Deutsches Biomasseforschungszentrum

Renewable transport fuels at scale

Lessons learnt from industry and demonstrations

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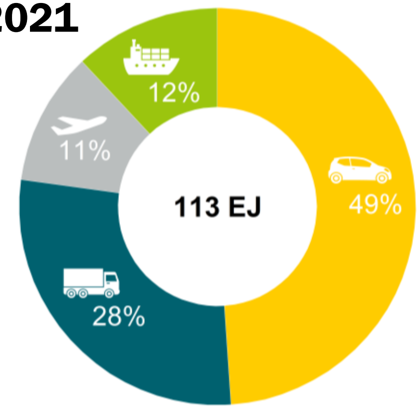
ETIP Bioenergy 12th Stakeholder Plenary Meeting | Brussels | March 12, 2025

Status quo and outlook

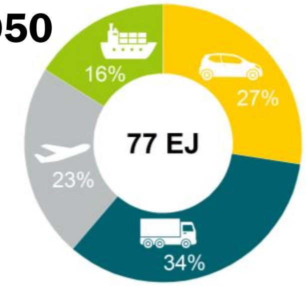
World energy outlook

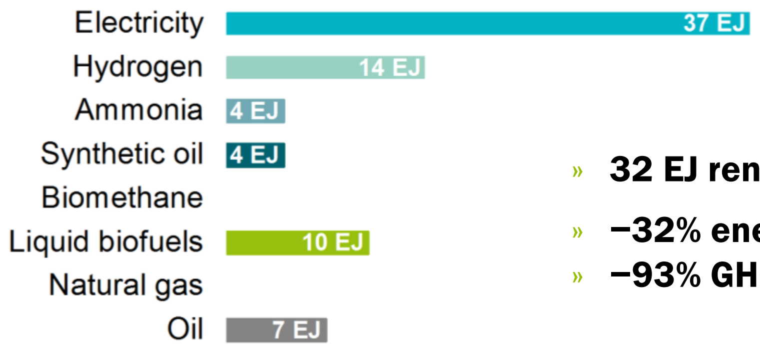
2021



IEA Net Zero Scenario

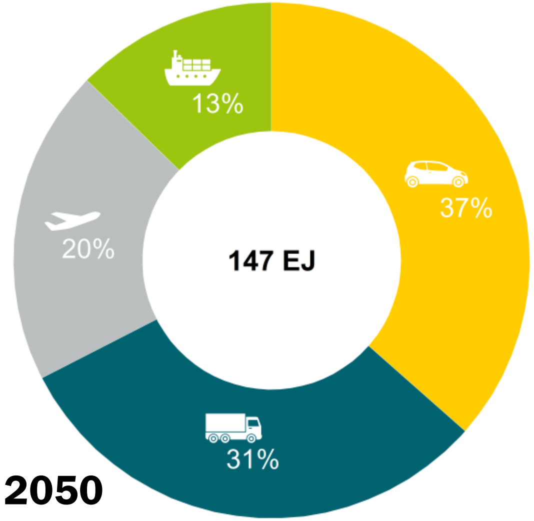
2050



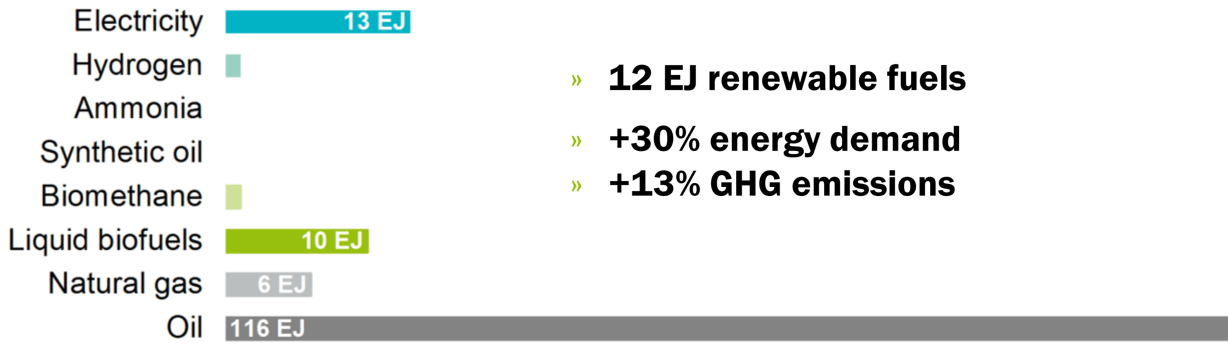


- **32 EJ renewable fuels**
- **−32% energy demand**
- **−93% GHG emissions**

IEA Stated Policies Scenario



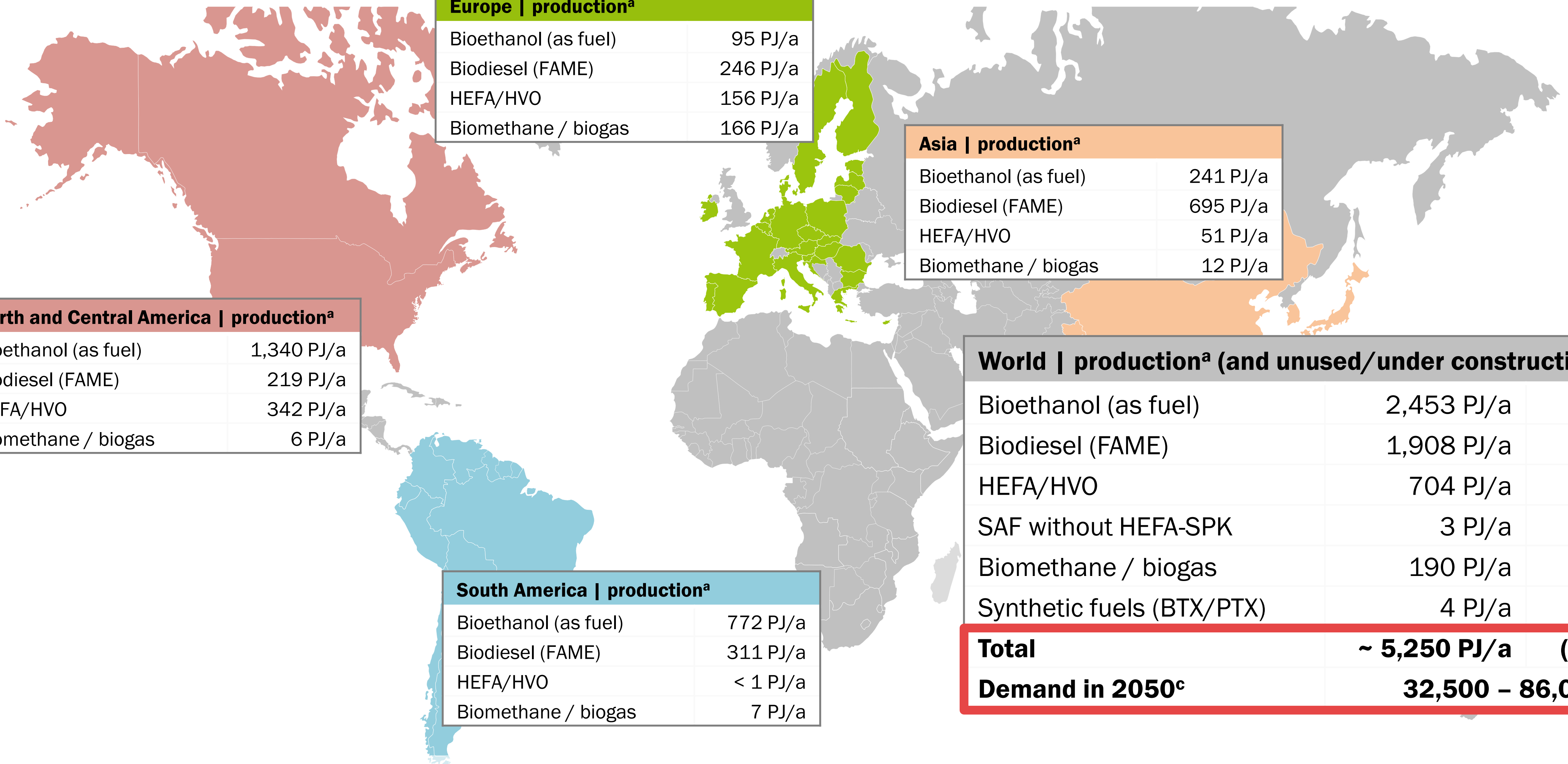
2050



- **12 EJ renewable fuels**
- **+30% energy demand**
- **+13% GHG emissions**

Note: Synthetic oil produced through Fischer-Tropsch conversion or methanol synthesis. It includes oil products from CTL and GTL, and low-emissions liquid hydrogen-based fuels.
Liquid fuels derived from biomass or waste feedstock, e.g. ethanol, biodiesel and biojet fuels.

Need of ~10 times more renewables in the next 25 years



Europe | production[a]	
Bioethanol (as fuel)	95 PJ/a
Biodiesel (FAME)	246 PJ/a
HEFA/HVO	156 PJ/a
Biomethane / biogas	166 PJ/a

Asia | production[a]	
Bioethanol (as fuel)	241 PJ/a
Biodiesel (FAME)	695 PJ/a
HEFA/HVO	51 PJ/a
Biomethane / biogas	12 PJ/a

North and Central America | production[a]	
Bioethanol (as fuel)	1,340 PJ/a
Biodiesel (FAME)	219 PJ/a
HEFA/HVO	342 PJ/a
Biomethane / biogas	6 PJ/a

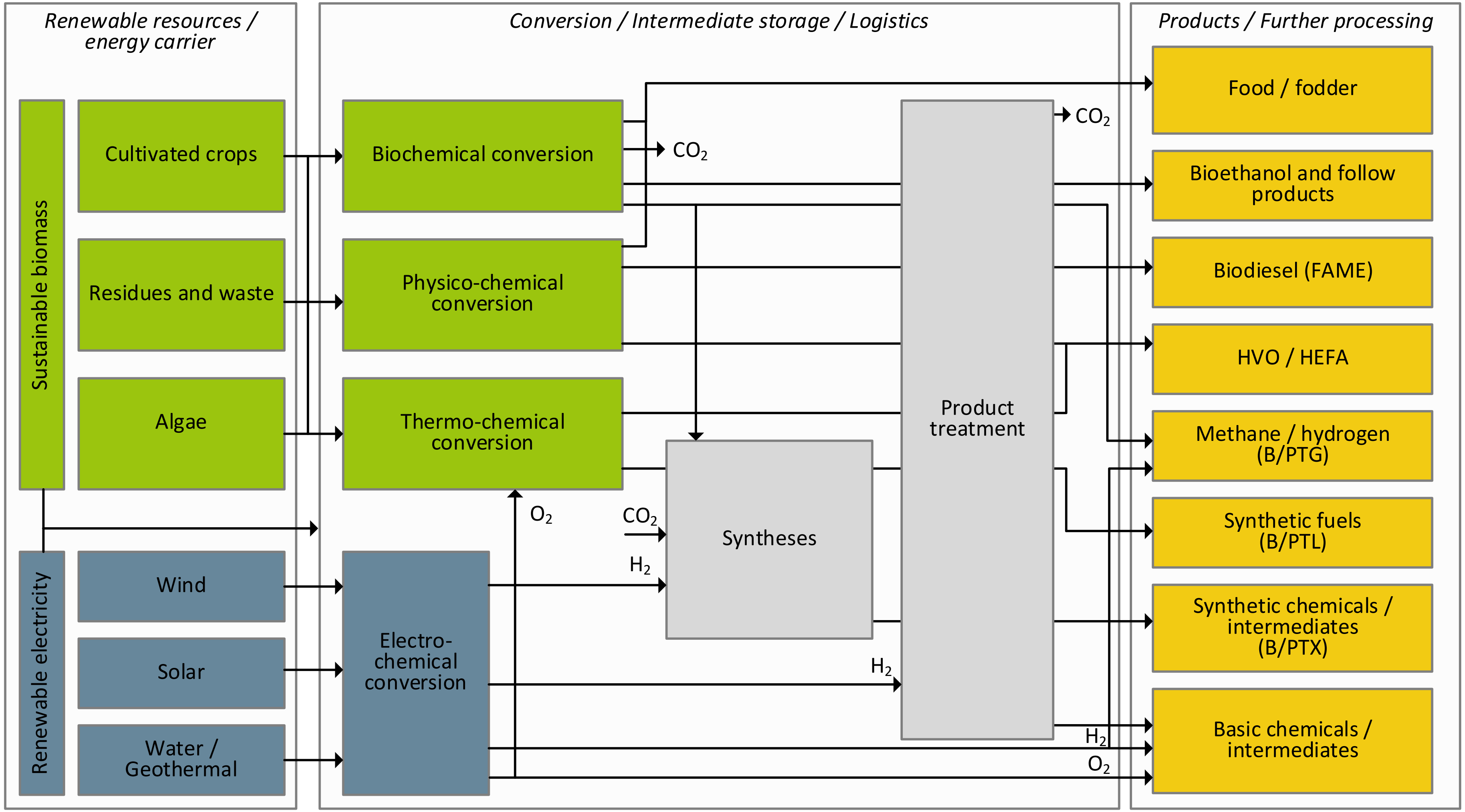
South America | production[a]	
Bioethanol (as fuel)	772 PJ/a
Biodiesel (FAME)	311 PJ/a
HEFA/HVO	< 1 PJ/a
Biomethane / biogas	7 PJ/a

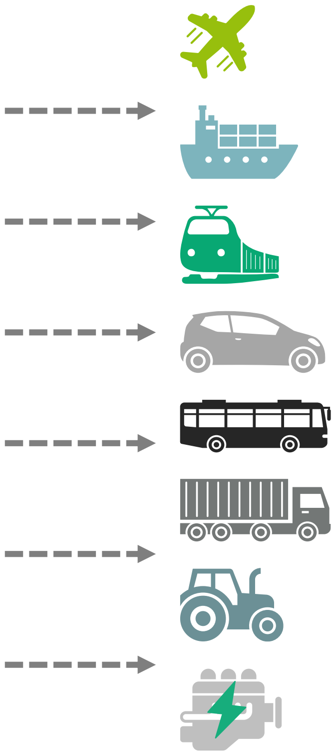
World | production[a] (and unused/under construction/planned[b])		
Bioethanol (as fuel)	2,453 PJ/a	(1,668 PJ/a)
Biodiesel (FAME)	1,908 PJ/a	(1,322 PJ/a)
HEFA/HVO	704 PJ/a	(3,907 PJ/a)
SAF without HEFA-SPK	3 PJ/a	(357 PJ/a)
Biomethane / biogas	190 PJ/a	(N/A)
Synthetic fuels (BTX/PTX)	4 PJ/a	(94 PJ/a)
Total	**~ 5,250 PJ/a**	**(~ 7,350 PJ/a)**
Demand in 2050[c]	**32,500 – 86,000 PJ/a**	

[a] production in 2023 and biomethane capacity in 2024; [b] unused/under construction/planned capacity in 2024; [b] planed capacity; [c] demand according to IEA World Energy Outlook 2021, DNV Pathway to Net Zero Emissions scenario 2023

Technology options for renewable transport fuels

Diverse technology routes, synergies and value networks





SynBioPTX ©DBFZ 11/2021 (w/o entitlement of completeness)
B/PTG – Biomass-/Power-to-Gas, B/PTL – Biomass-/Power-to-Liquids, B/PTX – Biomass-/Power-to-products X; FAME – Fatty acid methyl ester; HEFA – hydrotreated esters and fatty acids; HVO – hydrotreated vegetable oils;

Framework policy influences market and competition

DBFZ

	International	European Union	Germany
Fuels		ReFuelEU Aviation; EU-ESR; Fuel EU Maritime; ETD; EU-ETS; REACH; FQD; RED II / RED III	BEHG; LuftVStG; EnergieStG; EnergieStV; UERV; TA Luft; 10. BImSchV; 36. bis 38. BImSchV; *National Hydrogen Strategy*; Biokraft-NachV; BiomasseV
Fuels / Vehicles and infrastructure	**United Nations Framework Convention on Climate Change** – Paris Climate Agreement; Environmental Protection – CORSIA, Aeroplane CO_2 Emissions, IMO CO_2 targets, GHG Protocol	**European Climate Law**	BImSchG; **Federal Climate Protection Act**
Vehicles and infrastructure	MARPOL Annex VI SECA, EEDI; Type approval ECE Regulation; Transport guidelines: ADR, ADN, RID, IMDG-Code, ICAO-TI, IATA DGR	AFID / AFIR; CVD; CO2 fleet limits for passenger cars, light and heavy commercial vehicles; Exhaust gas stages for passenger cars, light and heavy commercial vehicles, tractors	SaubFahrzeugBeschG; EmoG; AwSV; *National Hydrogen Strategy*
Standards	ASTM standards; ISO standards	CEN EN standards	DIN standards; VDI guidelines

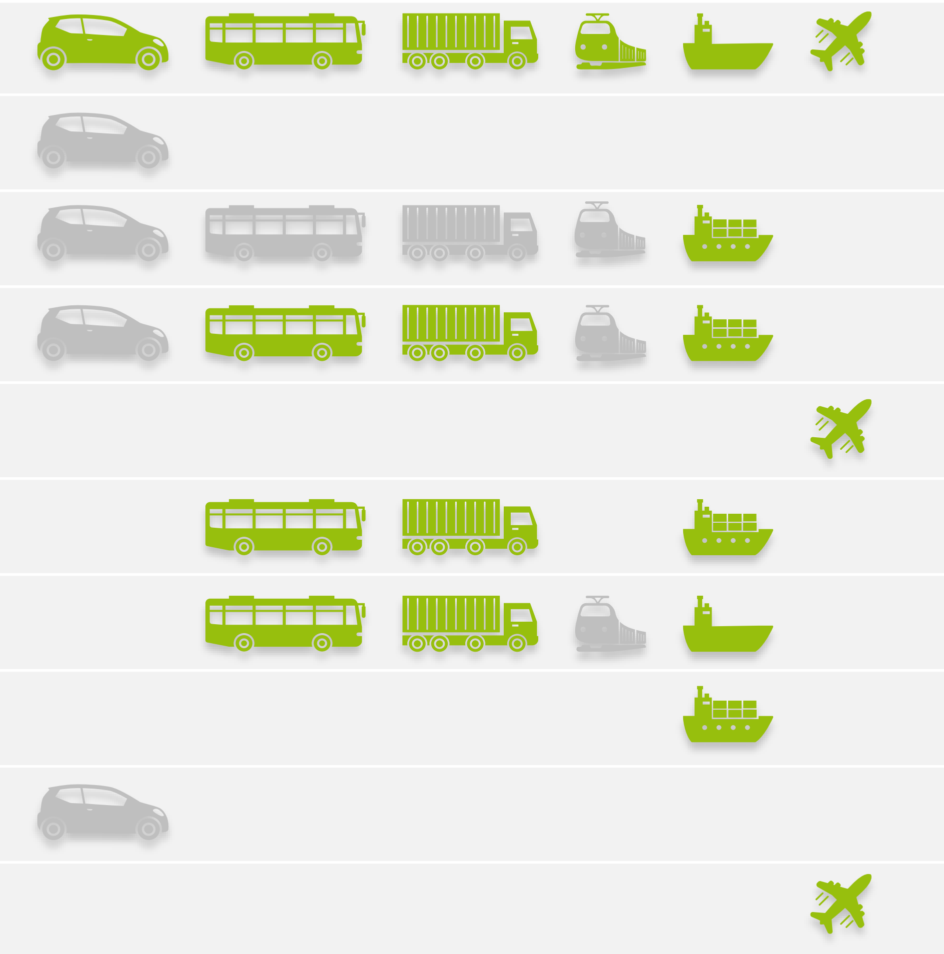
further information:

Reference: DBFZ-Report No. 44 [Schröder, Naumann 2022], adapted

Overview status of development

Fuel Readiness Level

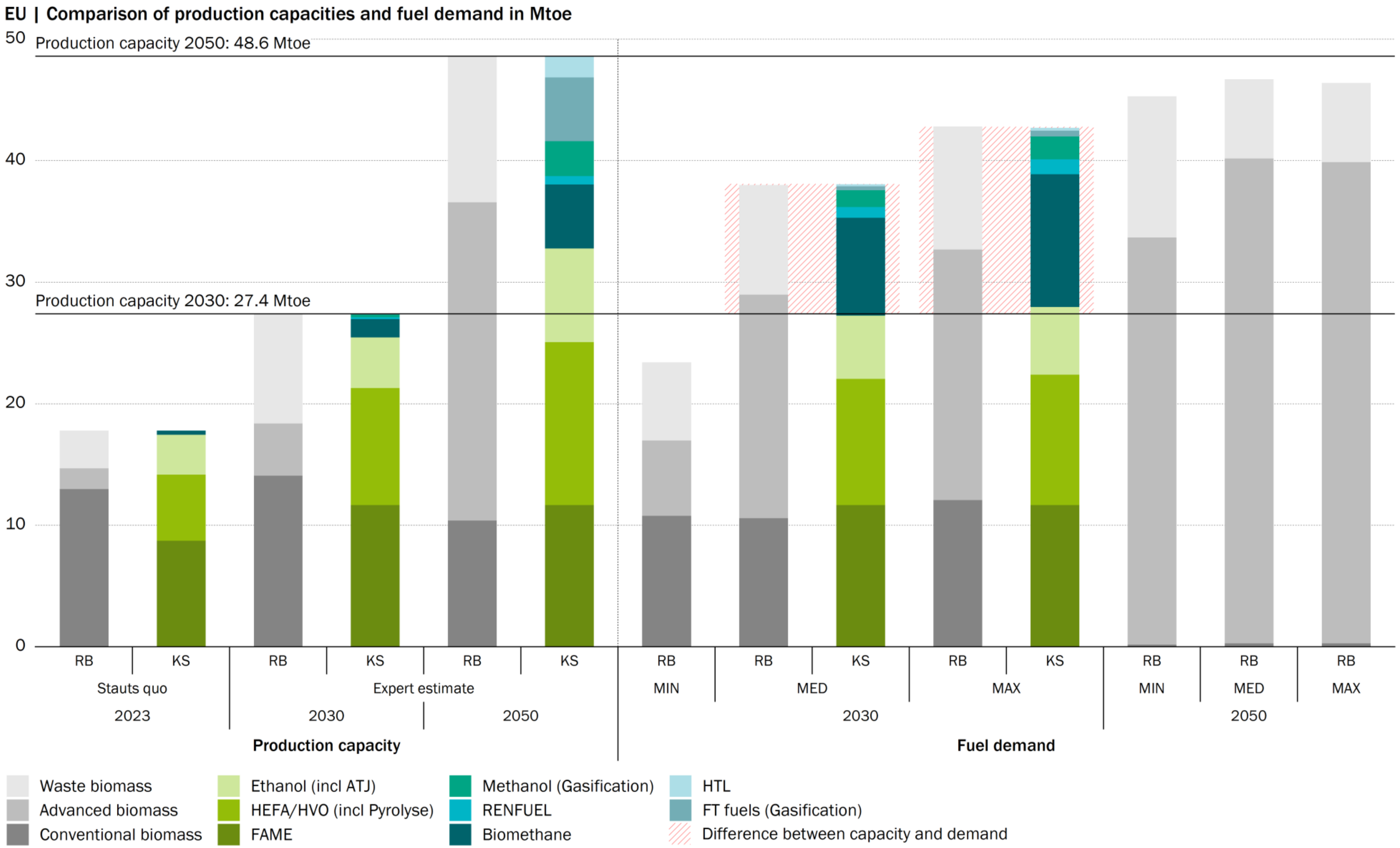
Reference year 2024	Technology Readiness Level TRL	Refuelling infrastructure	Long-term scope
Power	**11**	✓ ↗	
Ethanol	**Bio:** 9 – **11**	✓ *Blending*	
Biodiesel (FAME)	**Bio:** 4 – **11**	↗ ✓ *Blending*	
Paraffinic diesel	**Bio:** 4 – **11** PTx: 6	✓	
Paraffinic jet fuel	**Bio:** 4 – **10** PTx: 6	↗	
Methane	**Bio:** 8 – **11** PTx: 7	↗	
Hydrogen	Bio: 4 – 8 **PTx:** 6 – **9**	↗	
Methanol	Bio: 3 – 8 PTx: 3 – 8	↗	
Methanol-to-gasoline	Bio: 3 – 7 PTx: 3 – 7	✓ *Blending*	
Alcohol-to-jet	Bio: 3 – 8 PTx: 3 – 5	↗	



- ✓ Refuelling infrastructure established
- ↗ Refuelling infrastructure under development
- High energy demand for vehicle segment
- Low energy demand for vehicle segment (residual stock)

Reference: [Schröder, Görsch 2025], TRL – Technology Readiness Level (TRL 1: Basic principles observed, TRL 8: System complete and qualified, TRL 10: Market integration, TRL 11: Market stability);

Required capacities esp. for advanced technologies still pending



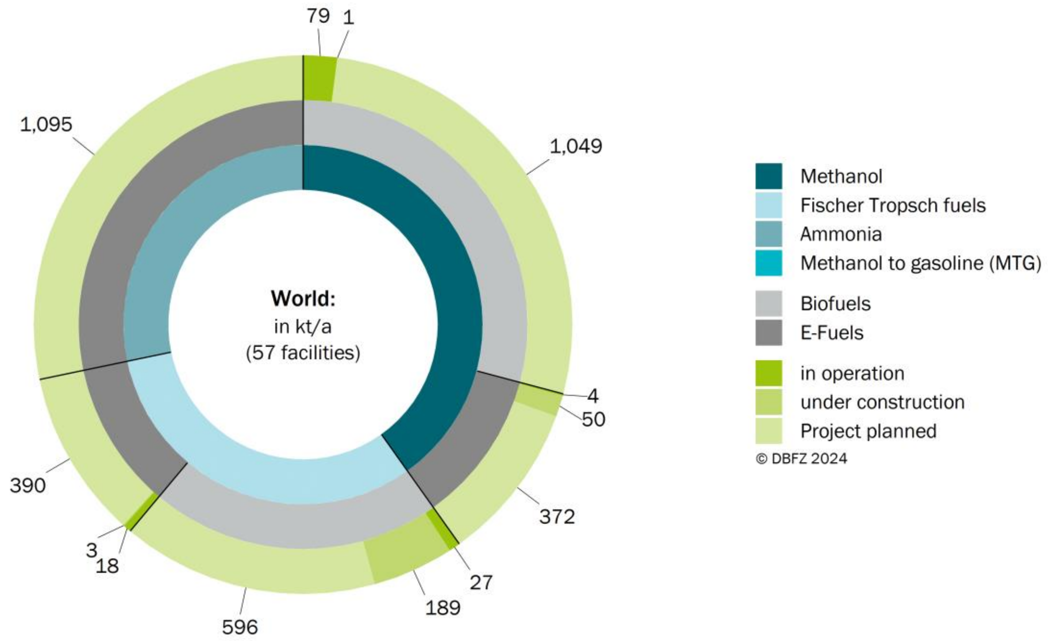
- Significant gap between expected fuel production capacities and fuel demand by 2030 including a shift to advanced biomass
- Dependence on reneweable fuel imports
- Disadvantage for the competitiveness of the EU
- Provide stronger incentives to develop production infrastructure within the EU

Reference: [Schröder, Görsch 2025], based on European Commission: "Development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels", RB – resource base, KS – fuel types

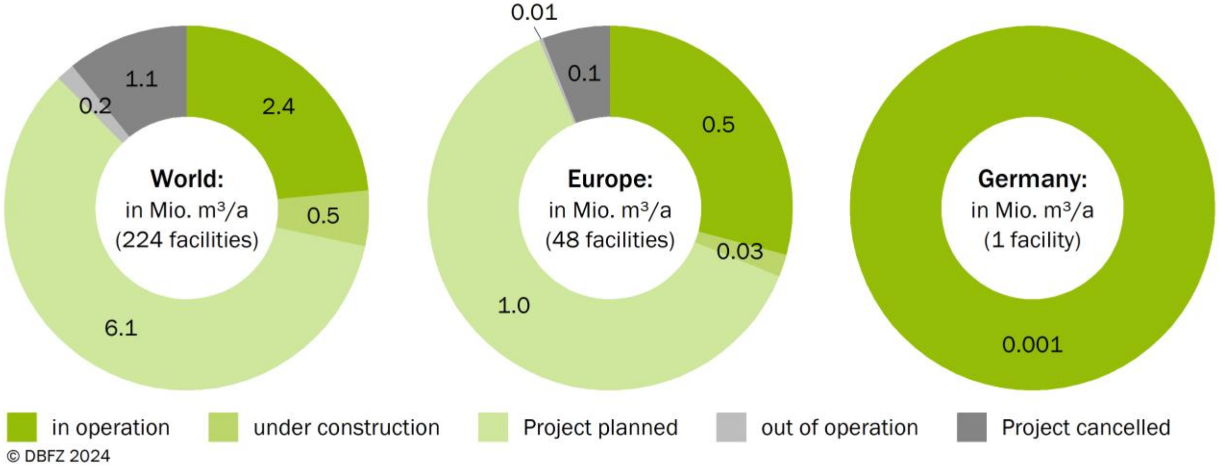
Lessons learnt technologies

Projected fuel capacities until 2030

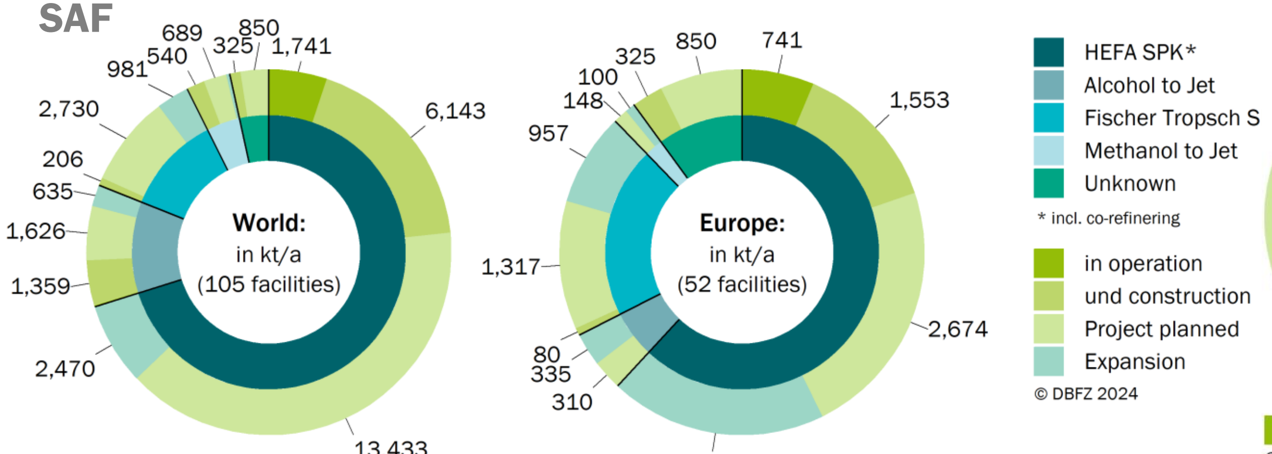
Renewable synthetic fuels



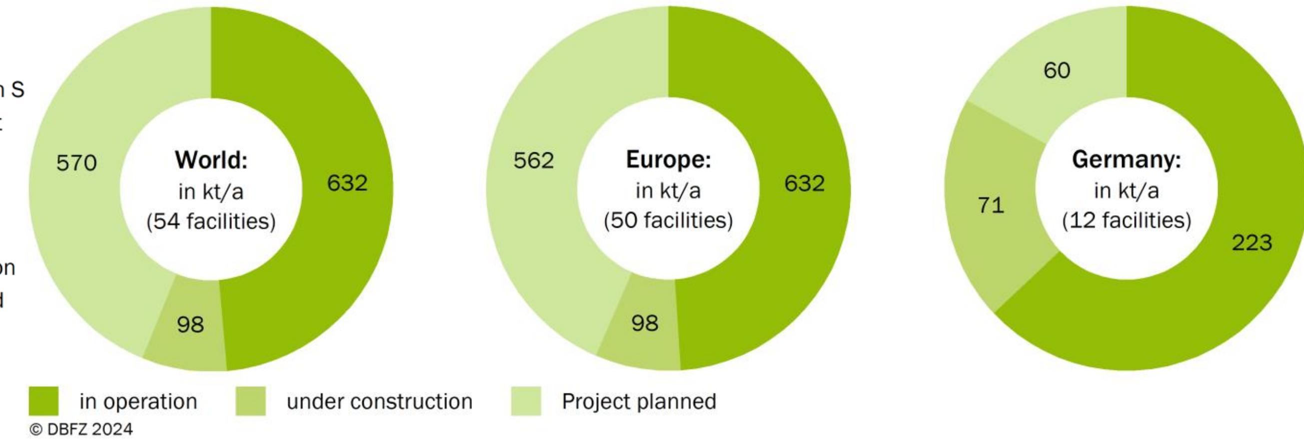
Lignocellulosic ethanol



SAF



Bio-LNG



Reference: [Schröder, Görsch 2025]

Lessons learnt technologies

Database on plants for advanced biofuels for transport

DBFZ

Technology Collaboration Programme
by iea

Task 39: Biofuels to decarbonize transport

Database on facilities for the production of advanced liquid and gaseous biofuels for transport

Explanations and definitions

To add your project please contact Andrea Sonnleitner.

Links to other databases

IEA Bioenergy Database
Biomass conversion facilities

Task 32 Database
Biomass Cofiring initiatives

Task 33 Database
Gasification of Biomass and Waste

Task 34 Database
Pyrolysis Demoplants

Publication based on database "Development and Deployment of advanced biofuel demonstration facilities IEA Bioenergy: Task 39, December 2024"

PDF

"Status of Advanced Biofuels Demonstration Facilities in 2012"

English

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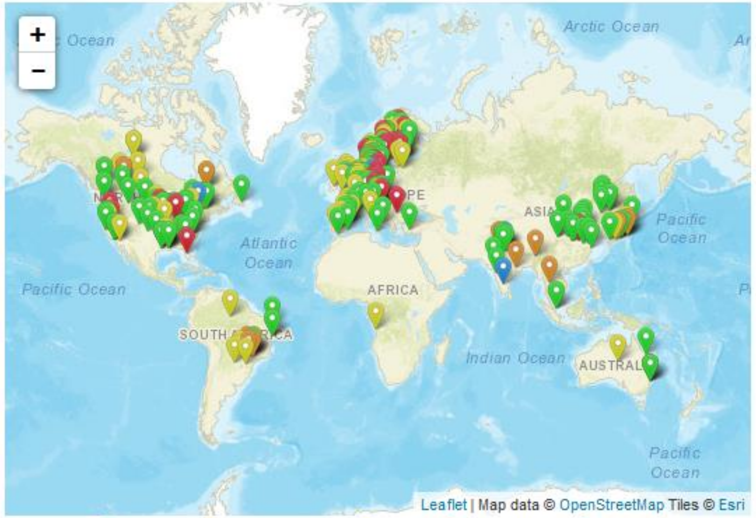
Projects

Search Owner/Name/Input | Submit

Owner	Name	Location	
Aarhus University	Center for Biorefining Technologies	Denmark	Info
Acelen	Acelen Bahia	Brazil	Info
Advanced Bioenergy Lab eGen	Reallabor ABL	Austria	Info
Advanced Biofuels Solutions Ltd	Swindon Advanced Biofuels Plant	United Kingdom	Info
Aemetis	Aemetis Carbon Zero 1	United States	Info
ALTACA ENERGY	ALTACA ENERGY	Turkey	Info
Anhui BBCA Biochemical	BBCA	China	Info
Anhui Guozhen Group and Chemtex Chemical Engineering	Fuyang project	China	Info
AquaGreen ApS	AquaGreen PCE	Denmark	Info
AquaGreen ApS	AquaGreen/Farevejle wastewater facility	Denmark	Info
Arbios Biotech (Joint Venture of Licella and Canfor)	CS-1 Facility	Australia	Info
Arbios Biotech (JV Canfor	Chuntoh Ghuna Low-carbon	Canada	Info

Map



operational | under construction | planned | non operational | no status

https://demoplants.best-research.eu/

IEA Bioenergy

» database with about 258 active entries, related to the different technologies

Example lignocellulosic ethanol | sunliquid®

Demo plant sunliquid® cellulosic ethanol in DE (© Clariant)

Commercial cellulosic ethanol plant in Romania (© Clariant)

- Process: steam explosion, enzymatic hydrolysis, fermentation, purification
- Pilot plant in Planegg/DE from 2008
- Demonstration facility in Straubing/DE with 1 kt/y cellulosic ethanol from 2012 (invest ~28 MEUR) >> test of diverse feedstocks, usage of demonstration facility to train personnel
- Business approach: focus on selling licenses of technology (e.g. Europe, China)
- First-of-a-kind in Romania with 50 kt/a with beginning of construction in 2018 and production from 2022 (invest ~290 MEUR)
- Plant and sunliquid® activities closed end of 2023 due to technical challenges to reach planned parameters
- Purchase by ICIG/Corden BioChem in 2024: focus on large-scale fermentation services, further investments in downstreaming processes (e.g. anaerobic fermentation)
- Driving factors for success: funding to projects focusing the technology development with industry/research, policies focused in GHG reductions targets (e.g. RED), expertise from institutions in the process development

Reference: IEA Bioenergy Lessons Learned 2023, Photos ©Clariant, cf. e.g. https://biooekonomie.de/nachrichten/neues-aus-der-biooekonomie/corden-biochem-uebernimmt-betrieb-von-ehemaliger-clariant

Example methanol/alcohols | Enerkem

Commercial plant in Edmonton and construction side Varennes (© Enerkem)

- Process: fluidised bed gasifier to process municipal solid waste to syngas for methanol synthesis and ethanol
- 2003 pilot plant in Sherbrooke
- 2009 demo plant in Westbury
- 2014 first commercial scale in Edmonton/CA (invest ~ 75 M$)
- plant retired in 2024 after reaching its objectives: e.g. up to 40 000 t of MSW capacity per year, 5 million liters of biofuels, 15 000 hours of operation producing ethanol and methanol
- Driving factors for success: grants and low-interest loans in RD&D and business planning plant construction, for production fuel tax exemptions, producer payments and price support with mandated biofuel blending requirements and tariffs.
- Planned projects incl. chemicals as products e.g. in Varennes/CA (initial operation 2026), El Morell/E (FID in 2025, initial operation 2029)

References: [IEA 2023 Lessons learned study], [Enerkem website and press releases 2025]

Example biodiesel and biobased products | Verbio

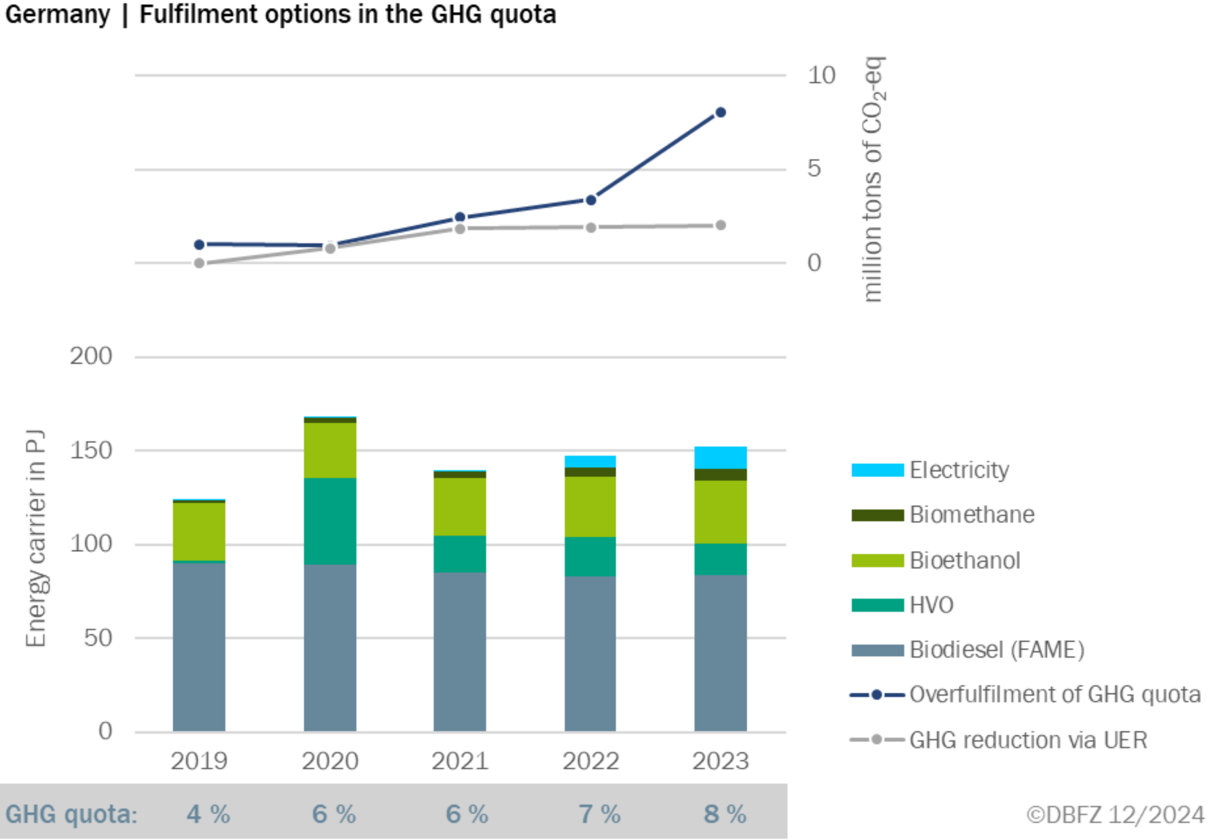
Verbio biodiesel plant in Bitterfeld and construction side ethenolysis plant (© Verbio SE)

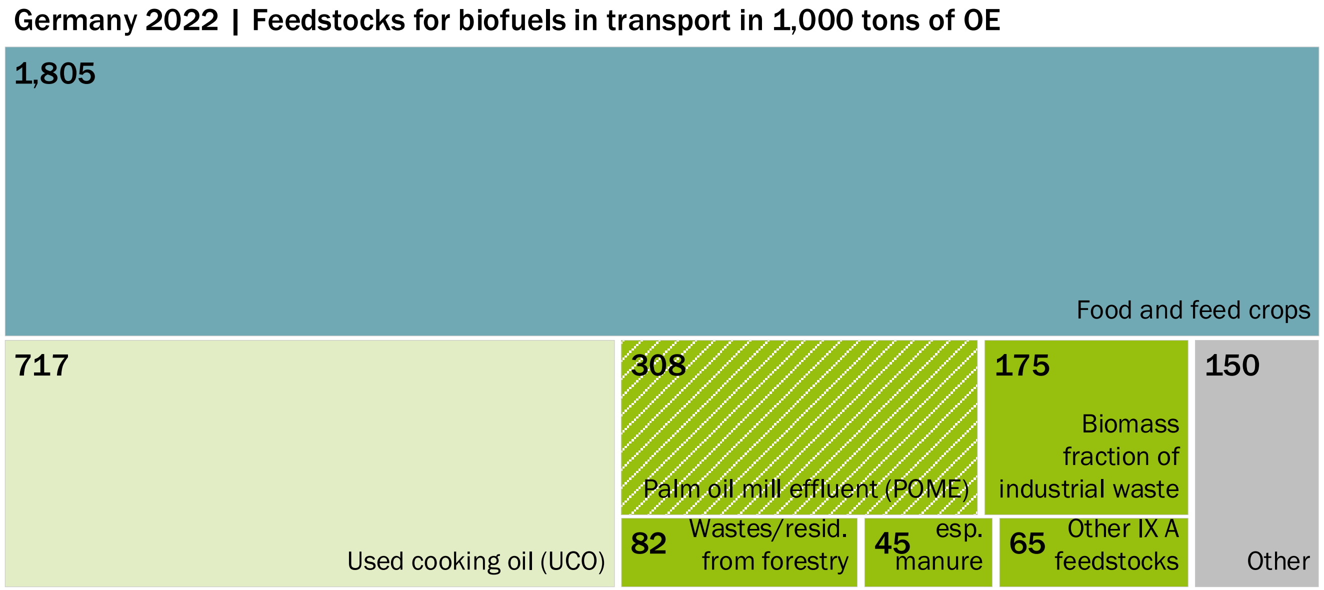
- Verbio’s portfolio of green products manufactured from biomass (e.g. fuels FAME, ethanol, biomethane)
- In 2001 start commercial biodiesel (rapeseed oil methyl ester) production in Bitterfeld/DE as well as pharma glycerine
- In 2014 start physterol production as high-quality raw material for foodstuffs and pharmaceuticals
- Currently construction of world’s first ethenolysis plant for specialty chemicals
  - annual capacity: 32,000 tonnes of methyl 9-decenoateand (detergents and cleaning agents, material for lubricants and polymers) 17,000 tonnes of 1-decene (high-performance lubricants)
  - Innovative olefin metathesis catalysts from XiMo (subsidiary of Verbio SE)
  - production start foreseen for 2026
  - other specialty chemicals planned with application for pharmaceutical or cosmetic products.
- Drivers for success: company acting along overall value chain, strong R&D activities, capacity built up almost independent from policy framework (cf. also international activities on biomethane)

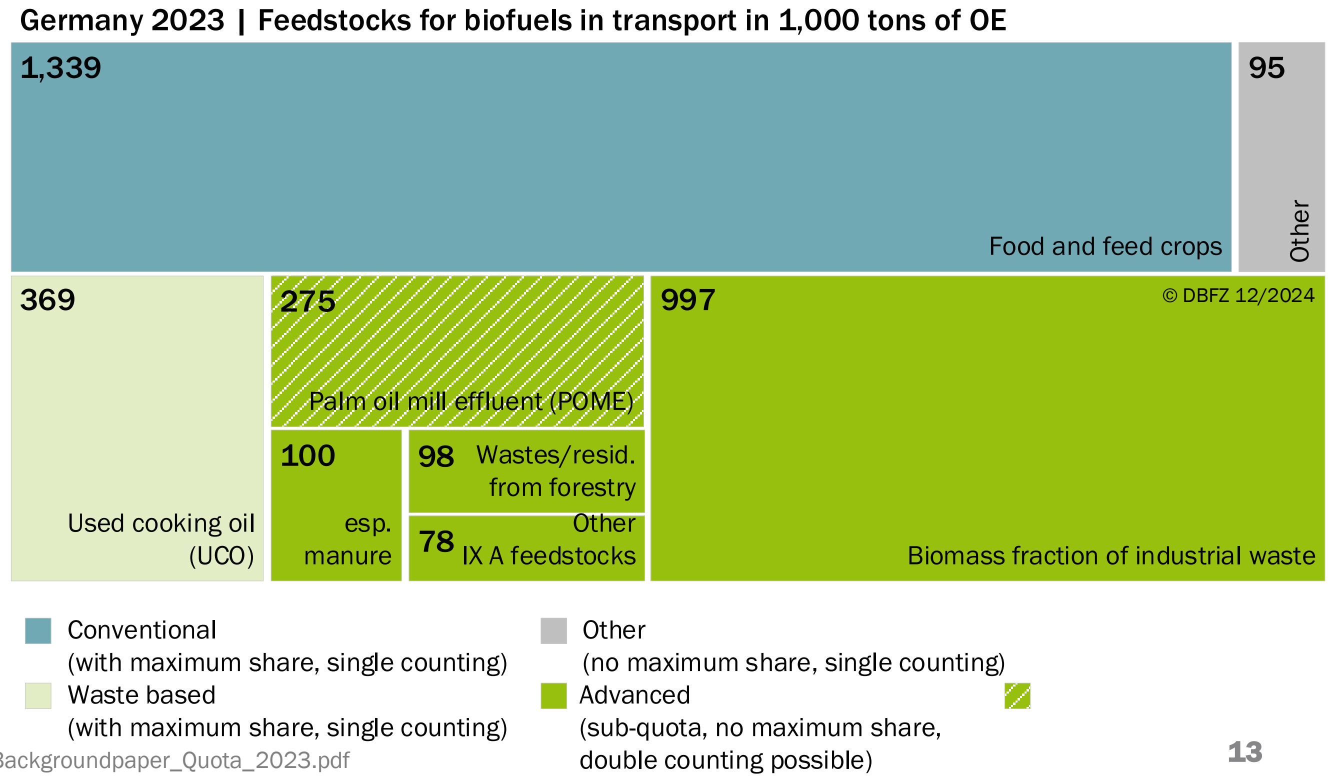
Reference: Press releases Verbio 01/2025, 2021;
https://www.process.vogel.de/gruene-chemieindustrie-verbio-ethenolyse-anlage-bitterfeld-a-937752ffee00867783f91a075df0d142/

Lessons learnt feedstocks

Example GHG quota in Germany







- In 2023 significantly higher GHG reduction than required: increase of average GHG mitigation to 90%, increase of double-counted advanced biofuels 15 PJ to 54 PJ (factor 10 of subquota), increase of triple counted electricity 12 PJ to 23 PJ
- Massive shift to industrial waste from Asia >> possible fraud

Conclusion

Need of harmonised technology push and market pull policies

- Pressure to act is increasing dramatically and drivers may change >> current forecasts show enormous need for renewable fuels and at the same time mineral oil companies step out of their renewable targets
- Ambitious strategies and targets do not automatically create a frame that allows increasing or building up innovative technologies in the intended regions with sustainable feedstocks (cf. Germany quota example)
- Case studies for advanced biofuels often showed technical success however not the required commercial success

Urgent needs

- Harmonise long-term technology push and market pull policies (incl. steering instruments to lower risks) for GHG mitigation and defossilisation of transport and other sectors >> same frame for renewable refineries independent of product application
- Monitor policy impacts on technology and market development in a comprehensive way
- Allow improvement of established biofuel options as ground base
- Push R&D&D on innovations of advanced biofuels including hybrids with other renewables that are more complex and thus (usually) more cost demanding (e.g. with regard to GHG mitigation)
- Accept a transition process that allow starting with promising technology options, gaining experience and learning lessons for continuous improvement.
- Encourage international cooperation to share opportunities and risks for new value chains as well as knowledge and technology transfer

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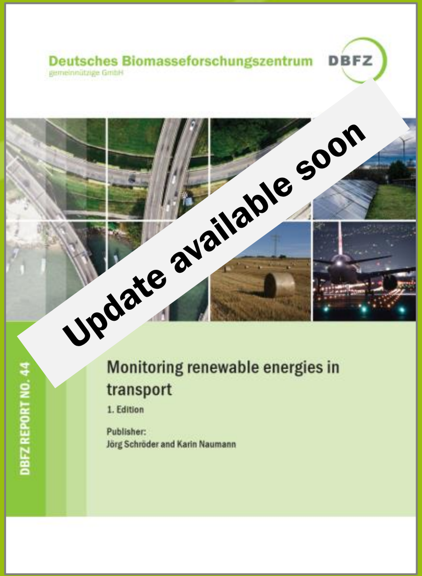
Interesting publications



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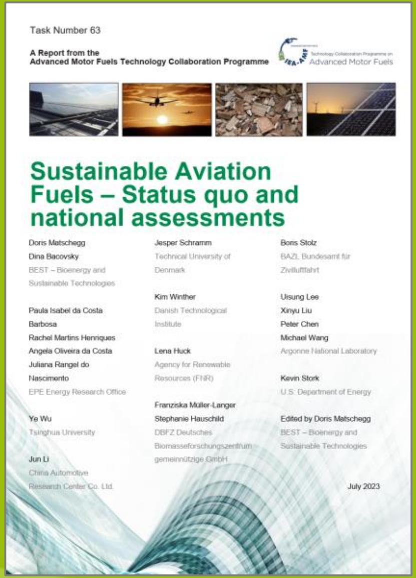
https://www.dbfz.de/monitoring-ee-im-verkehr/start

https://task39.ieabioenergy.com/wp-content/uploads/sites/37/2024/12/IEA-Bioenergy_T39P3_report_final.pdf

https://www.ieabioenergy.com/blog/task/lessons-learned-biofuels/#



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