Biomethane market: developments and achievements in EU and Italy

David Chiaramonti

Politecnico di Torino

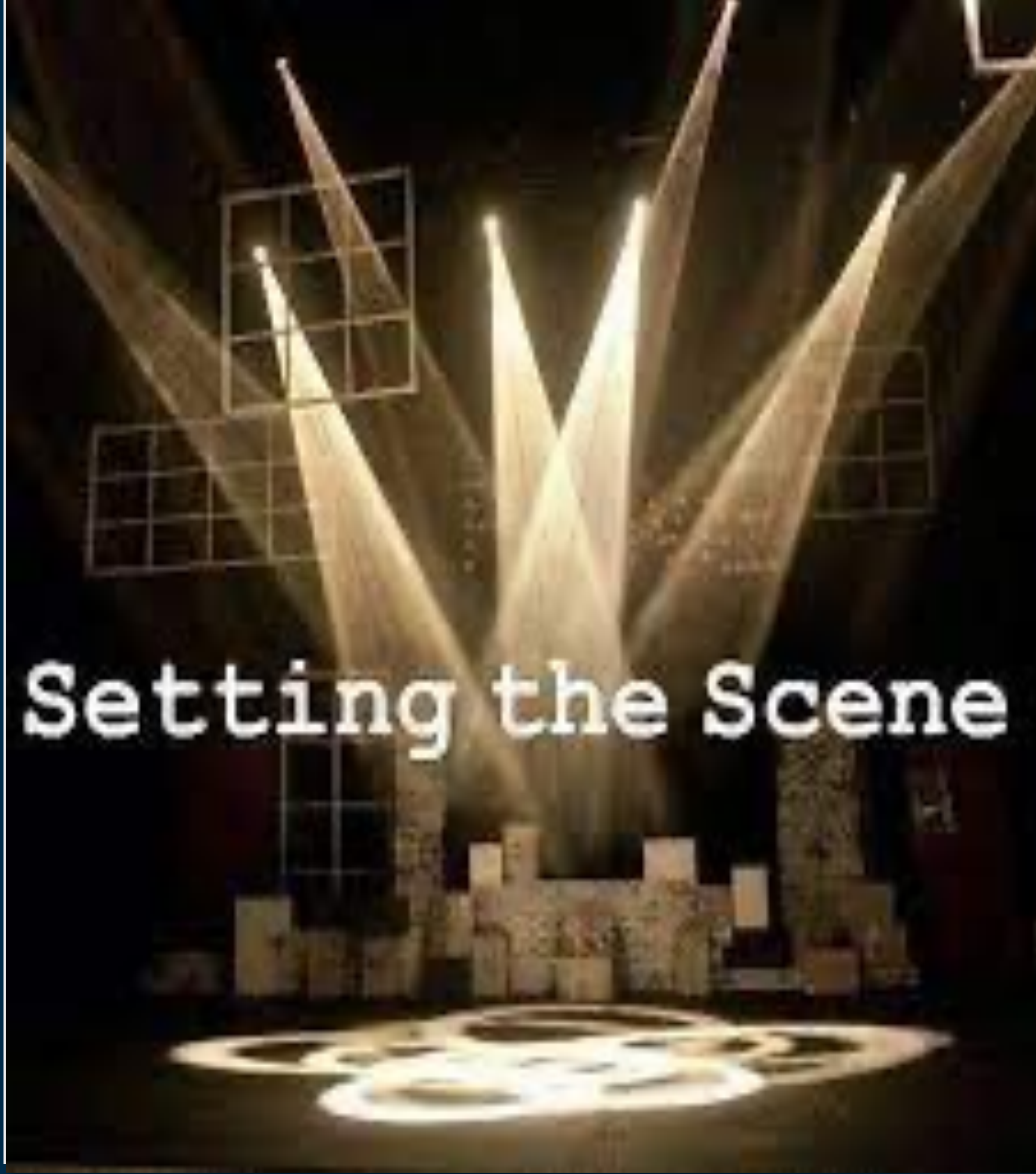
1859

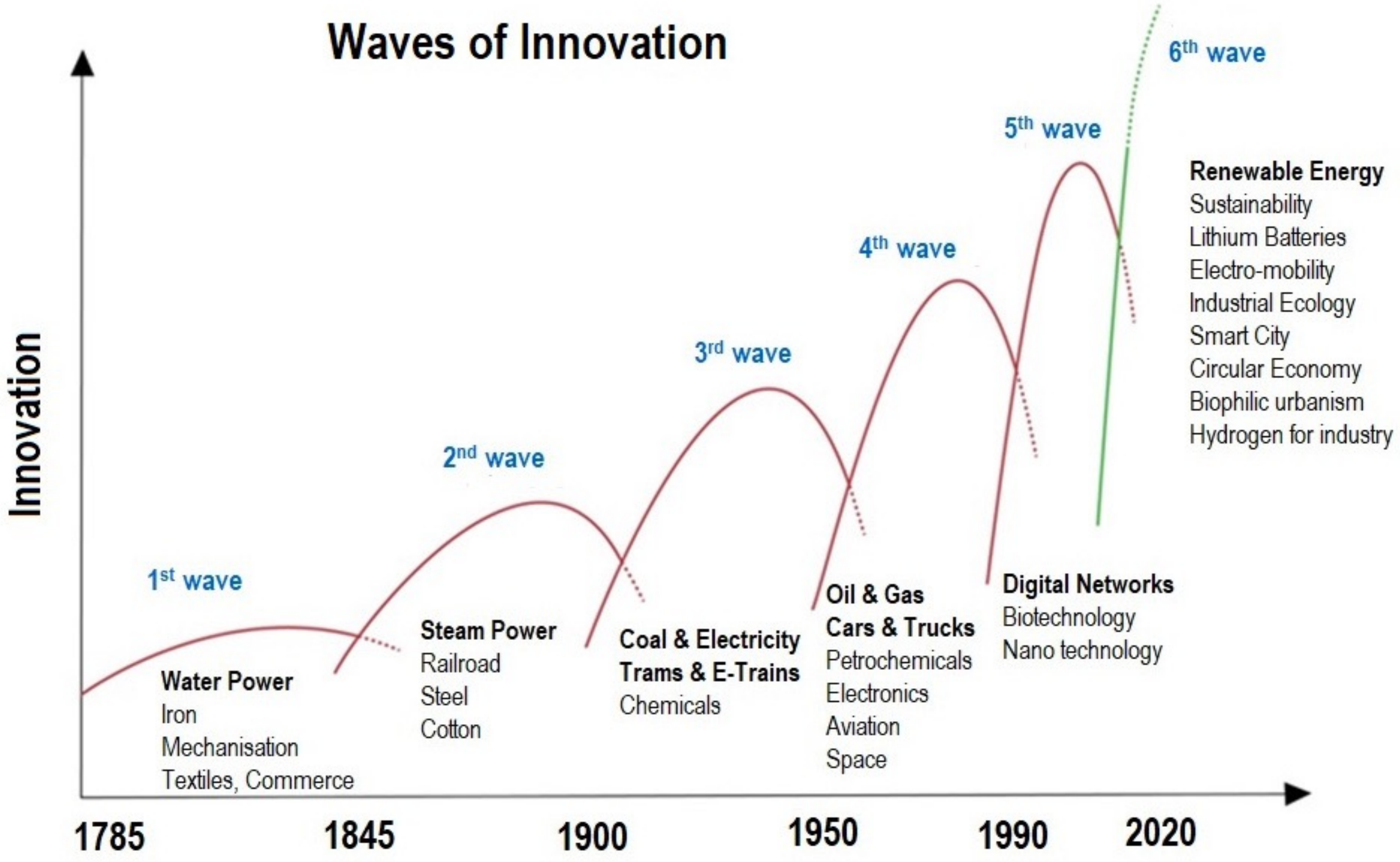
F4F Fit4Foresight FUEL

CAReGIVER SAPERE PER CONDIVIDERE

Setting the scene

- Waves of Innovation: Technology evolution vs industrial and policy implementation
- Fuel demand in the EU and IT
- Policies

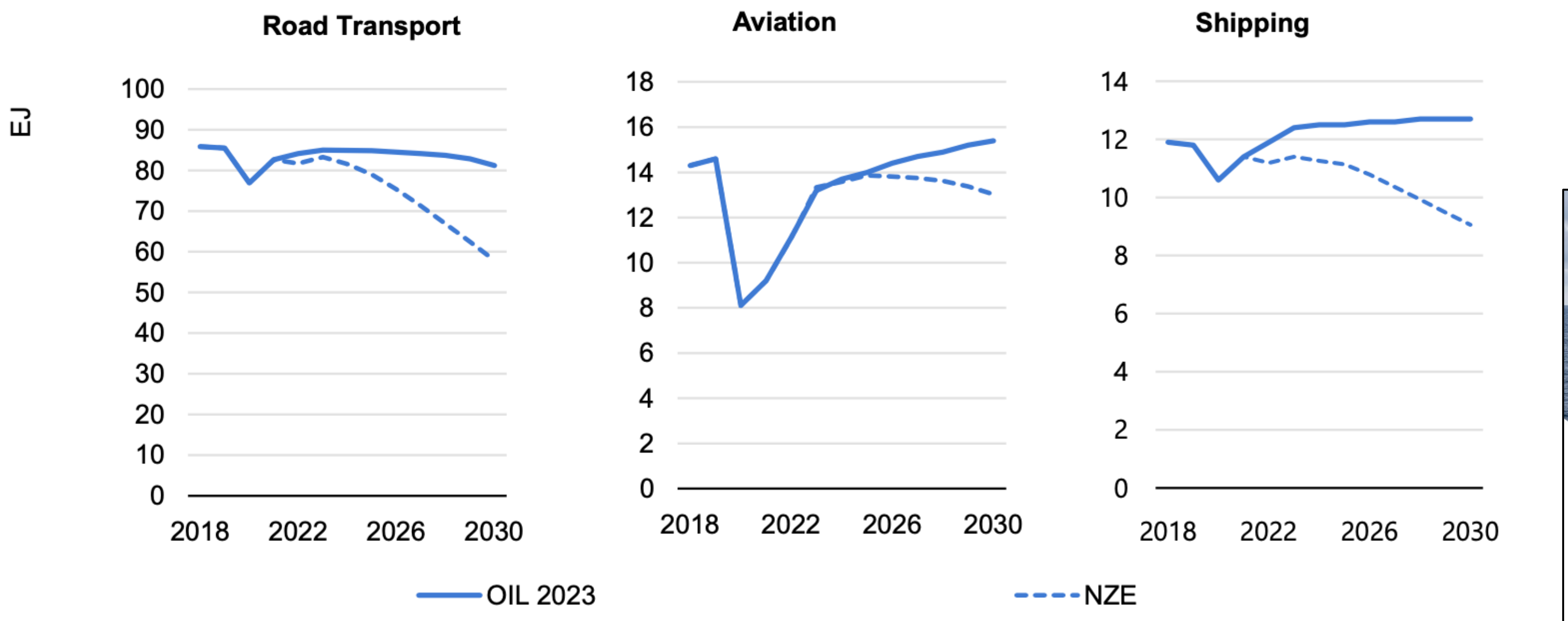




Adapted from:
Newman,P.COVID,CITIES and CLIMATE: Historical Precedents and Potential Transitions for the New Economy. UrbanSci. 2020, 4, 32, doi:10.3390/urbansci4030032.

- **Industrial scale-up & Policy making need to adapt their action to such fast changes**
- **What is achievable in the given timeframe? Is this compatible with the urgency need?**
- **Which socio-economic impacts? How to build consensus (No One Left Behind..)**

Transport sector oil demand under current policies and net zero targets



IEA. CC BY 4.0.

Notes: Oil 2023 = data from the IEA's Oil 2023 - Analysis and forecast to 2028. NZE = Net Zero Emissions by 2050 Scenario.

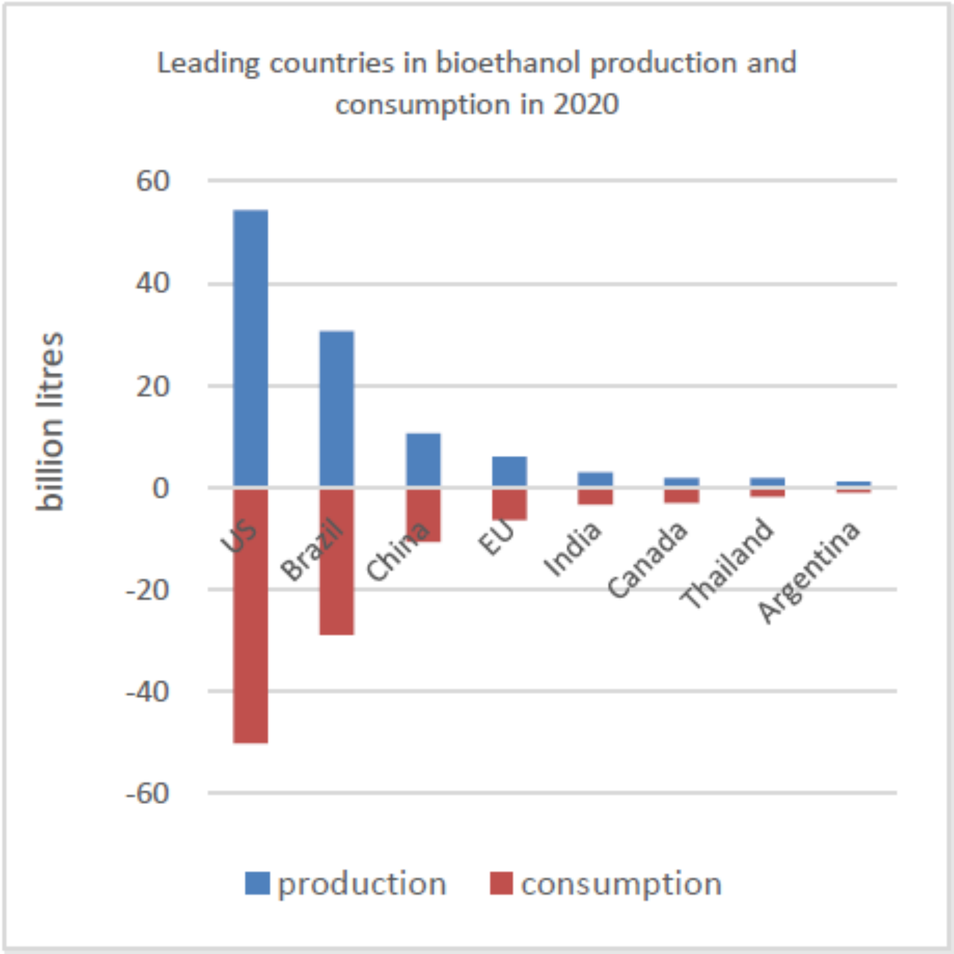
EJ		TWh		MWh
1	=	277.778	=	2.778e+8

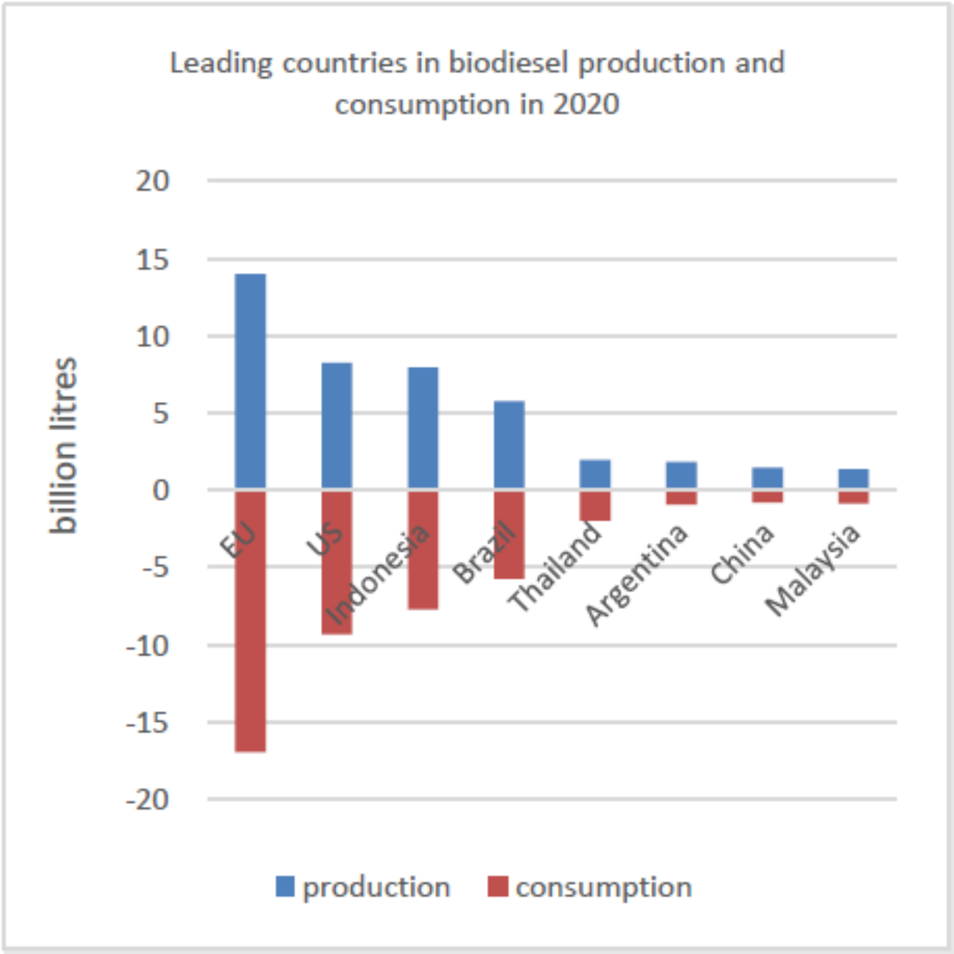
= 277,000,000 MWh

= 23.88 MTOE

Power consumption in IT 2022: 295.8 TWh

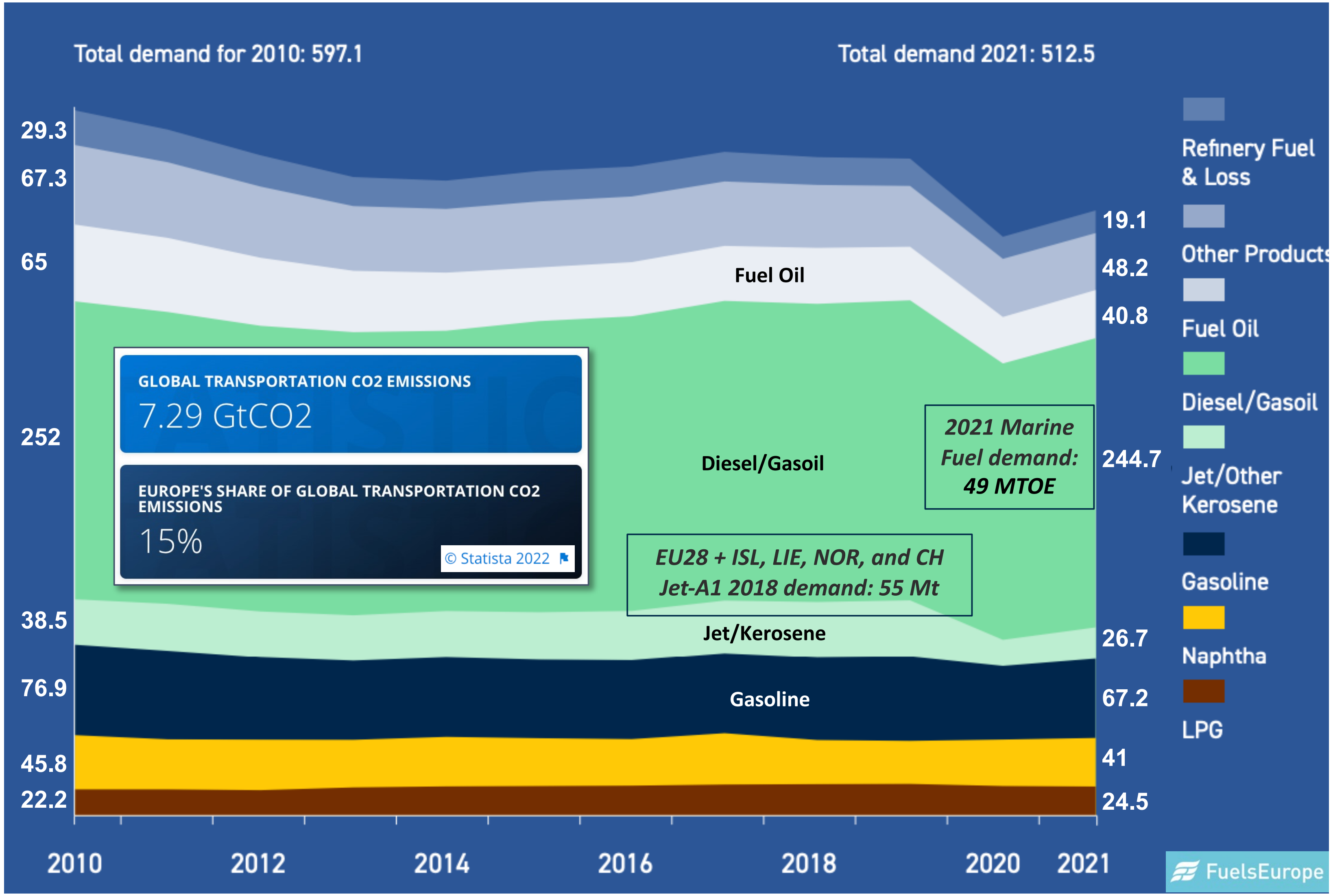
Leading countries

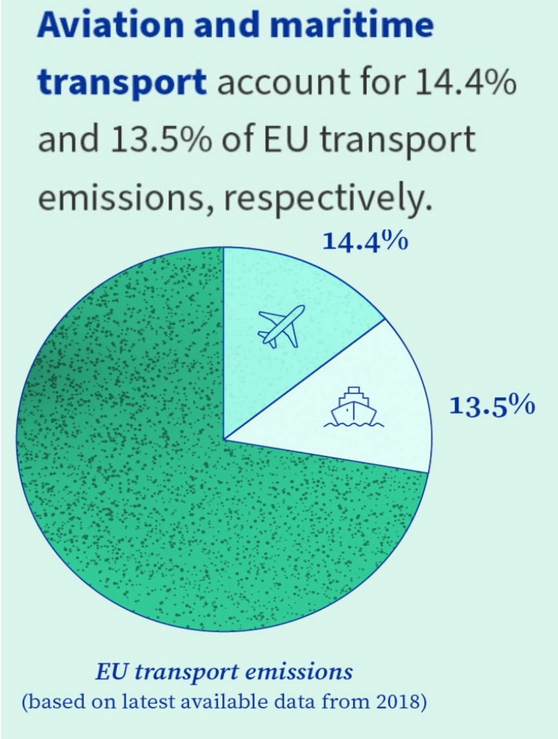




Source: (OECD, 2022b)

Source: JRC, 2022





EU Domestic Aviation: ~20% of EU Jet Fuel demand

Kerosene import dependency in the EU (excluding Bio component): approx 28% at 2020

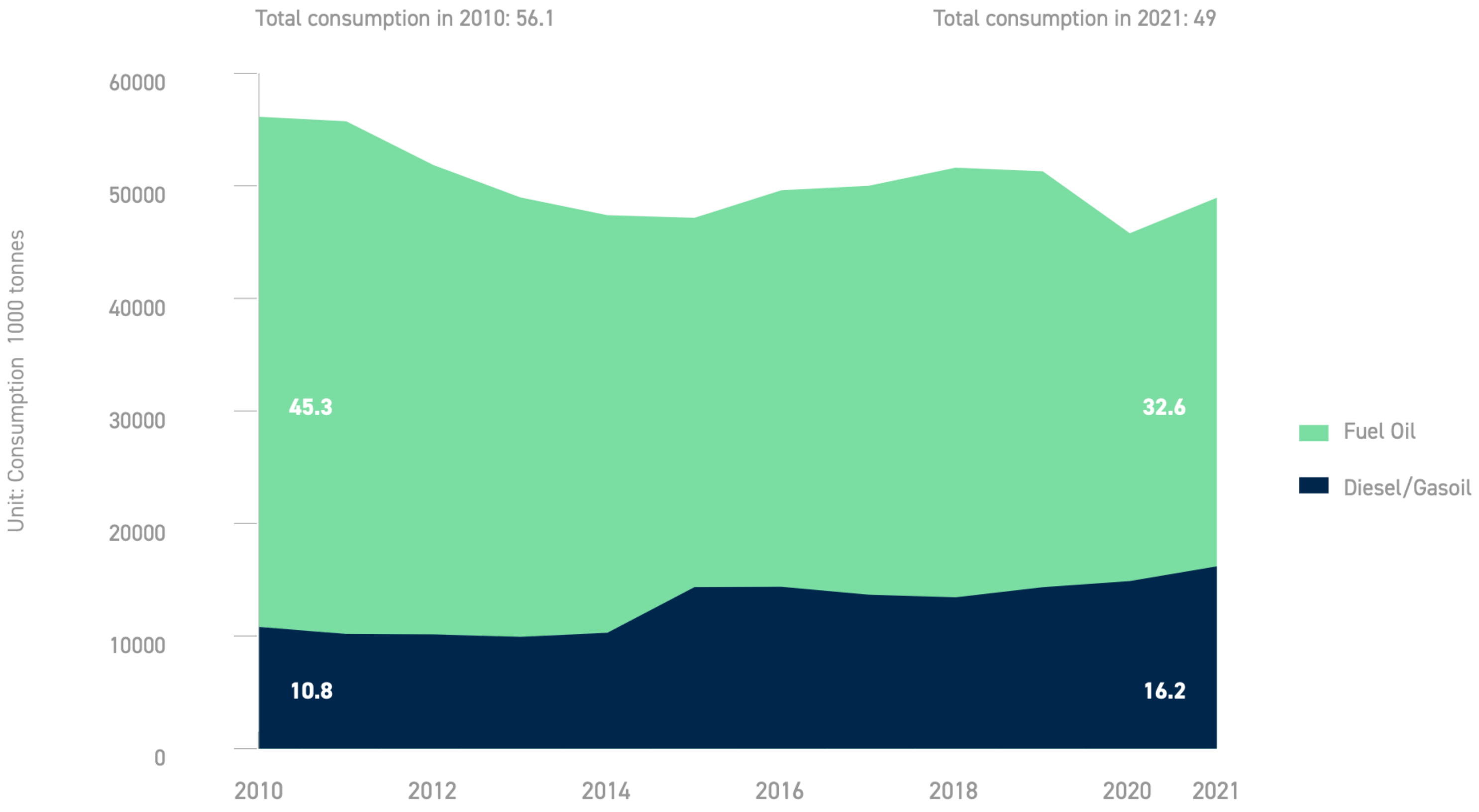
→ 77% of EU transport emissions came from road transport in 2020.

FIG.21

EU-27 MARINE FUEL CONSUMPTION

Source: Wood Mackenzie

During the past years there was a rise in marine gasoil consumption at the expense of fuel oil. Switching to LNG or using scrubbers are alternatives to meeting the new International Maritime Organisation (IMO) emissions limits.



Status of oil demand in the EU

FIG.17 **AVERAGE REFINERY OUTPUT BY PRODUCT TYPE** IN OECD EUROPE IN 2021

Source: International Energy Agency

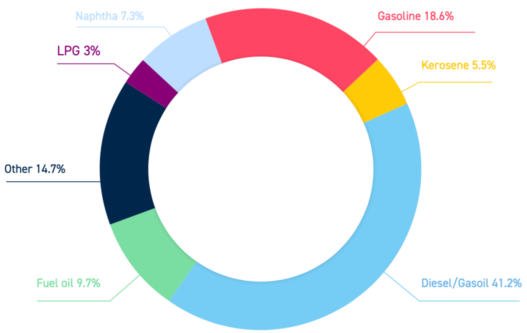
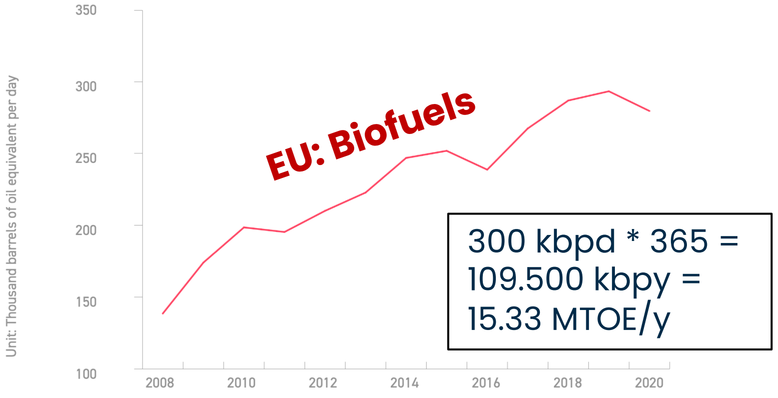


FIG.18 **BIOFUELS PRODUCTION** IN EU-27

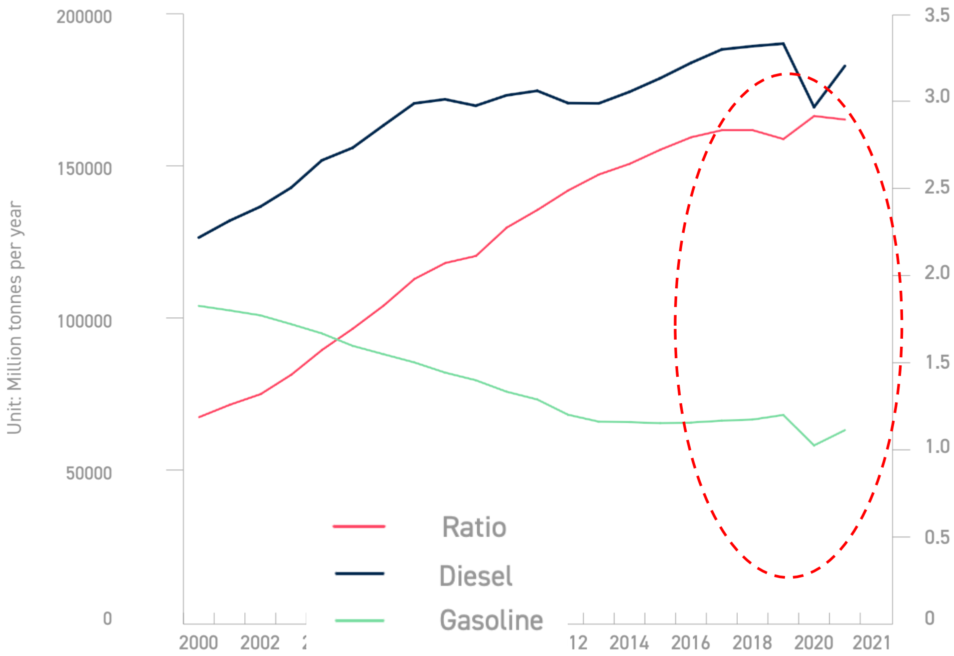
Source: BP Statistical Review of World Energy 2021



The overall production of biofuels in the EU has doubled since 2008; growing from 138 thousand barrels of oil equivalent per day to 280 in 2020.

Note: Includes biogasoline (such as ethanol) and biodiesel. Volumes have been adjusted for energy content.

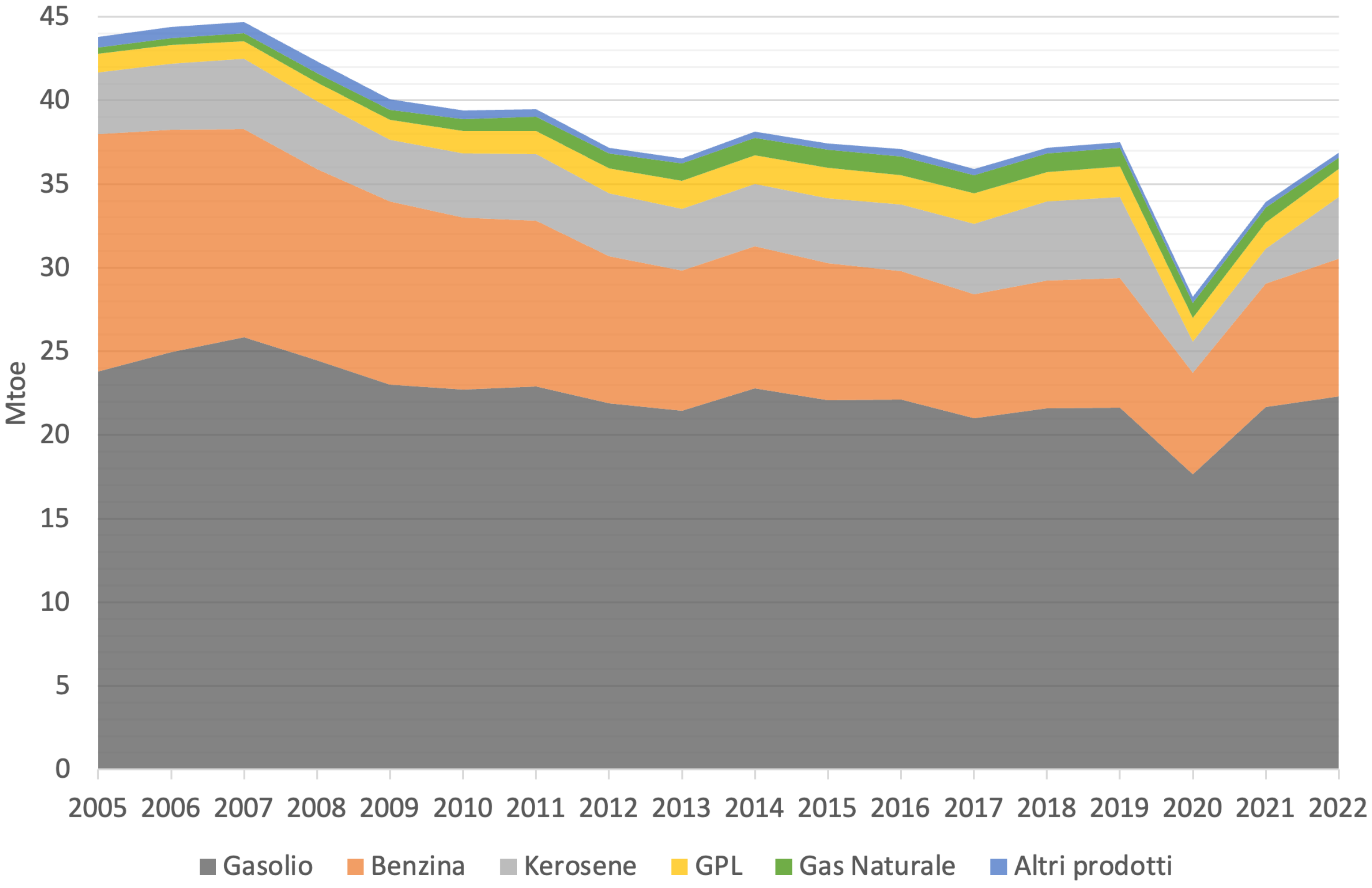
ROAD FUEL DEMAND IN THE EU-27 IN 2021



The tax-incentivised dieselisation trend has significantly contributed to a fundamental change in the EU's road fuel demand structure. The shift from gasoline to diesel began some 25 years ago and led to a major demand decline for gasoline as well as a shortage of diesel production in the EU. However, since 2017 this trend is reversing. The effect of the Covid-19 pandemic was significantly bigger on diesel than gasoline, and despite a progressive recovery pre-Covid levels have not been recovered yet (2021).

Fossil fuel consumption in Italy - General

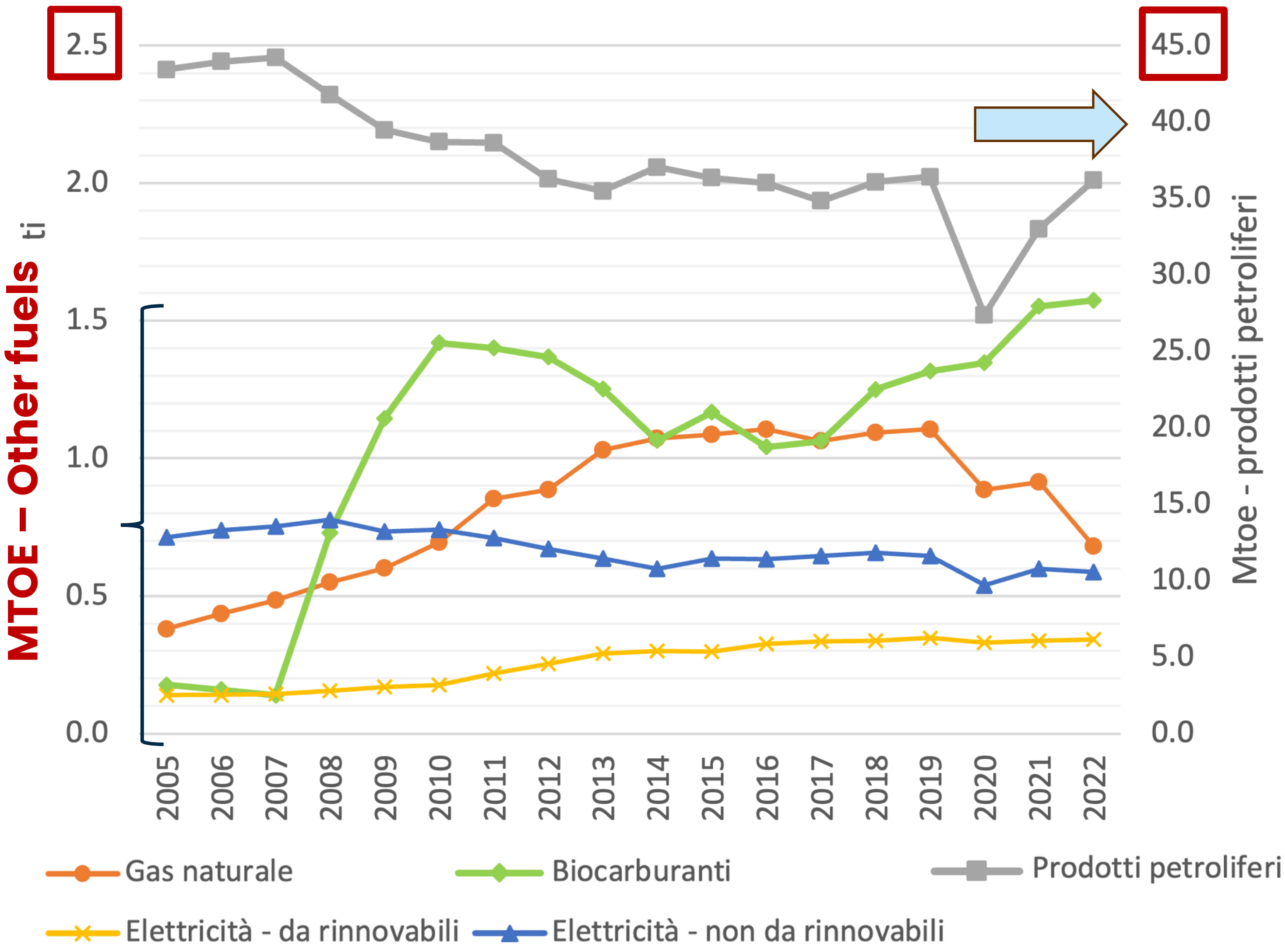
- Total fossil fuel consumption: -16% over 2005 – 2022
- kerosene contribution to fuel mix is recovering towards pre-COVID levels
- Gasoline reduction trend is slowed and reversing post 2017



Source: UNEM

Fossil fuel consumption in Italy - General

- Overall reduction for consumption trend: from **45** Mtoe (**2005**) to **39.4** Mtoe (**2022**).
- Pre-COVID (2019) levels recovered.
- **Fossil** sector contribution reducing (**- 6.8** Mtoe), but still **>90%** of total.
- Growing contributions from **biofuels** (**+1.4 Mtoe**).
- Total contribution of renewable power slightly increasing

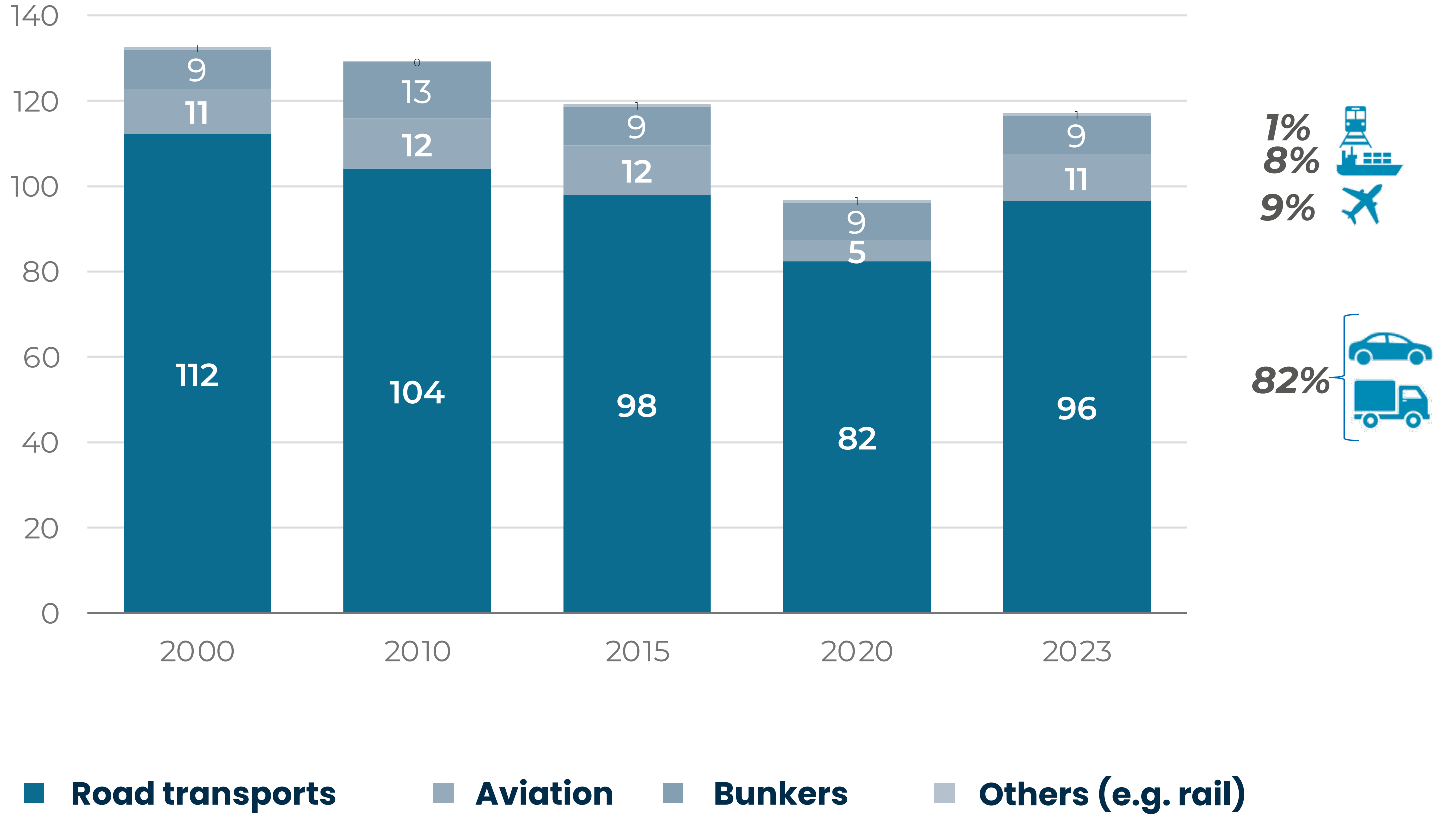


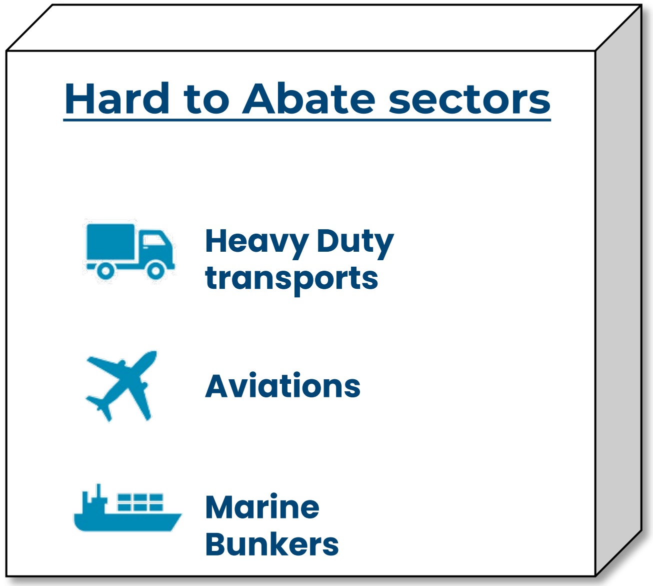
Source: UNEM

ITALY: emissions from transports

Transport emissions per transport mode

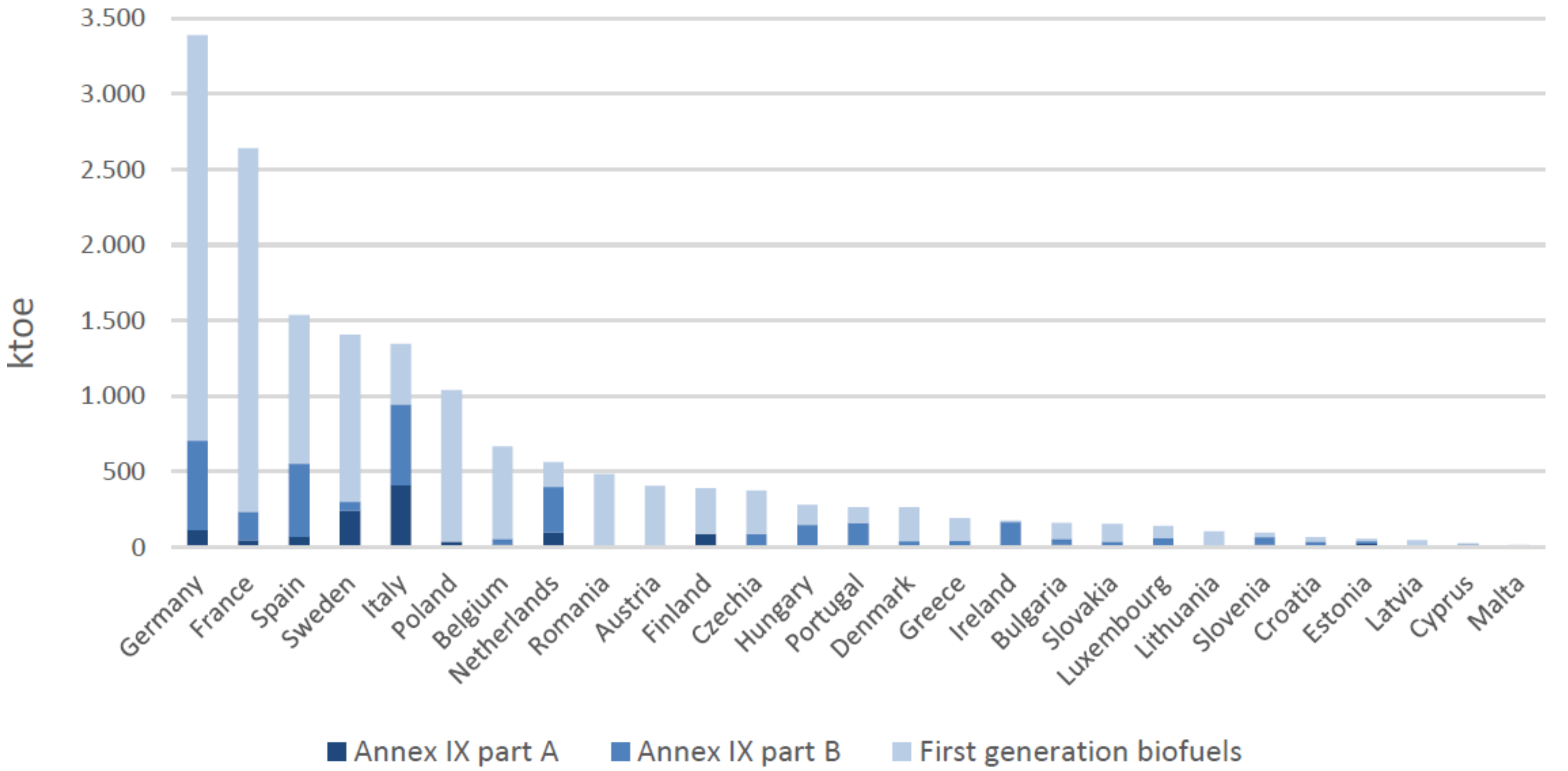
$MtCO_2/y$





Fonte: elaborazione ENI

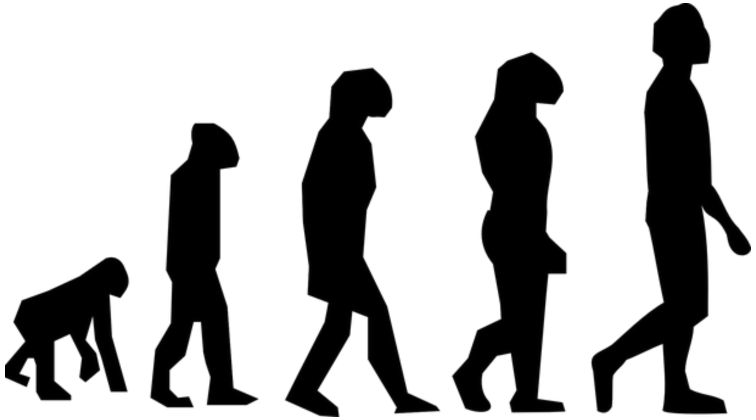
Biofuel use per Member State (2020)



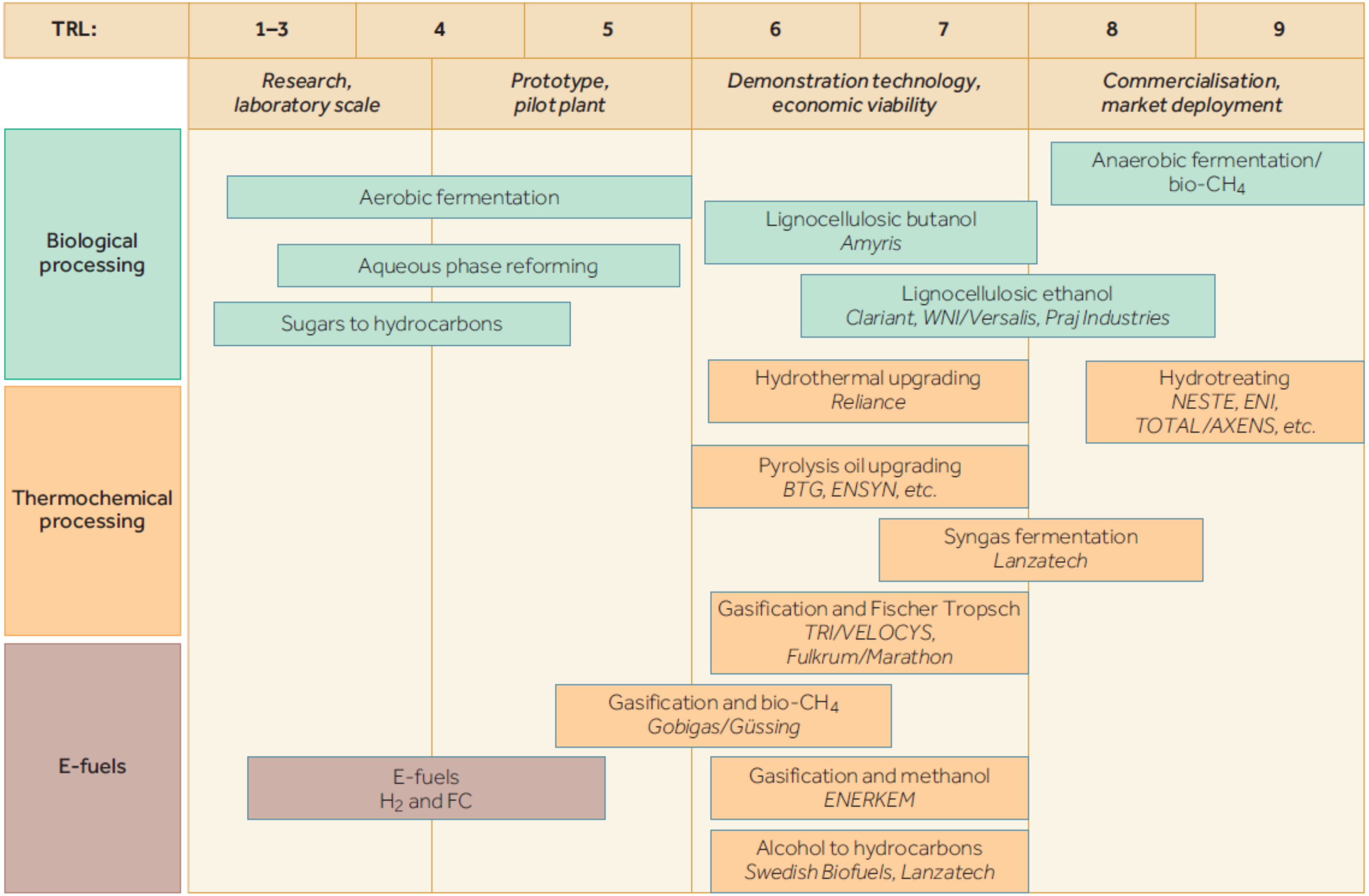
Source: (OECD, 2021)

Source: JRC, 2022

Technology Evolution, Policy and Scenarios in the EU



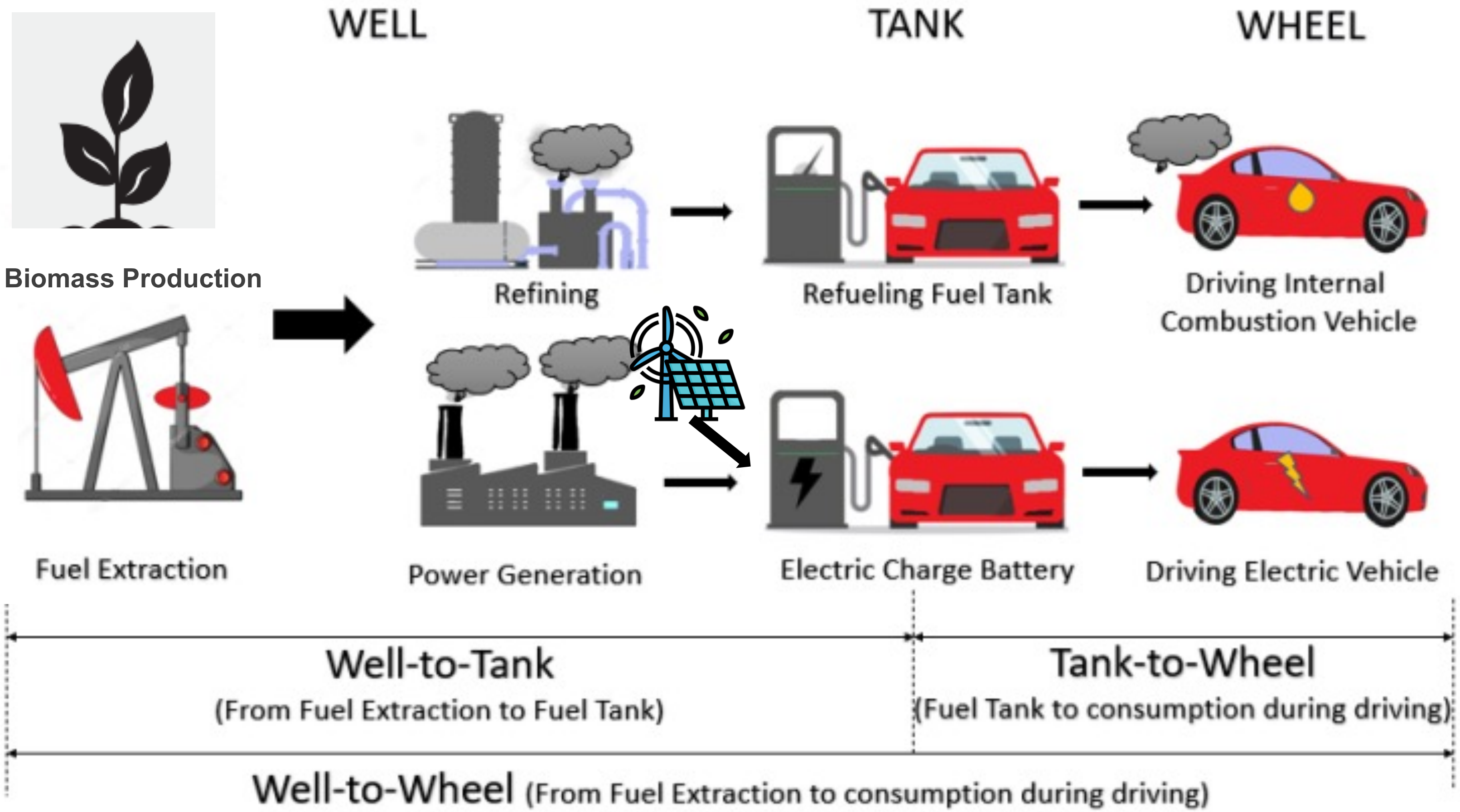
Technologies and value chains



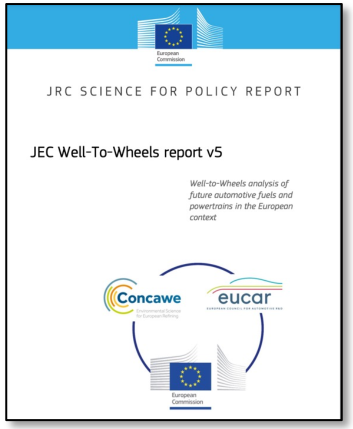
Source: Concawe, 2022

GHG assessment - Methodology: TtW vs WtW

- **A fair and scientifically sound comparison requires a WtW approach.**



Adapted from https://www.linkedin.com/pulse/do-you-think-electric-vehicles-completely-emissions-free-jadhav/



List of **eligible fuels**: JEC WtW Study Version5 (https://publications.jrc.ec.europa.eu/repository/handle/JRC121213)

WtW approach is fair and allow accounting multiple benefits

Development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels

Acknowledgements and Disclaimer

This presentation is based on results of the study „ *Development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels”* conducted in 2023 for the European Commission.

I would like to acknowledge the contributions of all study authors.


Development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels

Final Report

This presentation, however, reflects the views of the author of this presentation, and the European Commission shall not be liable for any consequences stemming from this presentation.

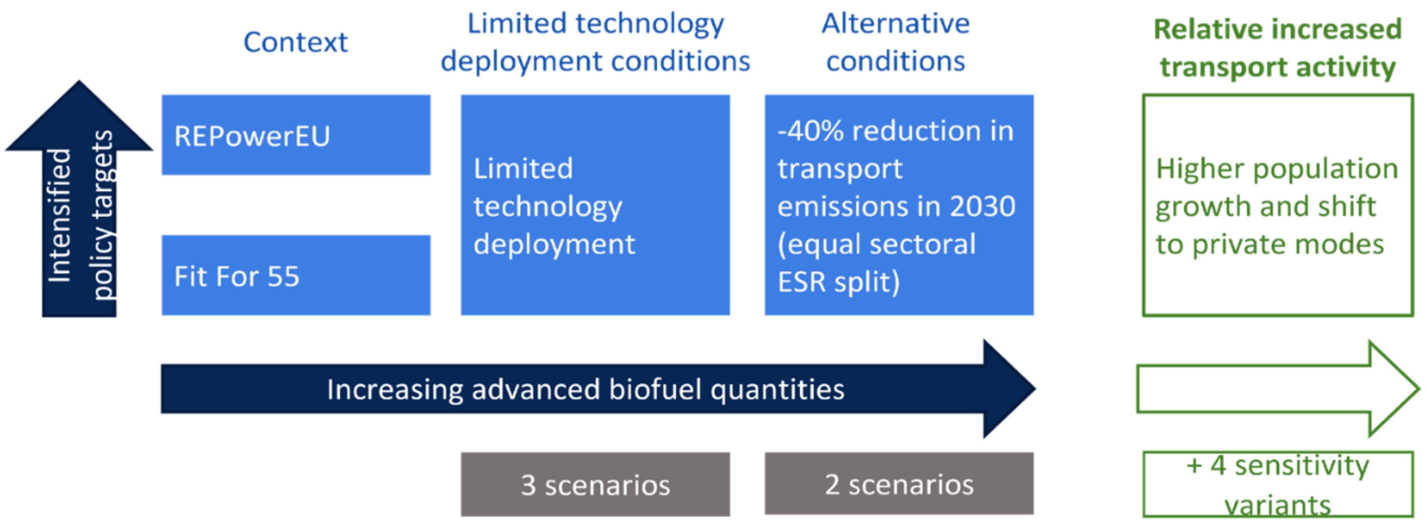
European Commission, Directorate-General for Research and Innovation, Georgiadou, M., Goumas, T., Chiaramonti, D., *Development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels – Final report*, Georgiadou, M.(editor), Goumas, T.(editor), Chiaramonti, D.(editor), Publications Office of the European Union, 2024, https://data.europa.eu/doi/10.2777/679307

Considered POLICIES and SCENARIOS

Policy background in EU includes **Fit for 55** package and **RePowerEU**

→ Relevant parts of Fit for 55:

- Renewable Energy Directive
- ReFuelEU aviation
- FuelEU maritime
- EU Emiss. Trading System ETS
- Effort Sharing Regulation ESR on emission reduction targets. 40% reduction by 2030



→ REPowerEU

Considered POLICIES

Renewable Energy Directive (RED)

Targets for share of energy from renewable sources in transport in MS

- 2020: 10%
- 2030: 14% (RED II, published 2018)
- NEW 2030 (revised RED II, published 2023):
  - 29%, or 14.5% GHG emission reductions
  - 5.5% share of advanced biofuels and RFNBOs combined
- Biofuels, biomethane, ren. electricity, RFNBOs, recycled carbon fuels

Shipping and Aviation

ReFuelEU aviation

- Minimum share of SAF supply:
  2025: 2%, 2030: 6%, 2035: 20%,
  2040: 34%, 2045: 42%, 2050: 70%

FuelEU maritime

- Reduction of GHG intensity of energy used on board:
  2025: -2%, 2030: -6%, 2035: -14.5%,
  2040: -31%, 2045: -62%, 2050: -80%

Other Regulations

- Effort Sharing Regulation (ESR)
  - 60% of EU GHG emissions:
    road transport + agriculture + buildings + small industries + waste
  - Target to reduce EU-wide GHG emissions of these sectors by 40% by 2030 versus 2005
  - Effort is shared between MS
- Emission Trading Scheme (ETS)
  - Creates a market for carbon
- REPowerEU
  - Save energy, produce more renewable energy

Modelled scenarios

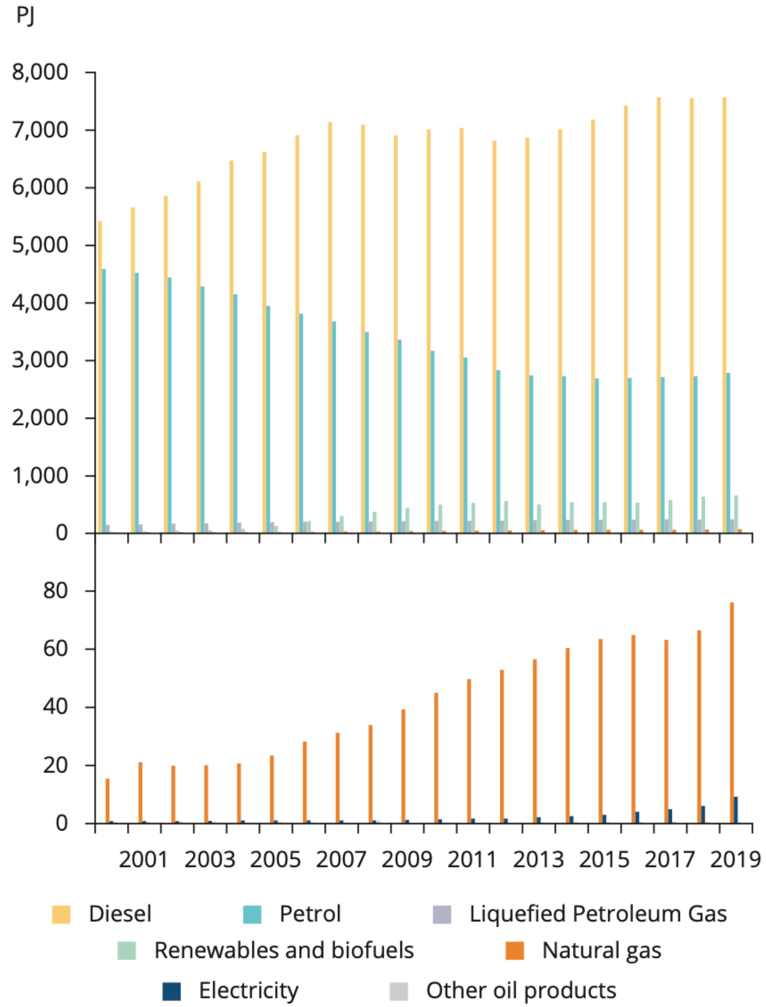
E3-Modelling:

- Considered policy background: Fit-for-55 and REPowerEU framework
- PRIMES-TREMOVE model applied to the simulation
- 5 scenarios and 4 sensitivity variants were developed
- Applied Limited Deployment of Technologies (LTD) and increased demand through ESR as drivers for biofuels

Projected 2030 policy-driven demand under the following scenario assumptions:

- 8-12 Mtoe conventional biofuels
- **15-19 Mtoe advanced biofuels**
- 9-10 Mtoe biofuels from Annex IX Part B feedstocks

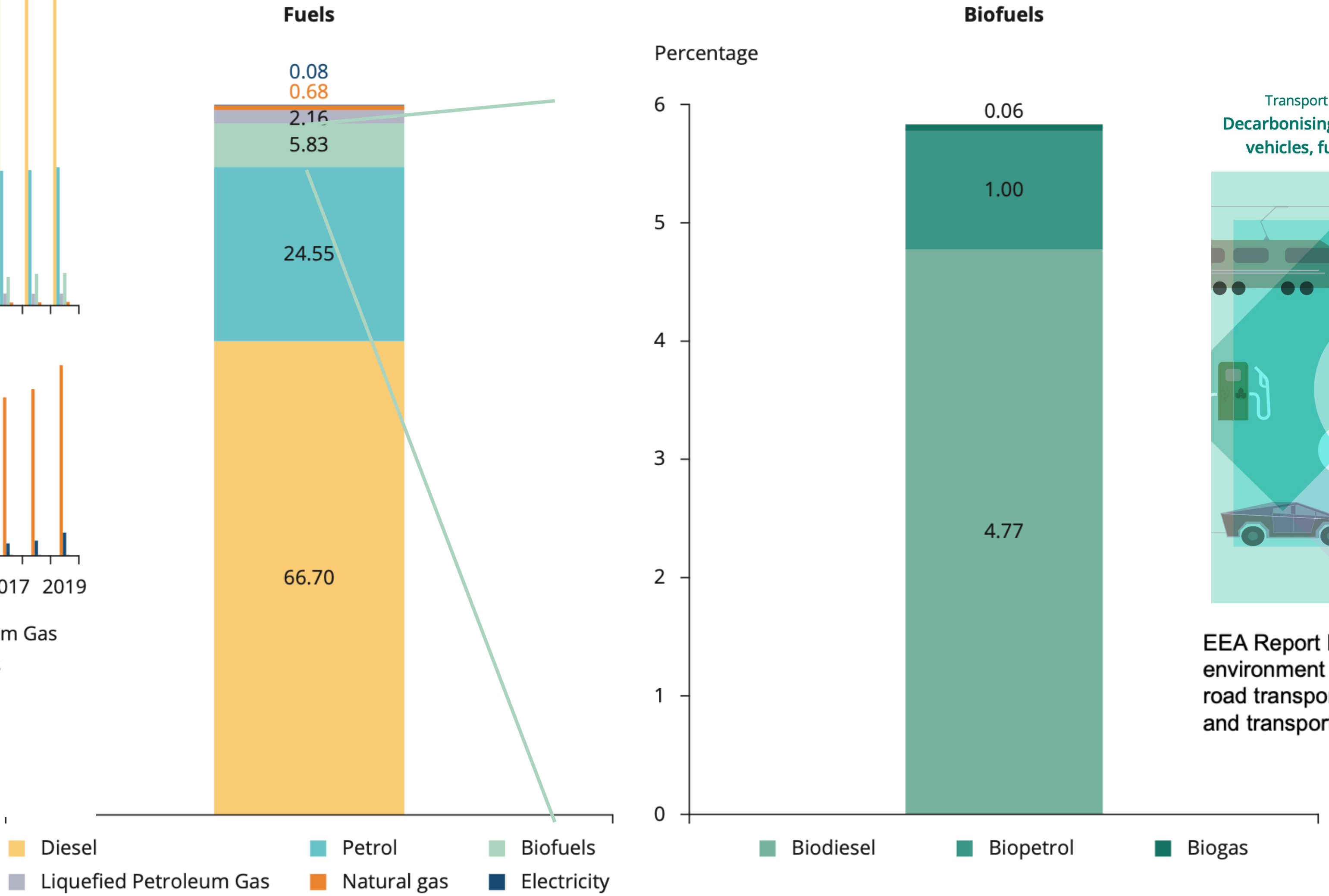
Transport fuels' share in the EU



Note: PJ - Petajoules.

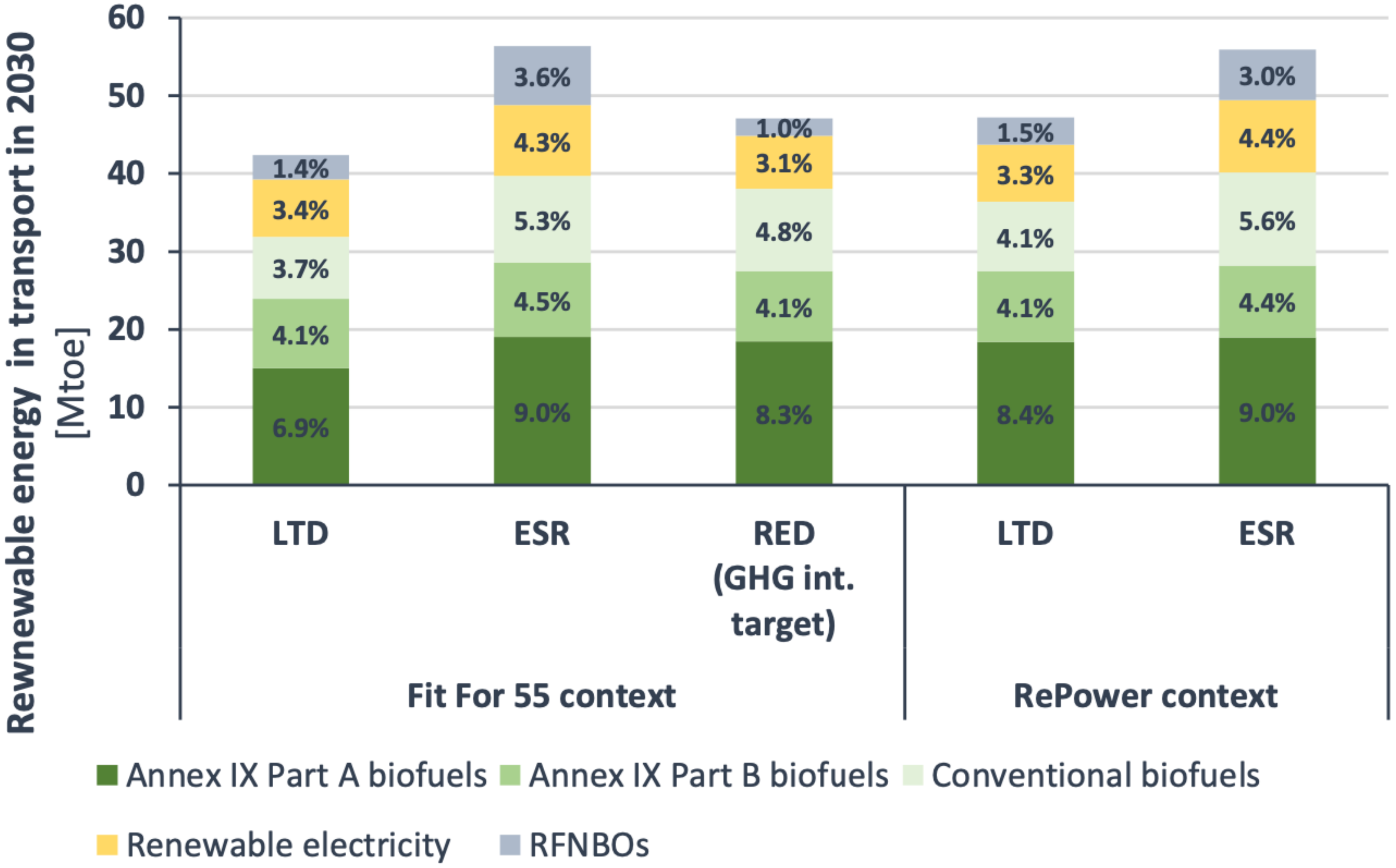
Source: EEA compilation based on Eurostat (2021).

Final energy consumption by road transport by energy type in the EU-27 in 2019

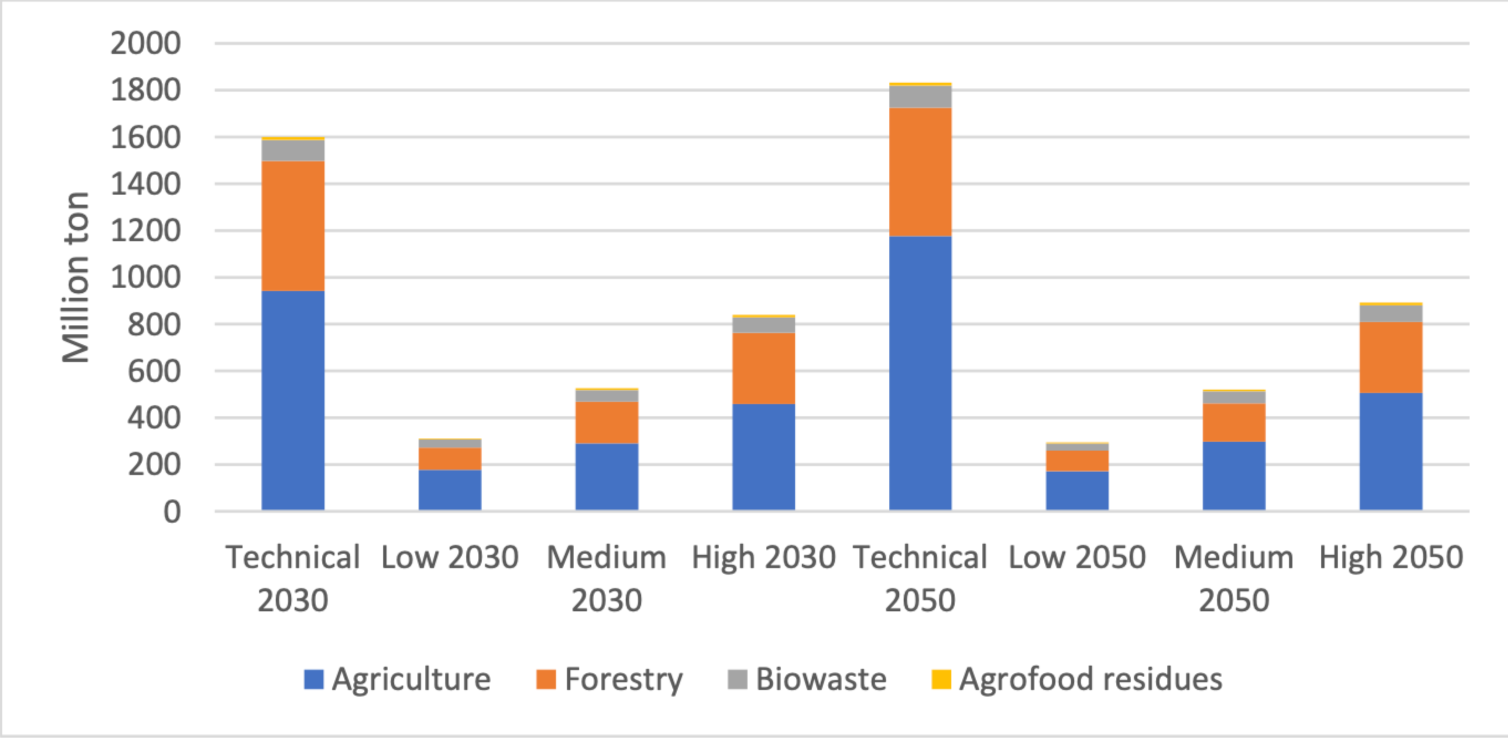


EEA Report No 02/2022. Transport and environment report 2021. Decarbonising road transport — the role of vehicles, fuels and transport demand

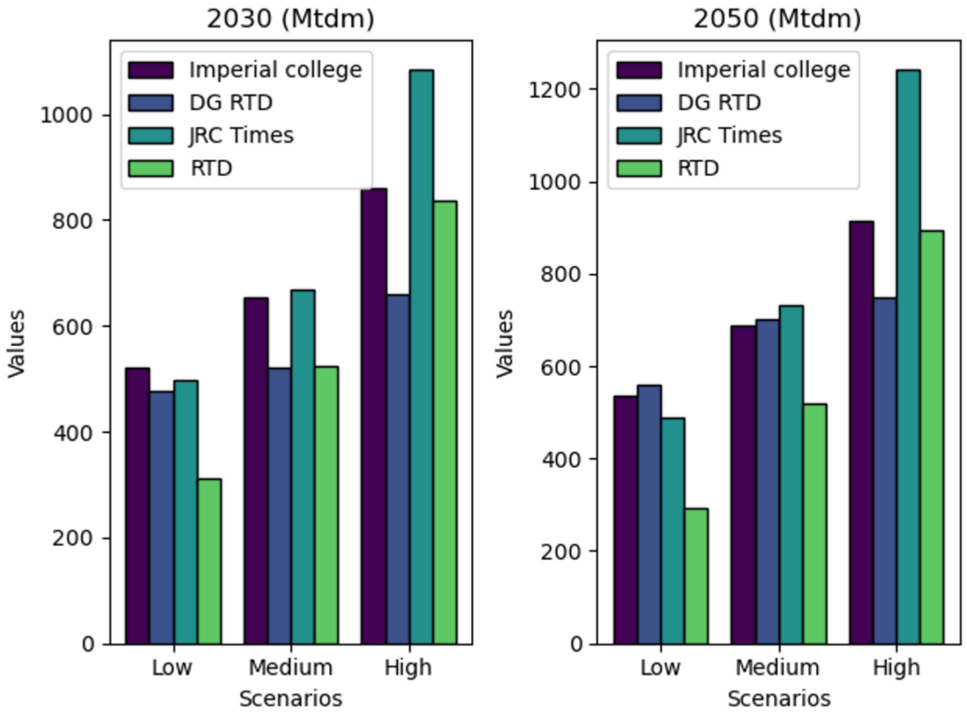
Modelling 2030 impacts under different scenarios



Biomass availability



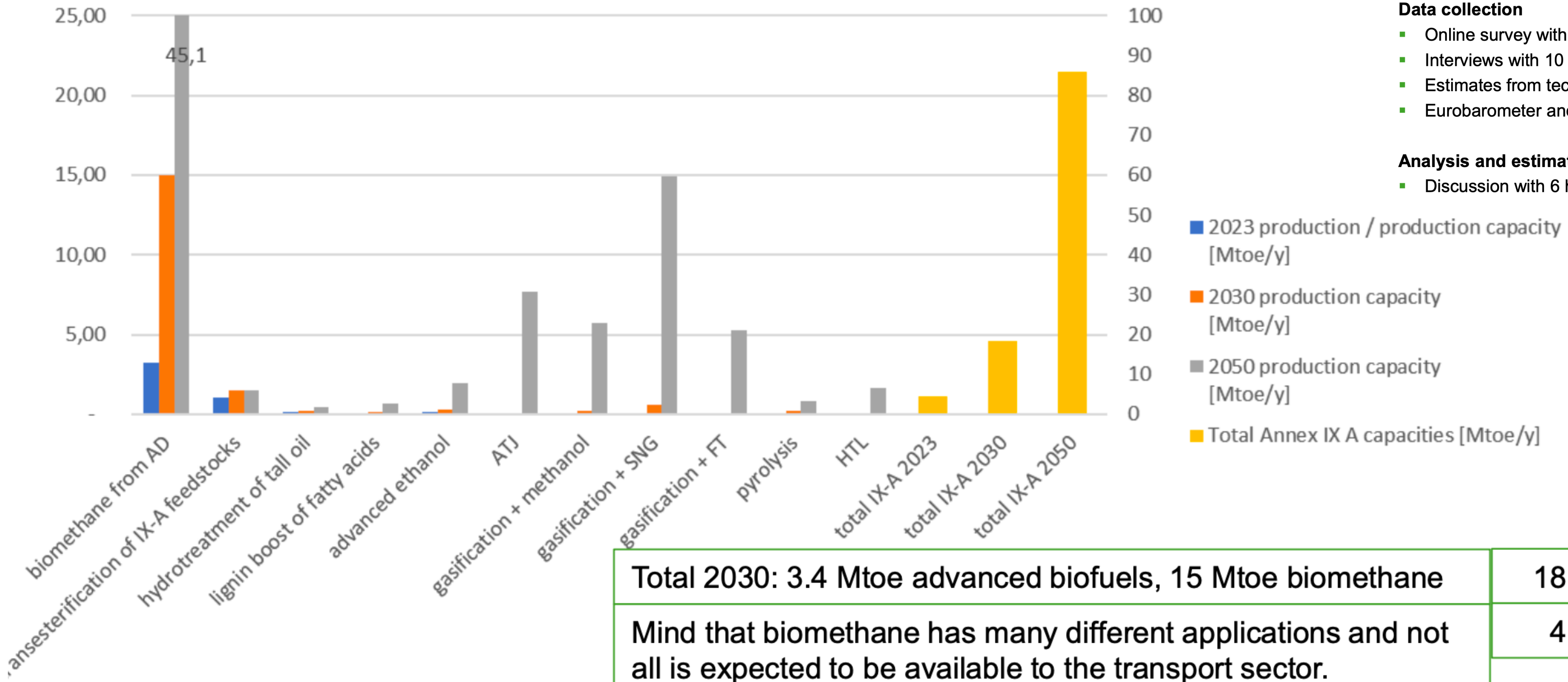
Annex IX/A, B biomass potential in technical, low, medium, and high potentials in 2030 and 2050 and distribution over sectors delivering biomass



Politecnico di Torino assessment of various studies

Current market conditions: industries' survey findings

Estimated evolution of biofuel and biomethane production capacities from Annex IX A feedstocks in Europe under current market conditions, converted to Mtoe/y



Current Market Conditions: Methodology

Data collection

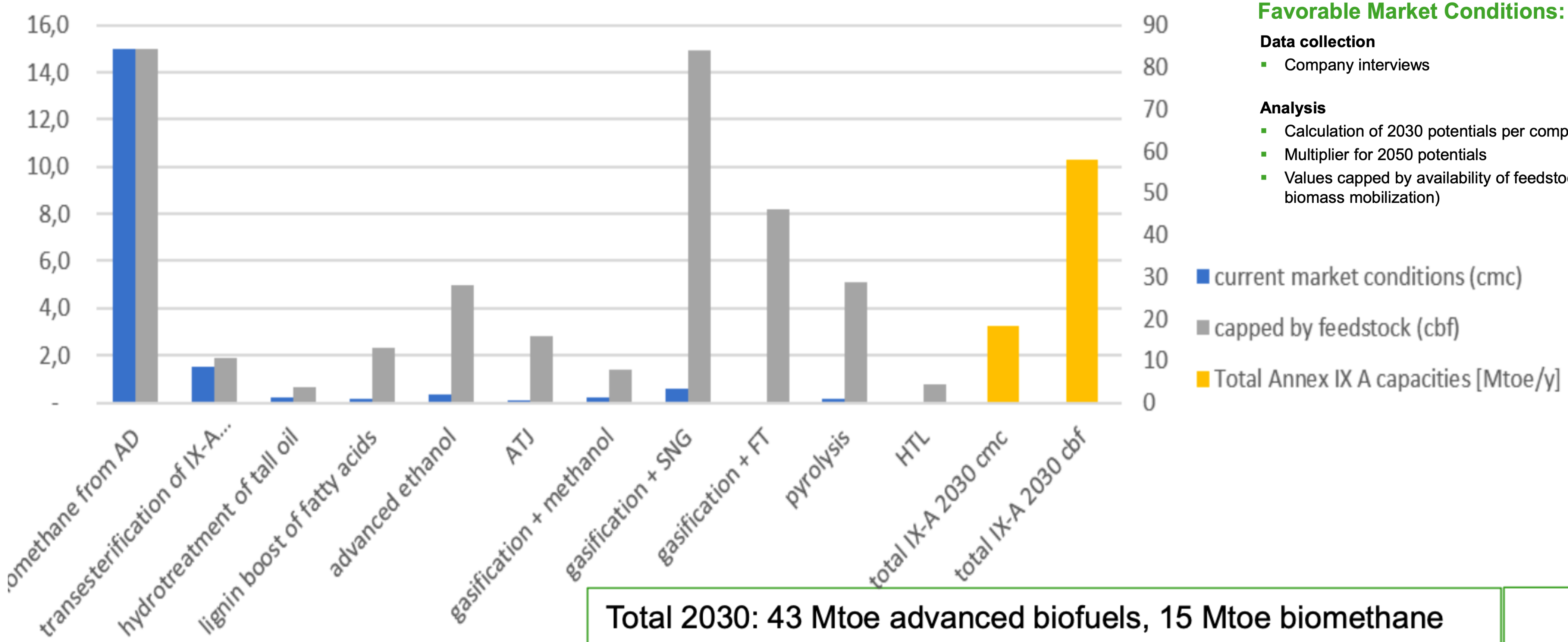
- Online survey with companies
- Interviews with 10 associations plus one big company
- Estimates from technology experts
- Eurobarometer and other public reports

Analysis and estimate

- Discussion with 6 high-level experts with a broad view on biofuels

Total 2030: 3.4 Mtoe advanced biofuels, 15 Mtoe biomethane	18.4 Mtoe
Mind that biomethane has many different applications and not all is expected to be available to the transport sector.	4.3 Mtoe

Current VS Favourable market conditions: findings



Favorable Market Conditions: Methodology

Data collection

- Company interviews

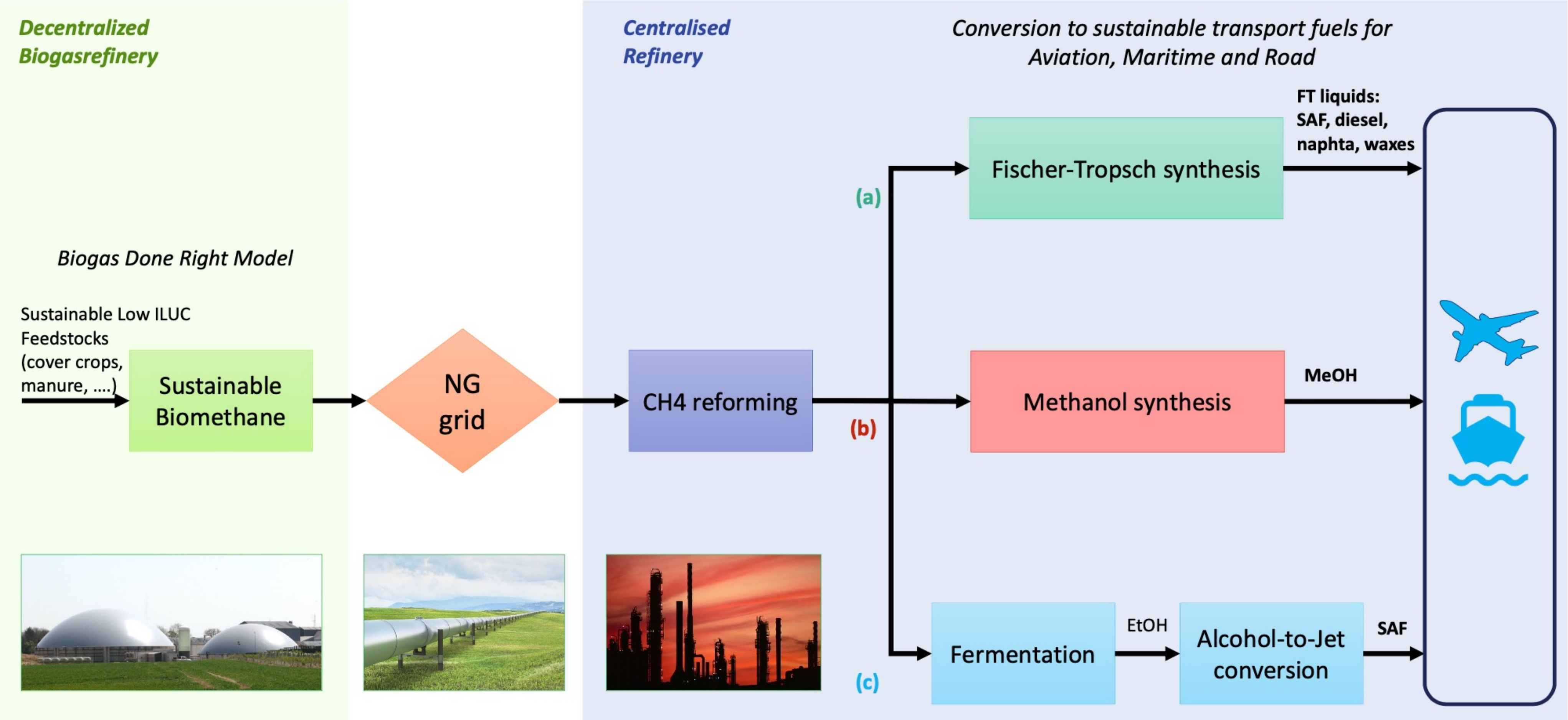
Analysis

- Calculation of 2030 potentials per company and per pathway
- Multiplier for 2050 potentials
- Values capped by availability of feedstock in Europe (Task 2 data for high biomass mobilization)

Total 2030: 43 Mtoe advanced biofuels, 15 Mtoe biomethane	58 Mtoe
Mind that biomethane has many different applications and not all is expected to be available to the transport sector.	30.3 Mtoe

Decentralised + Centralised schemes

Low-ILUC risk biofuels pathways: from Biomethane to liquid transport fuels



Assumptions for Potential estim.

EU-27 Biomethane (Gas4Climate)

- **38 bcm (2030)**
- **91 bmc (2050)**

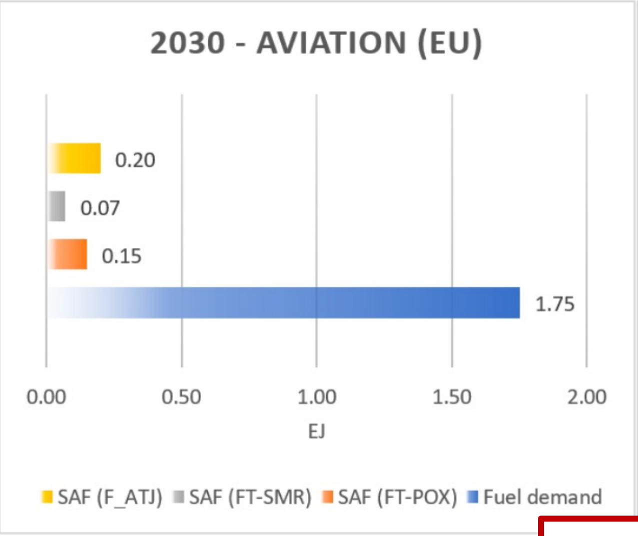
IT

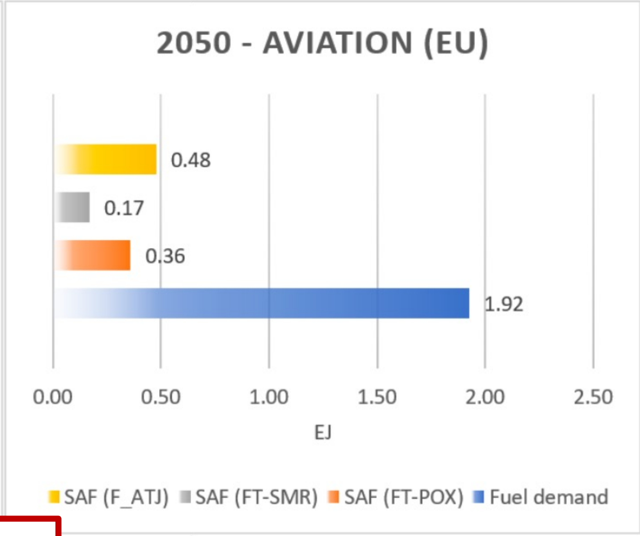
- **5.6 bcm (2030)**
- **8.2 bcm (2050)**

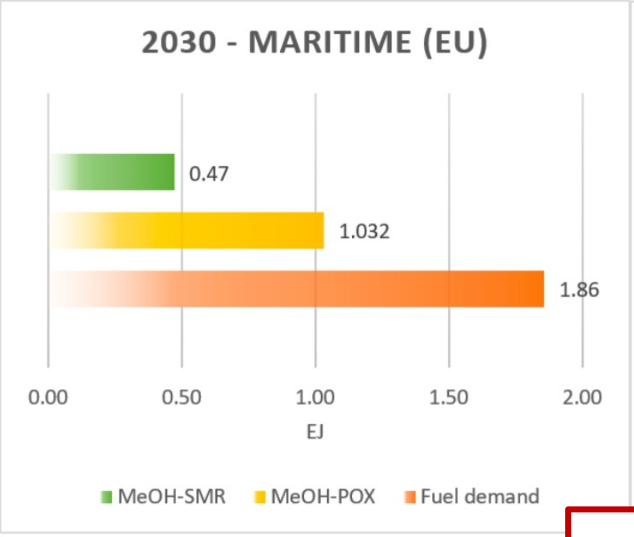
- **Decentralized bioenergy combined with infrastructure and conventional refining**
- **A win-win solution, deploying High-TRL demonstrated technologies.**

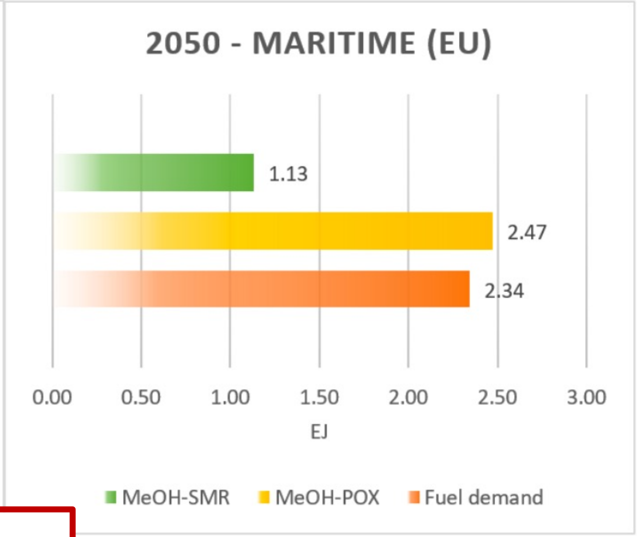
Contribution to EU/IT goals

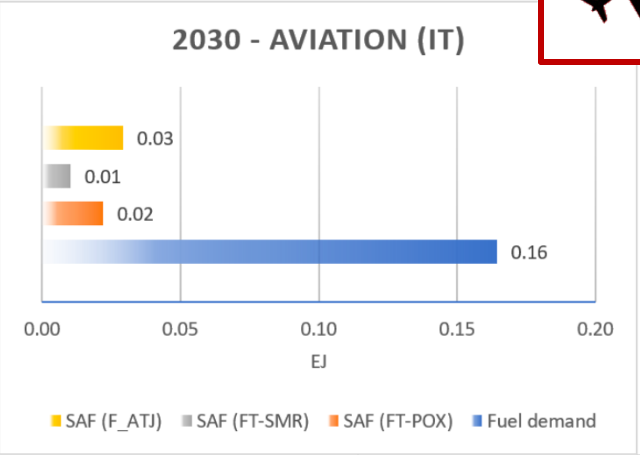
Assumptions for Potential estim. EU-27 Biomethane and IT (Gas4Climate) :
- **EU27: 38 bcm (2030), 91 bmc (2050)**
- **IT: 5.6 bcm (2030), 8.2 bcm (2050)**

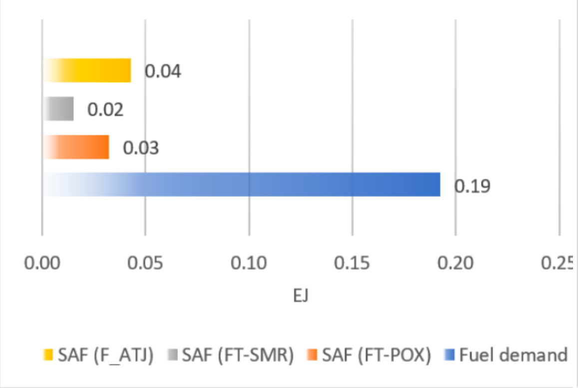


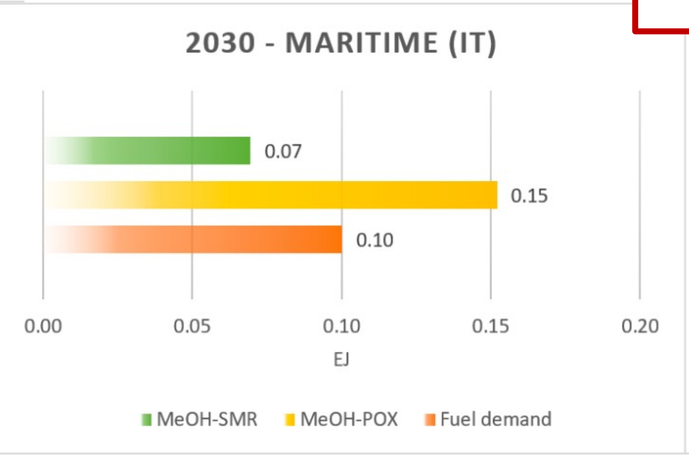


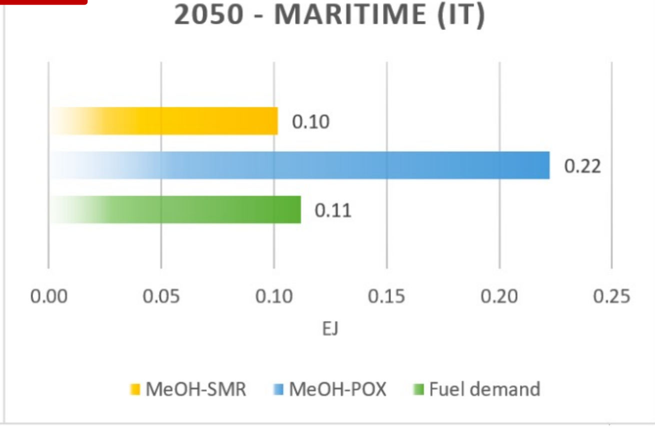












Contribution to EU/IT goals

		Fuels	H2
GTL-FT	**POX**	0.454	0
GTL-FT	**SMR**	0.207	0.666
GTL-MeOH	**POX**	0.682	0
GTL-MeOH	**SMR**	0.312	0.666
GTL-F_ATJ	**POX**	0	0
GTL-F_ATJ	**SMR**	0.188	0.660

Liquid Fuels and Hydrogen produced from each pathway (MJ/MJ$_{CH4}$)

		Nr of 1 MWe AD units per pathway	Potential contribution to EU Aviation 2030	Potential contribution to EU Maritime 2030	Potential contribution to IT Aviation 2030	Potential contribution to IT Maritime 2030
GTL-FT	**POX**	516	9%	-	13%	-
GTL-FT	**SMR**	1128	4%	-	6%	-
GTL-MeOH	**POX**	336	-	56%	-	152%
GTL-MeOH	**SMR**	735	-	25%	-	69%
GTL-F_ATJ	**POX**	-	-	-	-	-
GTL-F_ATJ	**SMR**	1126	11%	-	18%	-

EU on Carbon and Sust.Fuels: REDII - IR

(a) greenhouse gas emissions from the production and use of biofuels shall be calculated as:

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr},$$

where

E	=	total emissions from the use of the fuel;
e_{ec}	=	emissions from the extraction or cultivation of raw materials;
e_l	=	annualised emissions from carbon stock changes caused by land-use change;
e_p	=	emissions from processing;
e_{td}	=	emissions from transport and distribution;
e_u	=	emissions from the fuel in use;
e_{sca}	=	emission savings from soil carbon accumulation via improved agricultural management;
e_{ccs}	=	emission savings from CO_2 capture and geological storage; and
e_{ccr}	=	emission savings from CO_2 capture and replacement.

$$e_{sca} = (CS_A - CS_R) \times 3{,}664 \times 10^6 \times \frac{1}{n} \times \frac{1}{P} - e_f$$

27.6.2022 EN Official Journal of the European Union L 168/1

II

(Non-legislative acts)

REGULATIONS

COMMISSION IMPLEMENTING REGULATION (EU) 2022/996 of 14 June 2022

on rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land- use change-risk criteria

(1) Directive (EU) 2018/2001 expands the role of voluntary schemes to include the certification of the compliance of biomass fuels with sustainability and greenhouse gas (GHG) emissions saving criteria and the compliance of renewable liquid and gaseous transport fuels of non-biological origin and recycled carbon fuels with the respective GHG emissions saving criteria. Furthermore, the voluntary schemes can be used to certify biofuels, bioliquids and biomass fuels with low indirect land-use change-risk.

(2) In order to establish whether biofuels, bioliquids, biomass fuels, renewable gaseous and liquid transport fuels of non-biological origin and recycled carbon fuels comply with the requirements of Directive (EU) 2018/2001, the correct and harmonised functioning of voluntary schemes is essential. Harmonised rules should therefore be established, to apply across the certification system, bringing about the necessary legal certainty on the rules applicable to economic operators and voluntary schemes.

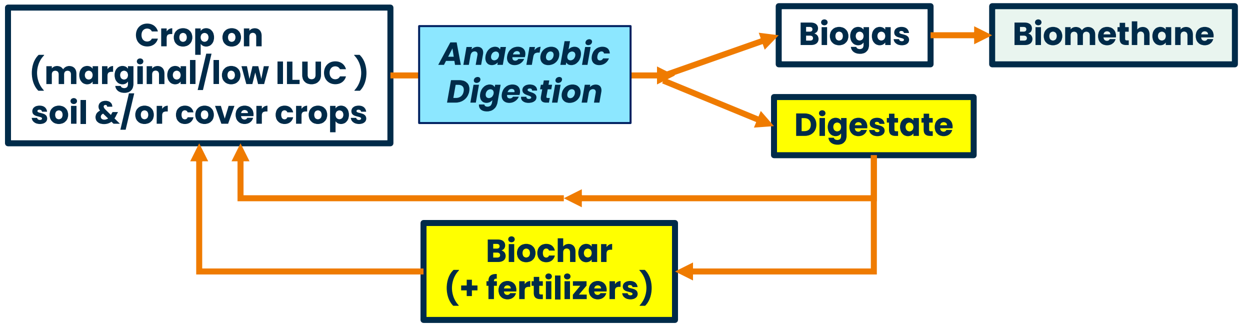
(3) With a view to minimising the administrative burden, the implementing rules should be proportionate and limited to what is required to ensure that compliance with the sustainability and GHG emissions saving criteria and other requirements is verified in an adequate and harmonised manner that minimises the risk of fraud to the greatest extent possible. The implementing rules should therefore not be considered as a comprehensive standard but rather as minimum requirements. The voluntary schemes may accordingly complement these rules as appropriate.

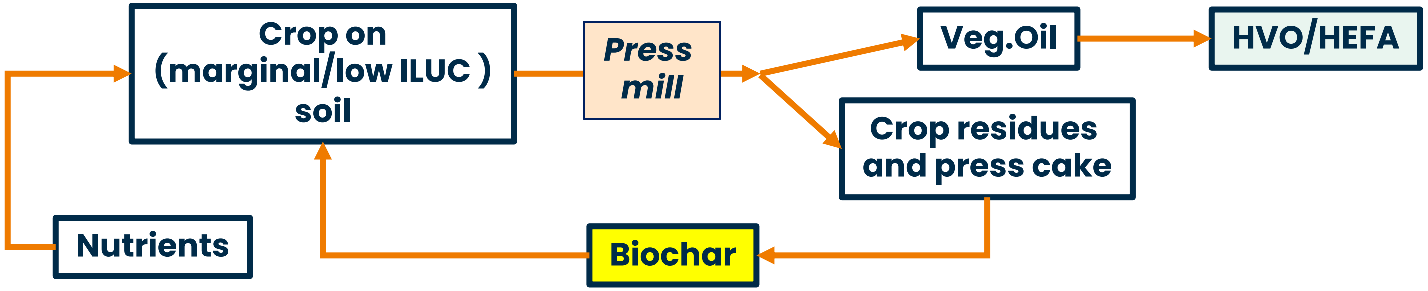
(4) Economic operators may decide at any time to participate in a different voluntary scheme. However, in order to prevent an economic operator that has failed an audit under one scheme from immediately applying for certification under another scheme, all schemes receiving an application from an economic operator should require that operator to supply information about whether it failed an audit in the previous 5 years. This should also apply to situations where the economic operator has a new legal personality but remains the same in substance, so that minor or purely formal changes, for instance, in the governance structure or the scope of activities, do not exempt the new economic operator from such a rule.

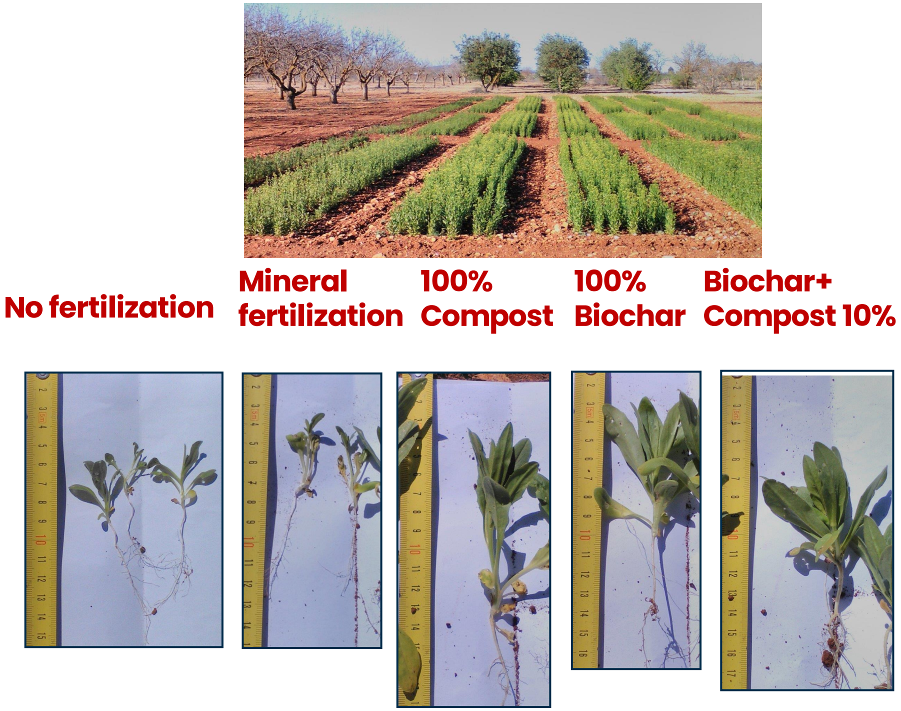
(1) OJ L 328, 21.12.2018, p. 82.

"Biofuels Done Right" can be Carbon Negative, support EU farming and even reverse ILUC,

- **Carbon NEUTRAL vs <u>Carbon NEGATIVE</u>: renewable BIOfuels can be C-Negative**
- **<u>Biogas Done Right</u> and <u>Digestate,</u> or <u>Pyrolysis</u> of residues to <u>Biochar</u> are some examples**
- **Fully deploying <u>REDII-IR</u> (<u>Esca</u> factor → C in soil in GHG assessment). Reverse ILUC?**







Bio4A

- **ICAO, 2017 → 142** Mt CAF at 2010 → 570-**860** Mt at 2050 (Intern. Aviation) + 400-600 % !!
- **100% CAF substitution (MAX scenario)** – **170 new biorefineries each year** from **2020 to 2050** (15-60 $B/y) –
- **MAX** would **reduce CO_2 emission by 63%**

LTAG Scenarios *(ICAO, March 2022)*

Key messages from ICAO

***None* of the scenarios *reach zero CO_2 emissions* (Net Zero) *using in-sector measures only*.**

***Offsetting* needed.**

† Caution required with the interpretation of absolute CO_2 emissions levels after 2050 due to modelling assumptions e.g., frozen aircraft technology after 2050. Under these assumptions, CO_2 emissions are higher than in an alternative scenario (and modelling approach) where aircraft technology would continue to improve after 2050.

Figure 1. CO_2 emissions from international aviation associated with LTAG Integrated Scenarios

- ***Aircraft Techn:*** *Advanced tube and wing, unconventional airframe/propulsion concept aircraft, non-drop-in fuels such as battery electric etc*
- ***Operations***: *improvements in the performance of flights across all phases*

Conclusions (1)

- Signifi**cant increase in biofuels** demand in transport **if** advancements in electric vehicle battery technology, alternative fuels infrastructure, electrolyzers, and direct air capture technologies **lag behind expectations** by 2030 (**LTD** scenario).
- If so, biofuel demand could rise by up to **2.5 times compared to 2021** levels (up to 42.8 Mtoe in 2030 compared to 16.5 Mtoe in 2021).
- Advanced biofuels will constitute about ~50% of all biofuel demand, translating to > 1/3rd of all renewable energy consumed in transport by 2030.

- **FEEDSTOCK POTENTIAL**: **310 to 836** million dry tonnes (132 - 353 Mtoe/yr) for **2030**, and **294 - 892** million tonnes (128 - 382 Mtoe/yr) for 2050.
- The largest potential in **AGRICULTURE**: primary residues from arable crops, manure and stemwood and primary forestry residues. 2050: dedicated lignocellulosic crops and oil crops on unused degraded lands and as cover & intercrop in combination with food production

Conclusions (2)

- **<u>INDUSTRY ASSESSMENT</u>**: capacity expansion for advanced biofuels and biomethane could reach **23.6 Mtoe/yr by 2030** satisfying demand of all other sectors in addition to transport.
- **Biomethane** is anticipated to be the most significant contributor, though there is uncertainty regarding its availability for transport and the fleet's readiness for high biomethane usage
- ADVANCED BIOFUELS: The present production capacity for advanced biofuels and biogas, standing at **4.6 Mtoe/yr**, is projected to potentially increase **sixfold**, reaching around **27.4 Mtoe/yr by 2030**.
- Potential synergied with RFNBO

- **<u>ENVIRONMENTAL & SOCIOECONOMIC IMPACTS</u>**: depending on scenario, avoided emissions by biofuels at 2030 could range from **70 to 126** MtCO2eq/yr (27 – 65 MtCO2eq/yr Ann.IX-A, 10 – 15 MtCO2eq/yr Ann.IX-B). By 2050, **> 151** MtCO2eq/yr.
- **> 53,000 new jobs** could be generated by **2030**, with the potential for this number to increase to **> 190,000 by 2050** in the central scenario, which would represent about **0.1% of the total EU jobs as of 2022.**

Conclusions (3)

- **Carbon Negative biofuels**: Biofuels are the only case of alternative fuels that can - already today, high TRL – be C negative, i.e. remove Carbon from the atmosphere.
- Not only: Carbon can be delivered to soil and other uses
- **Anaerobic Digestion and Biomethane** can be a champion in C-Negative chain, with Manure and Rotational/Cover crops.
- Deploying the environmental and economic value in Digestate is key!
- **Reverse ILUC Biofuels**: when this model is applied to dry marginal land, it can restore soil and support sustainable food production. It can be a reverse ILUC model.

Thanks for your attention

David Chiaramonti

Politecnico di Torino

david.chiaramonti@polito.it

Politecnico di Torino 1859

F4F Fit4Foresight FUEL