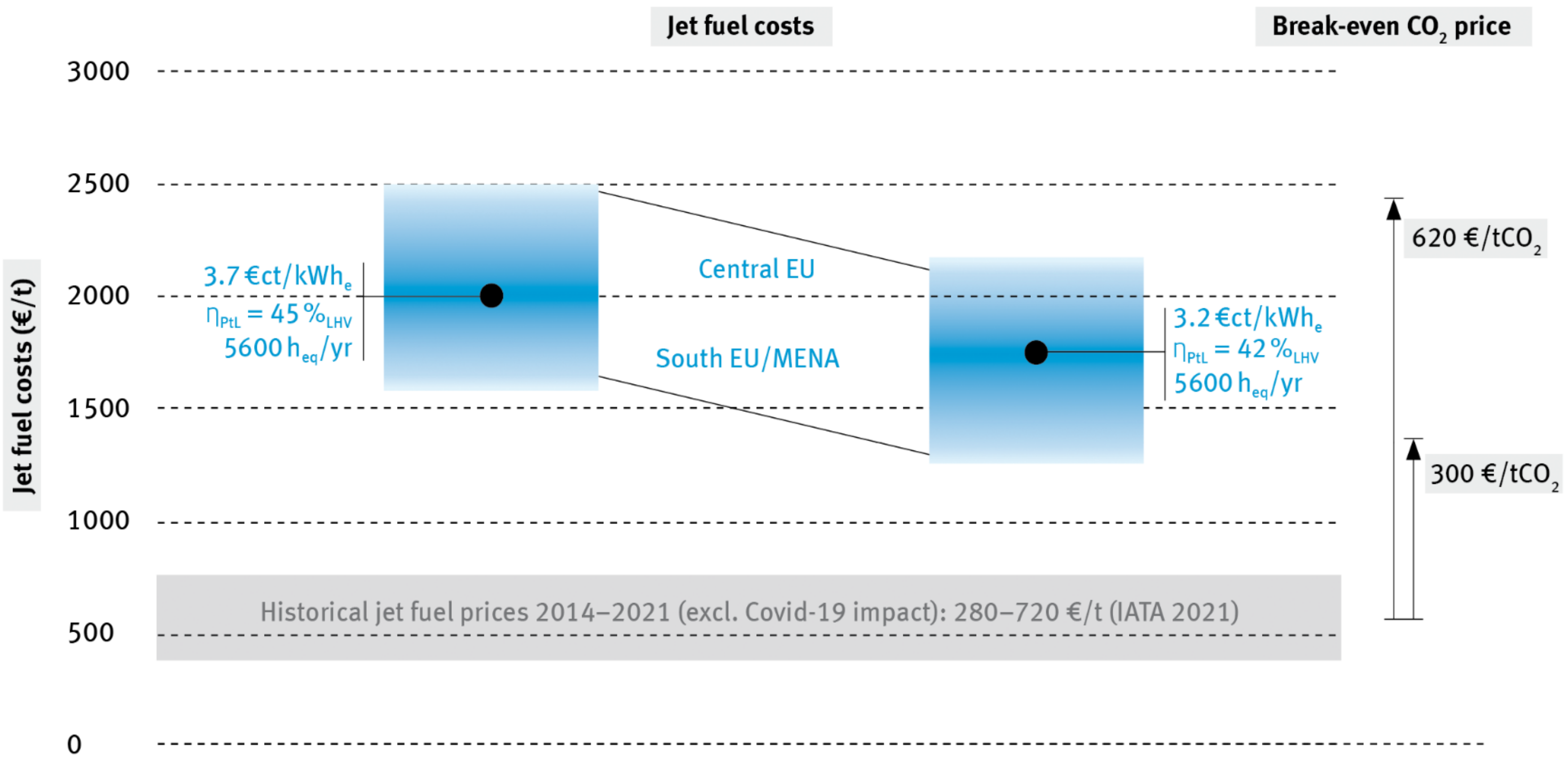
- **Key benefits**
  - High production potential
  - Low water demand
  - Low GHG intensity >> requires low-carbon electricity and sustainable carbon supply
- **Key challenges**
  - High fuel production cost
  - Complexity of projects & economies of scale
  - Uncertainties about off-take

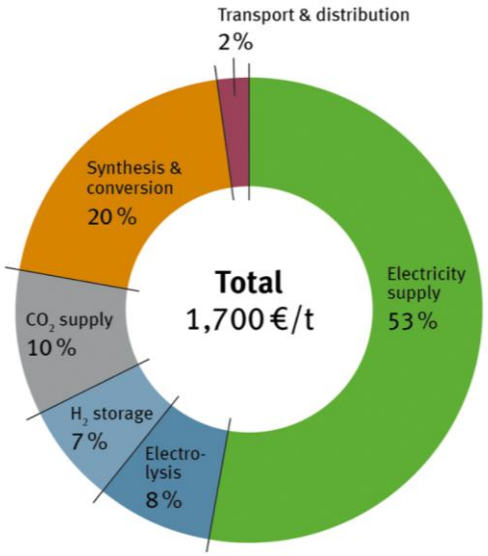
Water demand to produce 1 ton of jet fuel via different fuel pathways. One pool corresponds to 1500 L of water

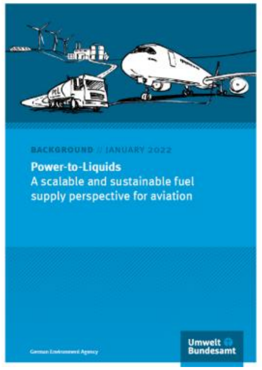


Source: BHL, LBST, *Power-to-Liquids – A scalable and sustainable supply perspective for aviation*, Background Paper 2022 www.umweltbundesamt.de/publikationen/power-to-liquids

Main challenge for e-fuels: Production cost







ludwig bölkow systemtechnik

Source: BHL, LBST, *Power-to-Liquids – A scalable and sustainable supply perspective for aviation*, Background Paper 2022 www.umweltbundesamt.de/publikationen/power-to-liquids

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E-Fuels: Scale-up potentials and cost reduction

- **Important sub-components relating to green H_2 cost get scaled**
  - Solar and wind generation, more recently also electrolyzers, H_2 infrastructures, (and batteries)
- **Early commercial e-fuel production, e.g.**
  - e-methanol in Kassø, Denmark 42 kt/yr
  - FT demo plant, Ineratec, Frankfurt, 2.5 kt/yr
- **DAC of CO_2: Project based upscale (R&D)**
  - Mainly driven by carbon removal community

Global annual investment in power generation by selected technologies, 2021-2024e

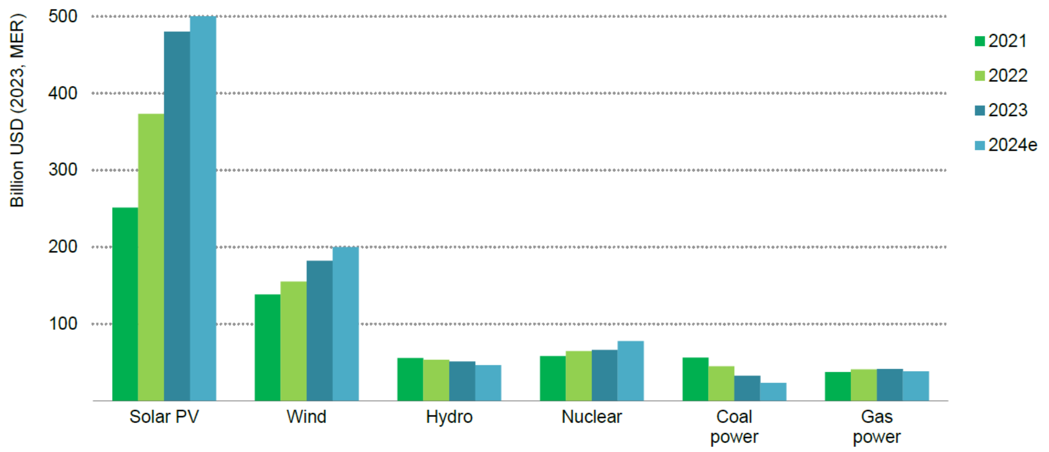
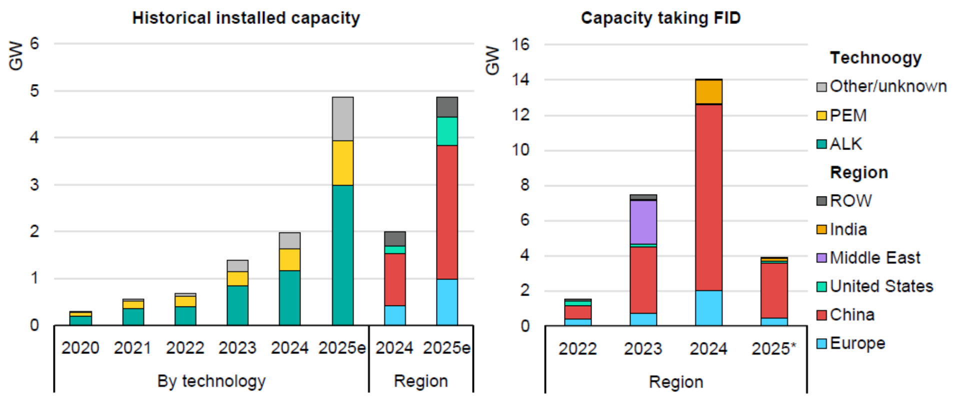


Figure 3.11 Installed electrolyser capacity by technology and region, 2020-2025e, and capacity reaching final investment decision by region, 2022-2025

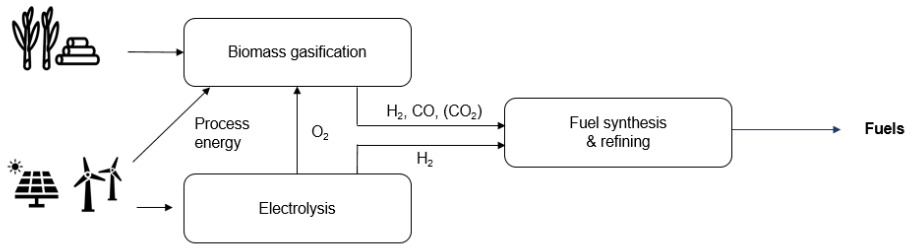


Sources: IEA World Energy Investment 2024; https://www.iea.org/reports/global-hydrogen-review-2025; https://europeanenergy.com/2025/05/13/kasso-e-methanol-facility-officially-inaugurated/
https://www.ineratec.de/de/news/ineratec-produziert-erstes-e-fuel-pionieranlage-frankfurt

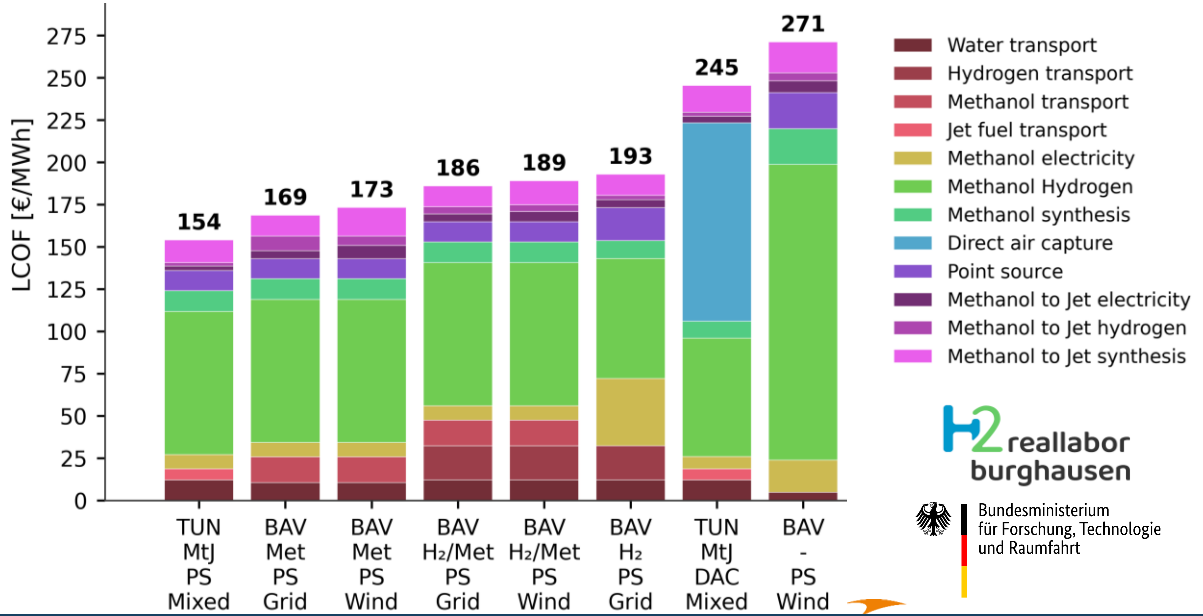
Coupling biomass and green H_2: PBtL & further hybrid pathways

- **Synergies & benefits**
  - Increased yield per unit biomass
  - Secured carbon supply for e-fuels
  - Coupling to H_2 pipelines infrastructure

Simplified scheme of Power-and-Biomass-to-Liquid (PBtL):



Methanol-to-Jet: Investigation of jet fuel, methanol & H_2 pipeline transport from Tunisia to Bavaria



H2 reallabor burghausen

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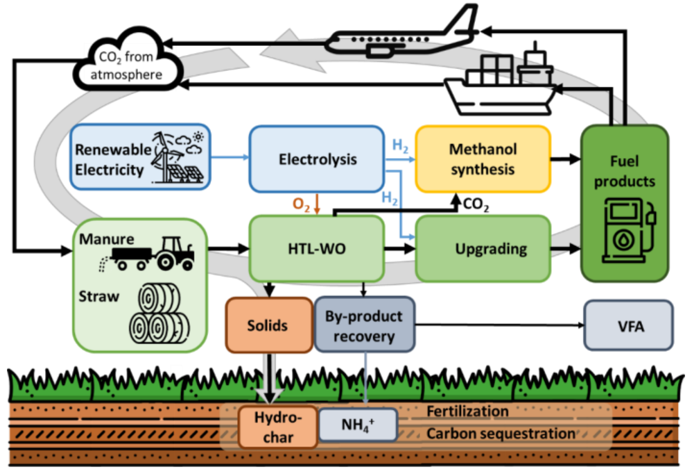
CO_2 utilization from advanced biofuel pathway for methanol synthesis:



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Summary

- Aviation needs large amounts of liquid fuels to achieve climate targets
- HEFA & co-processing of lipids play an important role in early transition, but the availability of sustainable feedstock is severely limited
- ATJ taps into different feedstock bases, relies often on food & feed crops
- Lignocellulosic biomass is available in large quantities, but suitable conversion pathways are less mature than HEFA and 1st Generation ATJ
- E-Fuels promise better sustainability at scale, challenges relate to production cost, financing of complex projects and carbon supply
- Synergies between green hydrogen and biomass conversion