A pathway for EU deep-decarbonization from a technology perspective

A preview of the POTEnCIA CETO 2025 Scenario

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Agenda

- Methodology:
  - The POTEnCIA model
  - The POTEnCIA CETO 2025 scenario
- Scenario results:
  - Energy system overview
  - Selected technology pathways
- Discussion & conclusion

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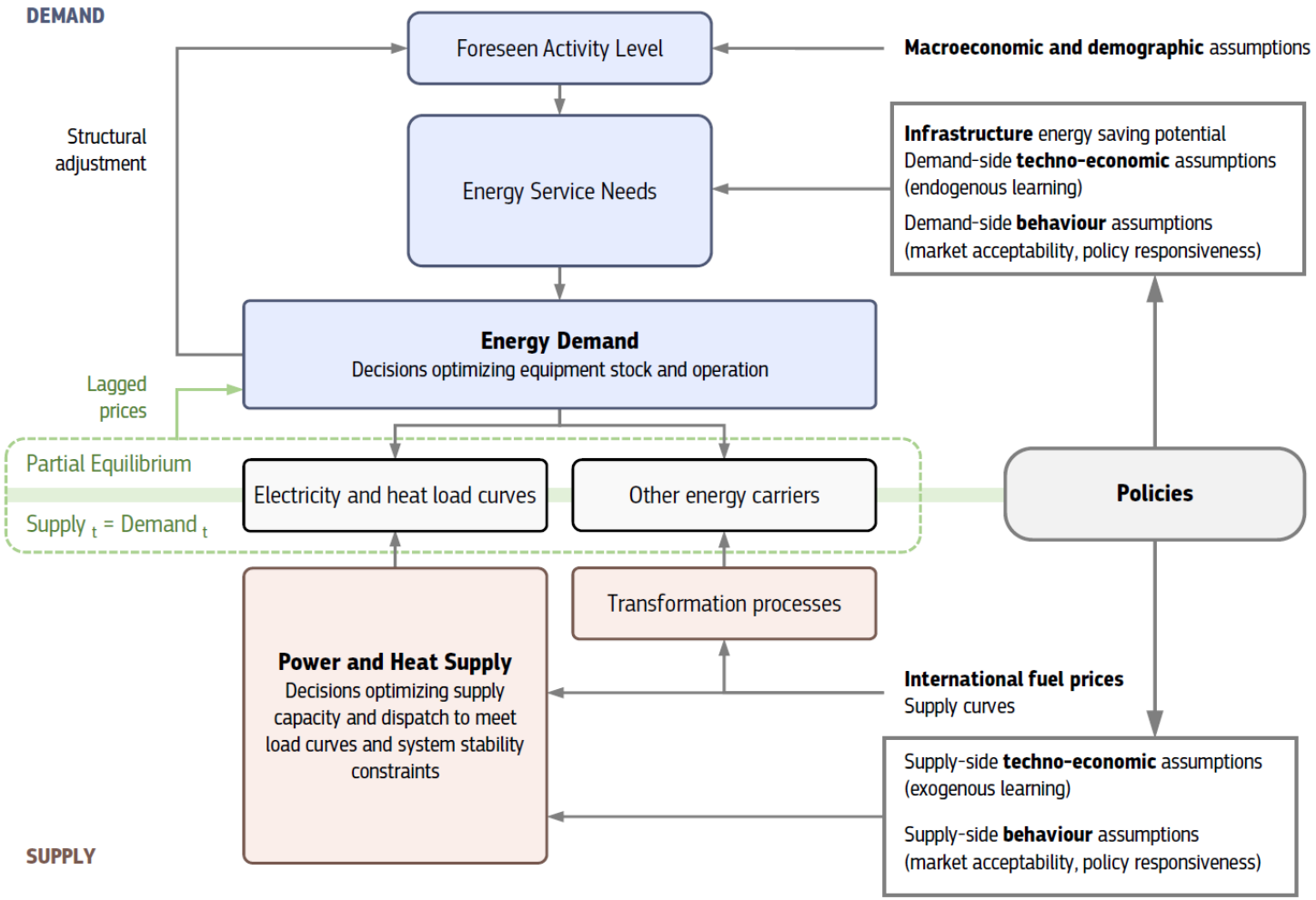
The POTEnCIA Model

- **JRC's in-house developed** "Policy Oriented Tool for Energy and Climate Change Impact Assessment"
- **Hybrid partial equilibrium** model of the EU energy system
- **Resolution:**
  - **Individual Member States**
  - **Yearly time steps**, up to 2070
  - **Hourly electricity dispatching** throughout the whole year
- **Historical data calibration based on JRC-IDEES[1]**

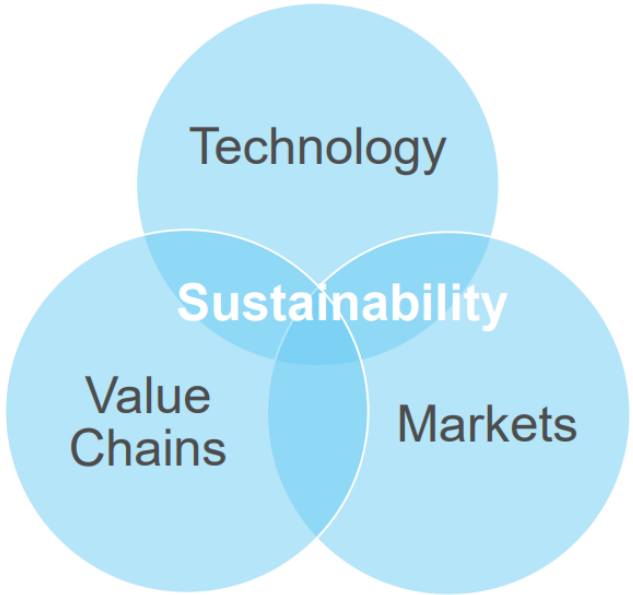


[1] JRC-IDEES : The JRC Integrated Database of the European Energy System

The Clean Energy Technology Observatory - CETO

- **Stakeholders:** CETO, the Clean Energy Technology Observatory[1], is a collaboration between the JRC, DG RTD, and DG ENER
- **Objective:** Monitoring the status of EU clean energy technologies across value chains, markets, and their future prospects
- **Output:** Publication of annual technology reports (e.g. electrolysers, photovoltaics, heat pumps)
- **Interaction with POTEnCIA:** Technology insights used as input for scenario development to then provide scenario projections of future technology deployment in the EU

→ Dedicated, technology-driven POTEnCIA CETO 2025 Scenario[2]



[1] More info on CETO and the technology reports can be found on the CETO Website ; [2] Displaying on the bottom right the POTEnCIA CETO 2024 scenario report

The POTEnCIA CETO 2025 Scenario

- Calibrated to **IDEES23**
- Inclusion of latest **NECP targets**
- **Technology assumptions** based on:
  - **CETO research**
  - **EC communication on a 2040 climate target (CT2040)** and its Impact Assessment
- **Policy framework:**
  - GHG emissions **aligned with ECL** and the **2040 proposed target**
  - High detail modelling of **relevant policy framework** (such as ETS & ETS2, ESR, EED, RED III, CO2 emission standards for new vehicles, FuelEU Maritime, ReFuelEU Aviation,…)

Figure 2. EU emission targets in the *POTEnCIA CETO 2025 Scenario*

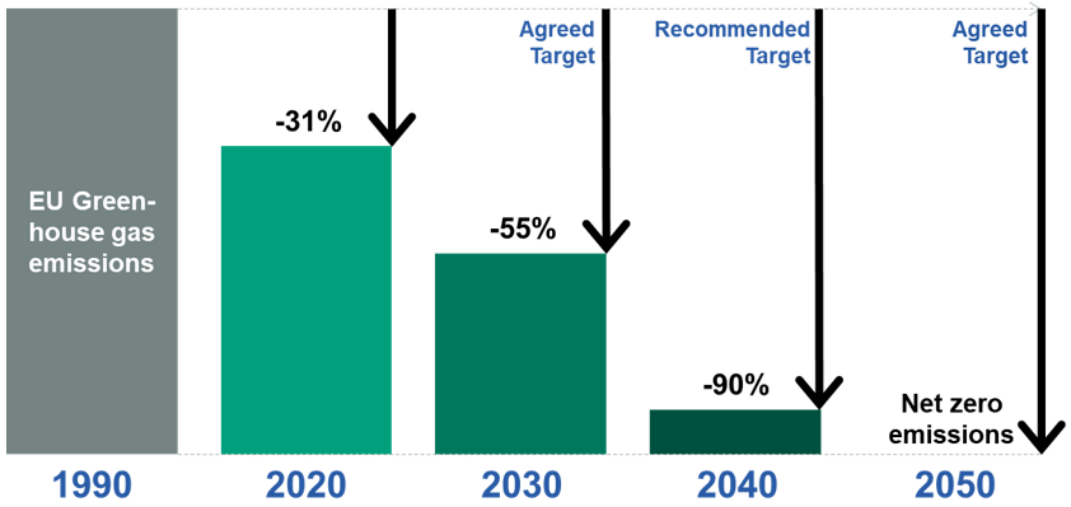


Table 1. CO_2 Emission Standards for New Vehicles

VEHICLE TYPE	2025-2029	2030-2034	2035-2039	2040- ONWARDS
CARS	-25%	-55%	-100%	-100%
LIGHT COMMERCIAL VEHICLES	-17%	-50%	-100%	-100%
HEAVY-DUTY VEHICLES[4]	-15%	-45%	-65%	-90%

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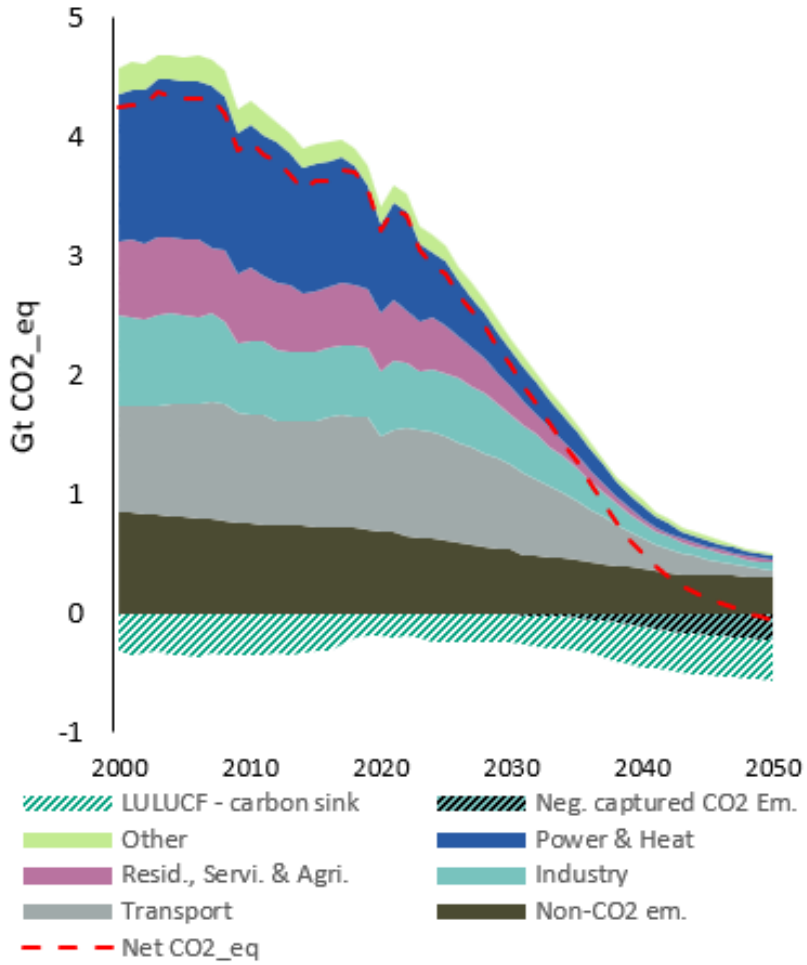
EU Emissions

- **Decarbonization** needs to:
  - Accelerate in end demand sectors
  - Continue with same trend for power & heat
- By 2050, **residual emissions** remain in
  - Aviation & maritime
  - Most industries
  - Agriculture (esp. non-CO_2)
- Those are **off-set by carbon removals**, primarily from BECCS application

Figure 7. EU emissions overview[13]



[13]Other includes emissions from petroleum refineries, primary energy production sectors, other energy branches (incl. blast furnaces), fugitive emissions from fuels, and waste management; Transport emissions include 50% of Extra-EEA international navigation emissions following the methodology of the MRV maritime regulations and Intra-EEAwUK aviation emissions; Industry includes emissions from energy transformation and auto-consumption in blast furnaces; Neg. CO2 emissions include equivalent negative CO2 emissions due to biogenic carbon being stored in chemicals and biochar sequestration

Energy consumption

- **Energy consumption decreases** rapidly from 1023 Mtoe in 2023 to 710 in 2050 due to **energy efficiency measures**, especially in industry & transport
- **Electrification** across all sectors
- **Fossil fuel decrease** from 67% to 16%
- **Clean fuels** emerge and grow with H2 often in direct competition to biofuels

Figure 16. Energy consumption by demand sector[20]

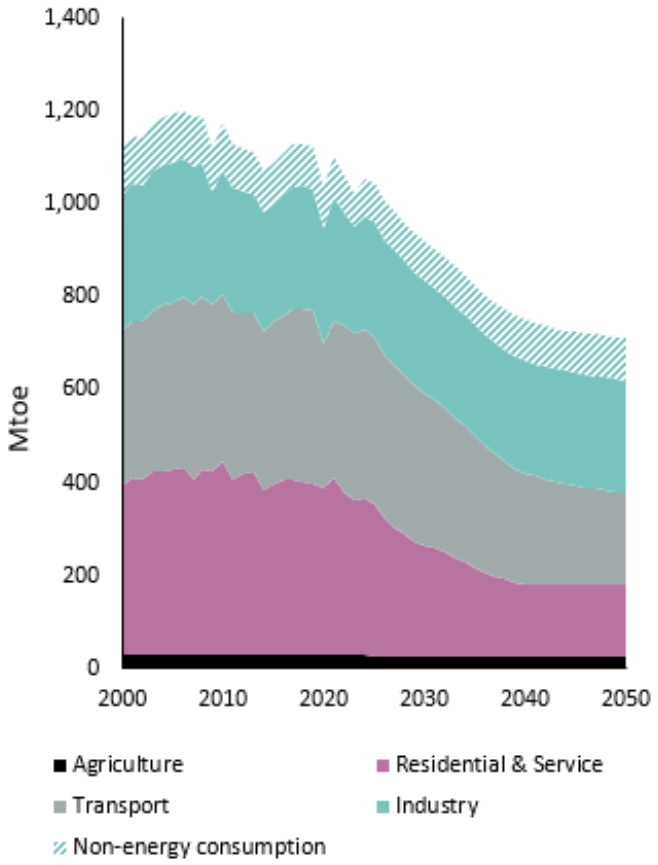
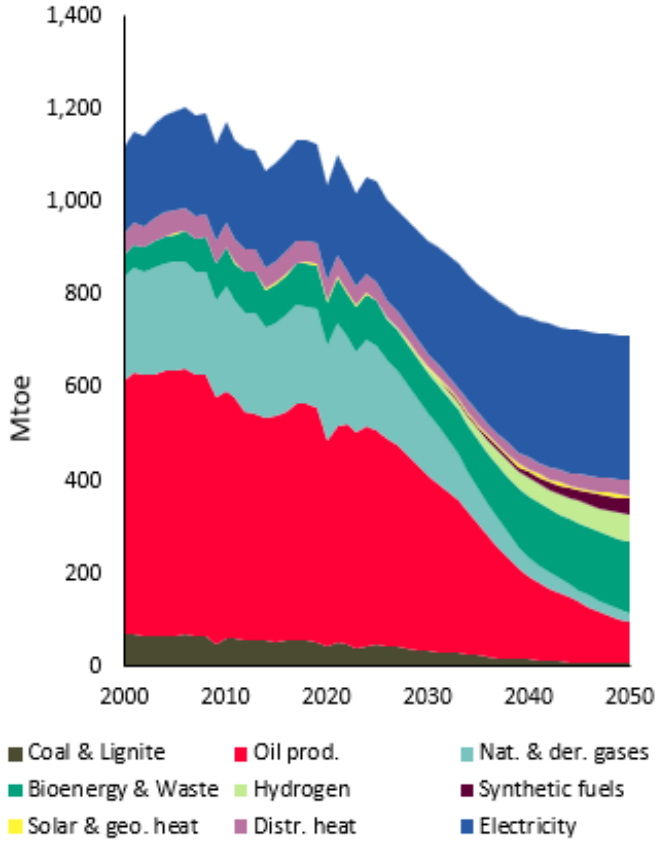


Figure 17. Energy consumption by fuel[21]



[20] Energy consumption in this visualization includes FEC, energy demand of marine bunkers, which is attributed to transport, and transformation losses and auto-consumption of blast furnaces, which are attributed to Industry and final non-energy consumption (FNEC)

[21] Fuel consumption in this visualization includes FEC, final non-energy consumption (FNEC), energy demand of marine bunkers, and energy demand for transformation losses and auto-consumption of blast furnaces

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Power sector – Generation and Demand

- **Electricity demand** more than **doubles by 2050** driven esp. by industry, road transport, and H2 production
- **Electricity supply:**
  - **VRE-share grows** from 28% to 79%
  - **Nuclear remains important** (esp. due to NECPs targets)
  - **Coal almost phased out** in 2030
  - **Natural gas** remains but **with CCS**

Figure 77. Electricity demand by sector[68]

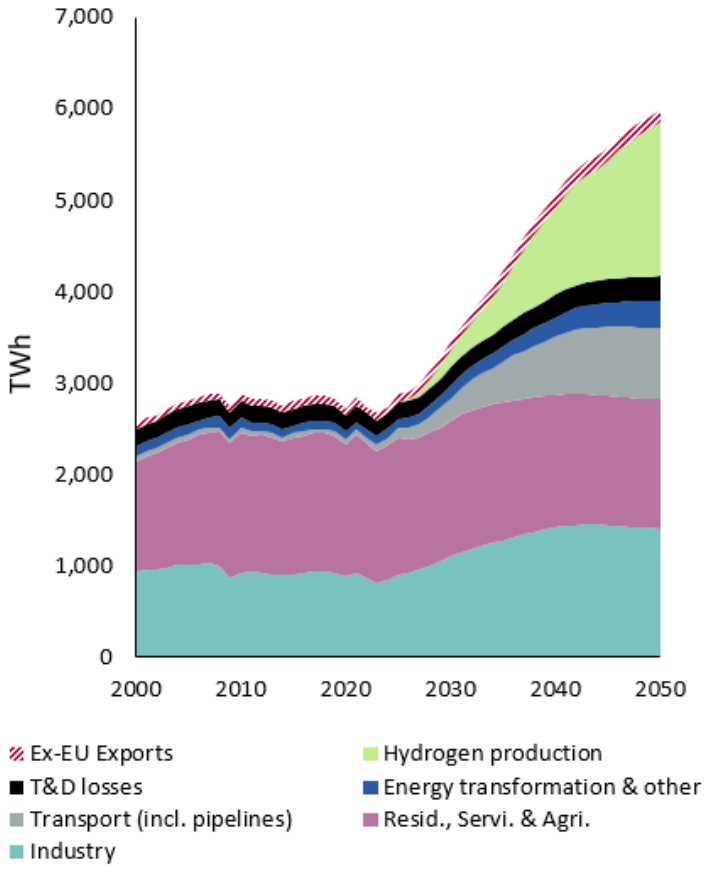
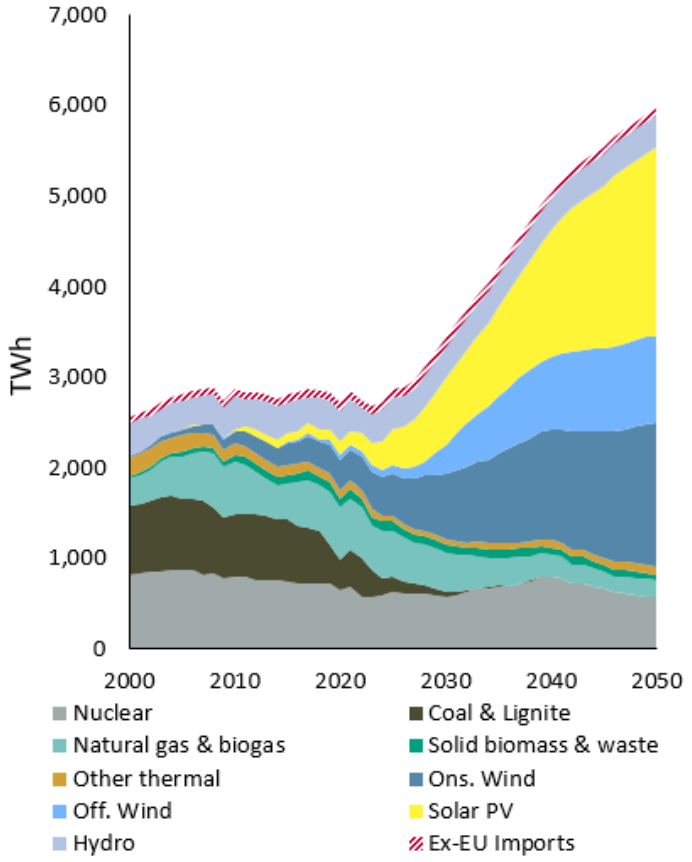


Figure 78. Net electricity generation by technology[69]



[68] Energy transformation & other includes amongst other refineries, storage losses, CO2 capture and storage, synthetic fuel processing, and others

[69] Hydro includes run-of-river and hydro dams, and tide, wave, and ocean, but excludes hydro pump storage; Other thermal includes derived gas, refinery gas, diesel oil, fuel oil, solar thermal, and geothermal

Power sector – Flexibility

- **Storage and flexibility measures** needed due to intermittent VRE:
  - **Batteries become dominant storage technology** reaching 64% of stored energy generation by 2040
  - **Flexible electrolysers** reach almost 30% of total electricity demand
  - **Flexible BEV charging** provides significant grid flexibility
  - **H2 for power** primarily used for **seasonal storage**

Figure 79. Power generation from storage units

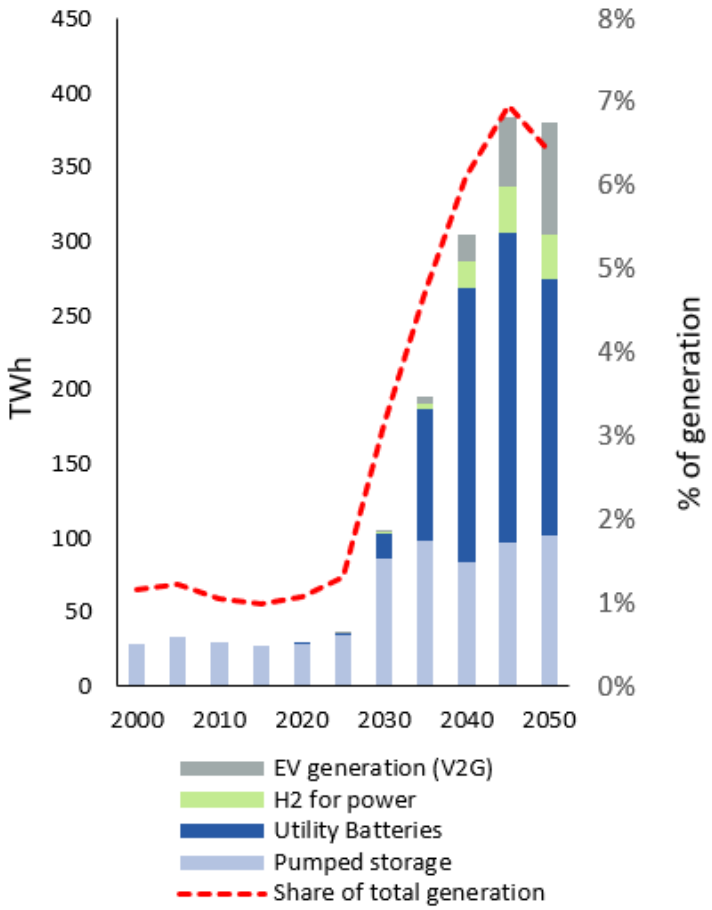
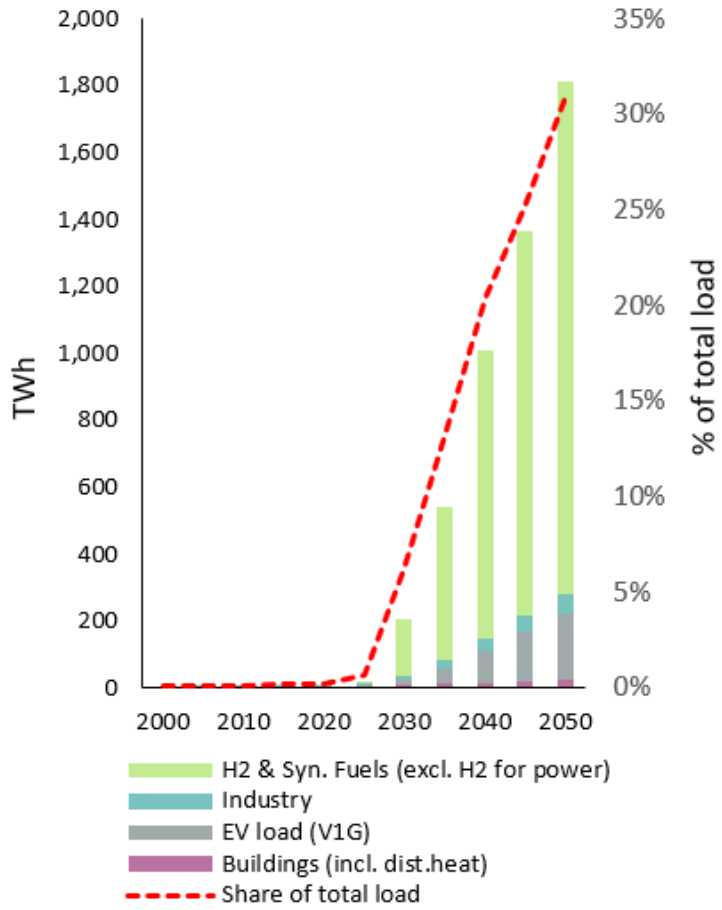


Figure 80. Flexible demand by sector[71]



[71] "H2 & synthetic fuels" excludes off-grid electrolyzers, because these do not allow for grid flexibility, and hydrogen produced for use in the power sector, because the hydrogen is not produced for a demand sector

Hydrogen

- **Strongly supported by NECPs and EU policies** (esp. RED III, FuelEU Maritime, ReFuelEU Aviation, AFIR)
- Reaching an ambitious **3.5 Mt H2 production in 2030** wit early demand coming from chemicals, I&S, and first synthetic fuels*
- Reaching **39 Mt H2 in 2050** destined for various industry and transport sectors, directly and indirectly via synthetic fuels

Figure 85. Green Hydrogen sources

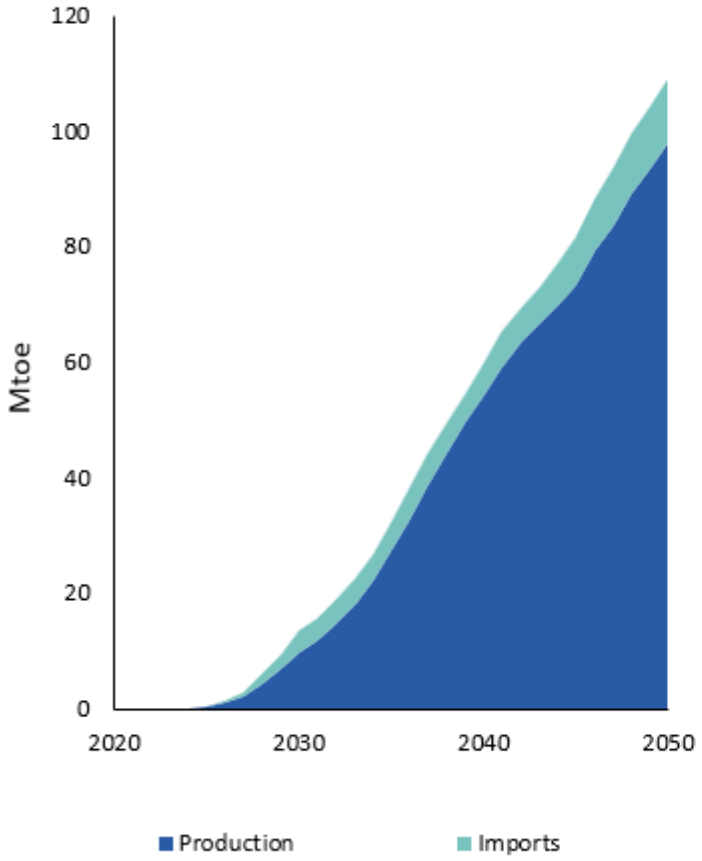
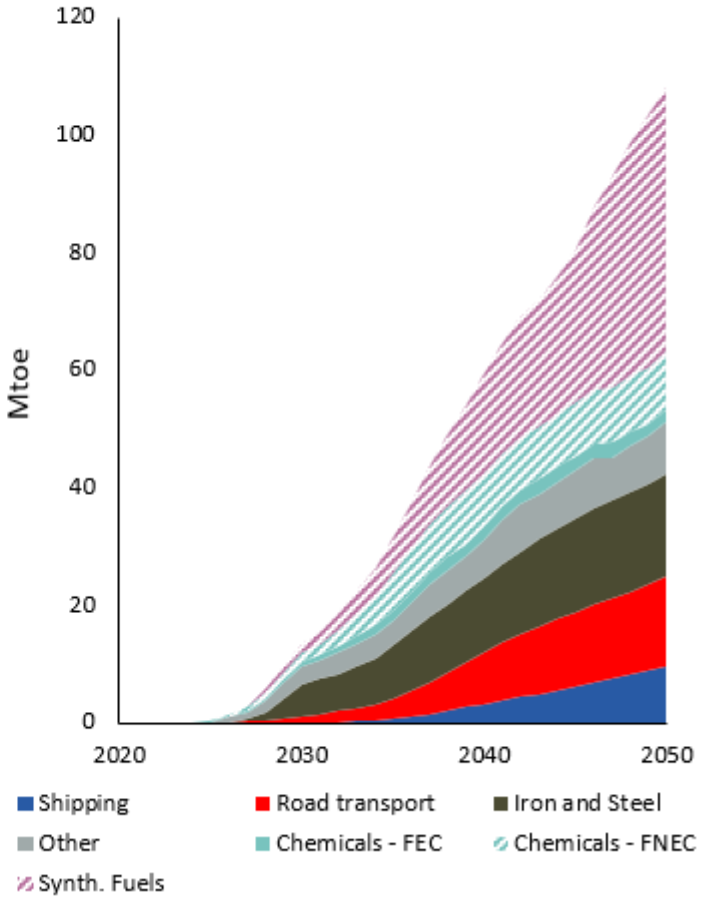


Figure 86. Green Hydrogen demand by sector[78]



71 "H2 & synthetic fuels" excludes off-grid electrolyzers, because these do not allow for grid flexibility, and hydrogen produced for use in the power sector, because the hydrogen is not produced for a demand sector

* Many NECPs have sector-specific or overarching high H2 production targets

Carbon Capture Utilization and Storage

- **Early growth in industry** (especially non-metallic minerals and chemicals) reaching **~50 Mt CO_2 in 2030**
- **By 2050, >400 Mt CO_2** are captured, 36% from industry, 33% from power & heat
- **DAC emerges in 2030s** reaching 14% capture share by 2050
- **Most CO2 stored underground**, but starting from 2030s increasing shares used for synthetic fuel production

Figure 94. Captured CO_2 by sector of origin

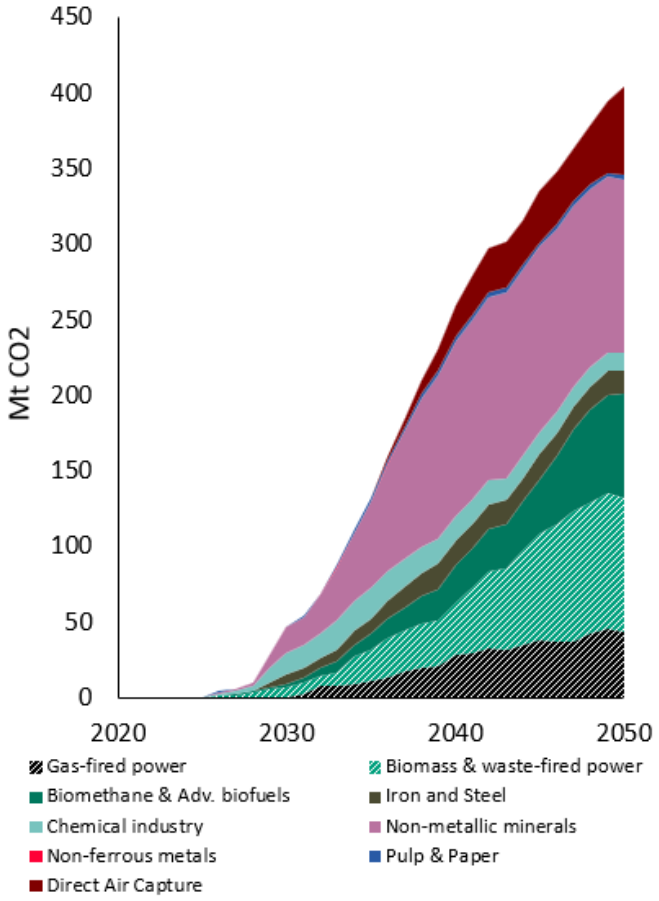
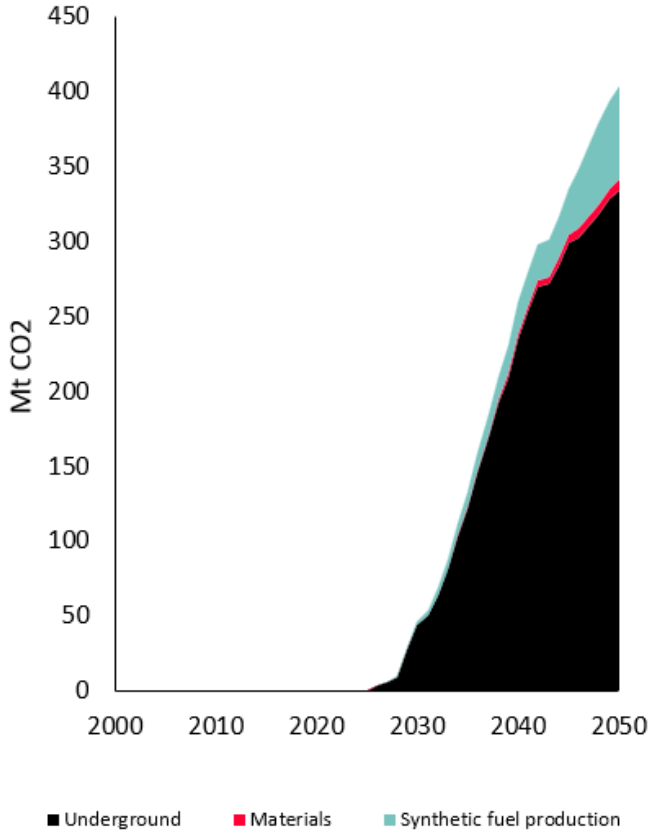


Figure 95. Captured CO_2 by type of storage & use



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Conclusion

The **POTEnCIA CETO 2025 Scenario**:

- is **technology-driven** using the insights of the CETO initiative
- explores a **pathway for deep-decarbonization** aligned with European Climate Law
- shows how **energy efficiency measures and electrification** lead to a 38% reduction in final energy consumption
- specifies the **critical role of clean energy technologies** (CCUS, electrolysers, biofuels, etc.)

→ *The POTEnCIA CETO 2025 Scenario report will be published in the coming month*

Thank you

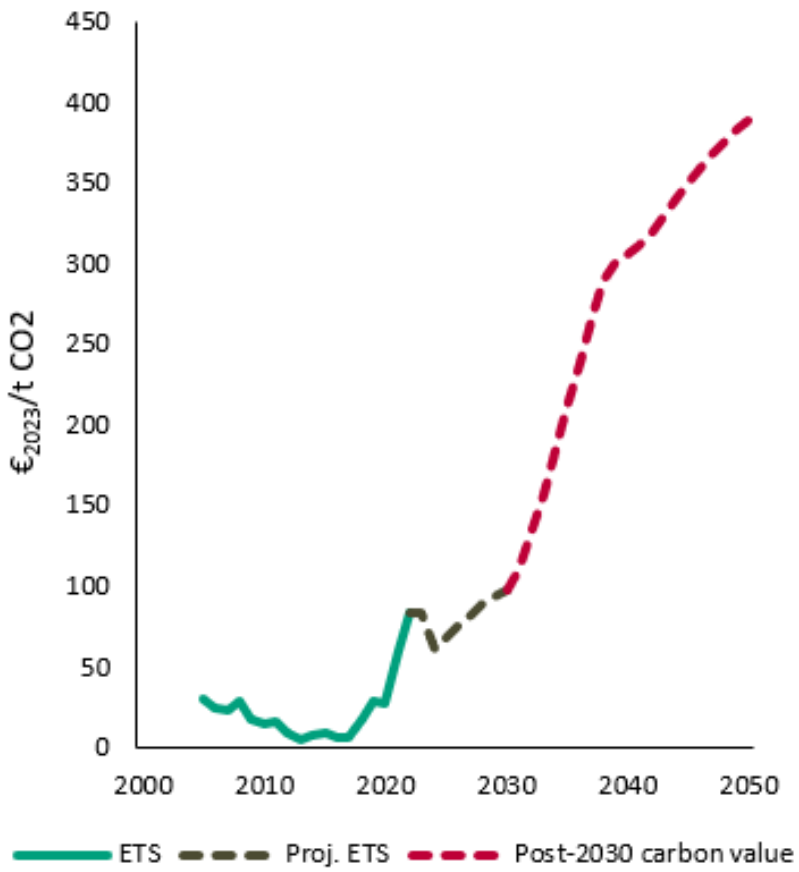
Contact: JRC-C6-JRC-IDEES@ec.europa.eu

A pathway for EU deep-decarbonization from a technology perspective

ETS price and carbon value

- ETS price to recover and further rise to **98 €/t by 2030**
- After 2030, a **universal carbon price** is applied to all sector
- Reaching **>300 €/t by 2040** due to progressively tightening emission constraint
- Afterwards, **slower further decrease** towards 2050

Figure 9. EU ETS price & carbon value



Synthetic fuels

- **xxx**

Figure 87. Synthetic fuel production by type

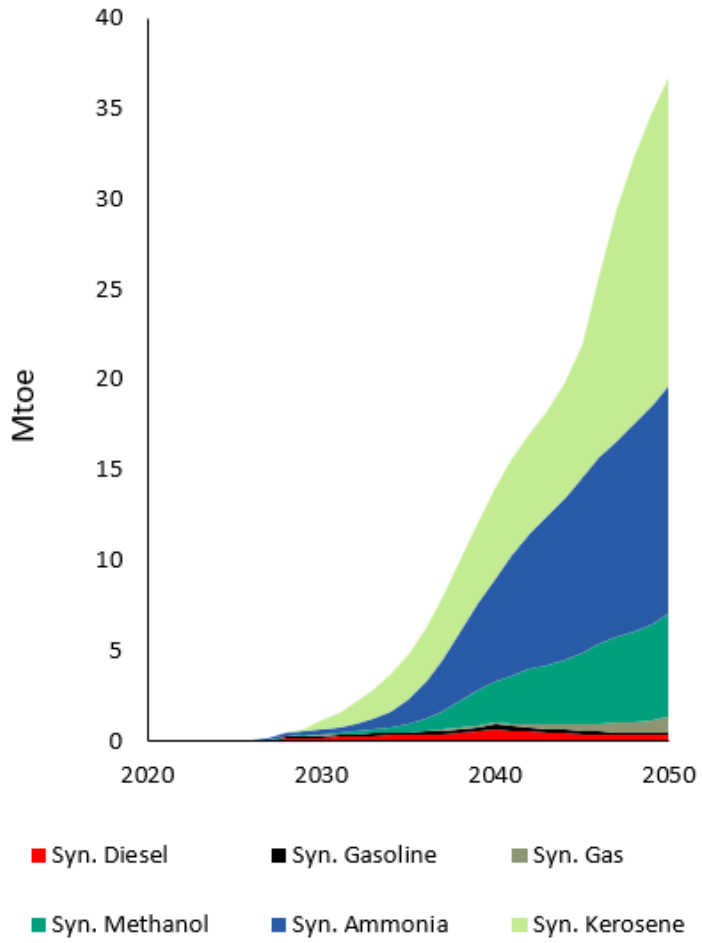
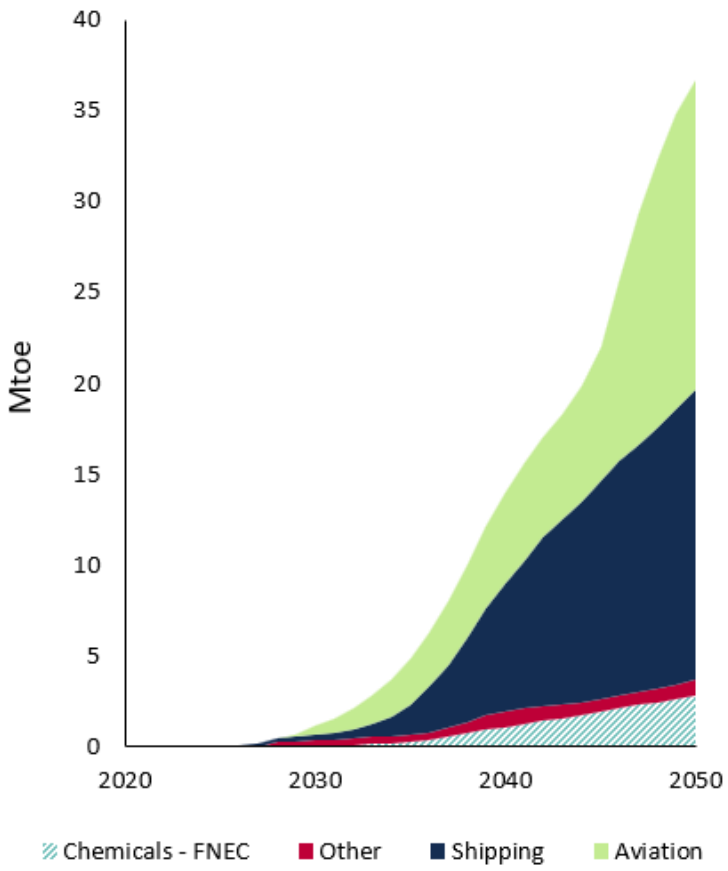


Figure 88. Synthetic fuel demand by sector[80]



Biofuels

- **xxx**

Figure 89. Biofuel consumption by type

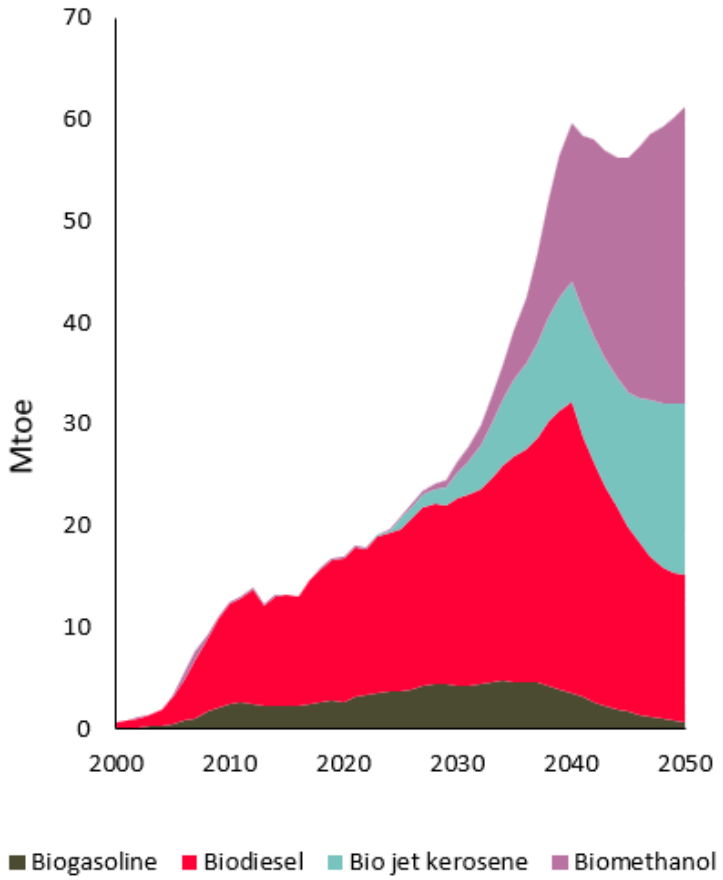
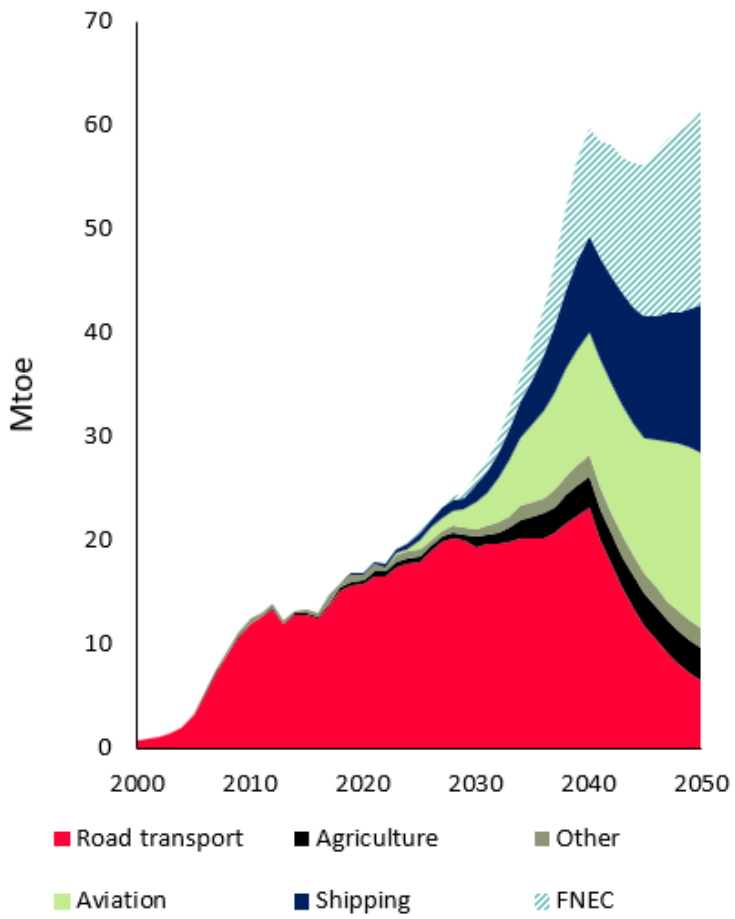


Figure 90. Biofuel consumption by sector[81]



Industry

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Figure 19. GHG emissions for the industry sector[24]

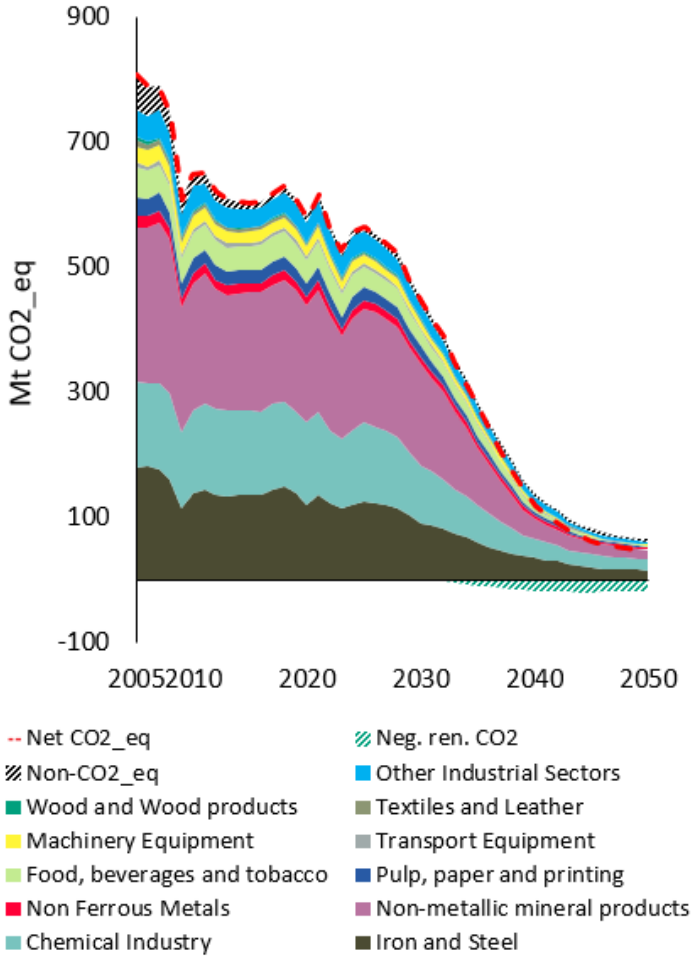
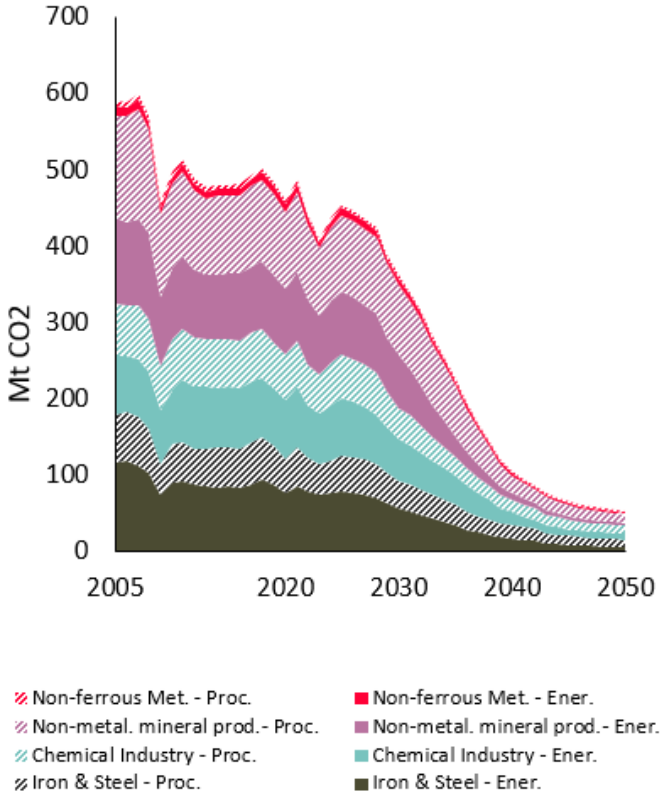


Figure 20. Energy & process emissions for selected energy-intensive industries[25]



Transport

Figure 41. Emissions in the transport sector

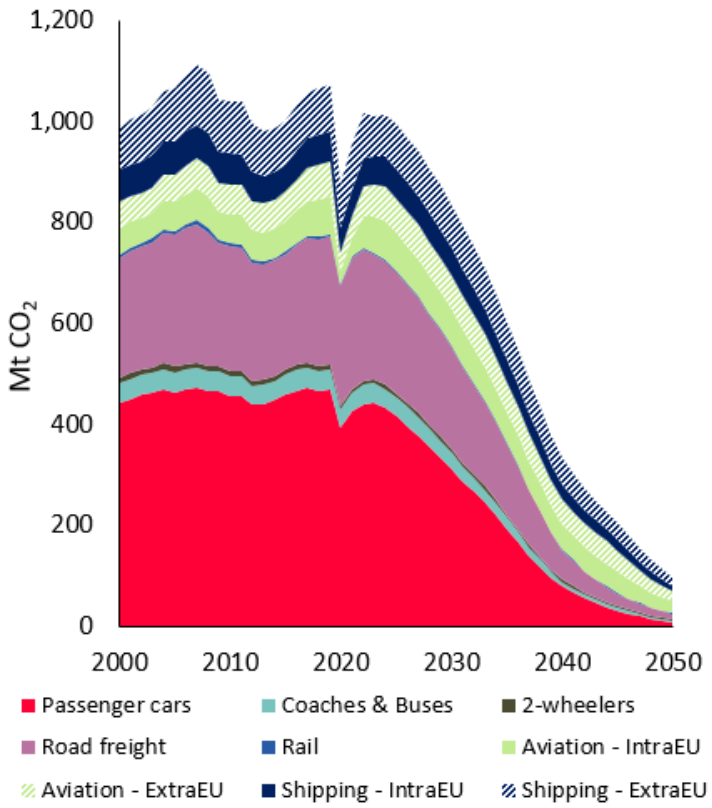


Figure 46. Energy demand in transport by sector[46]

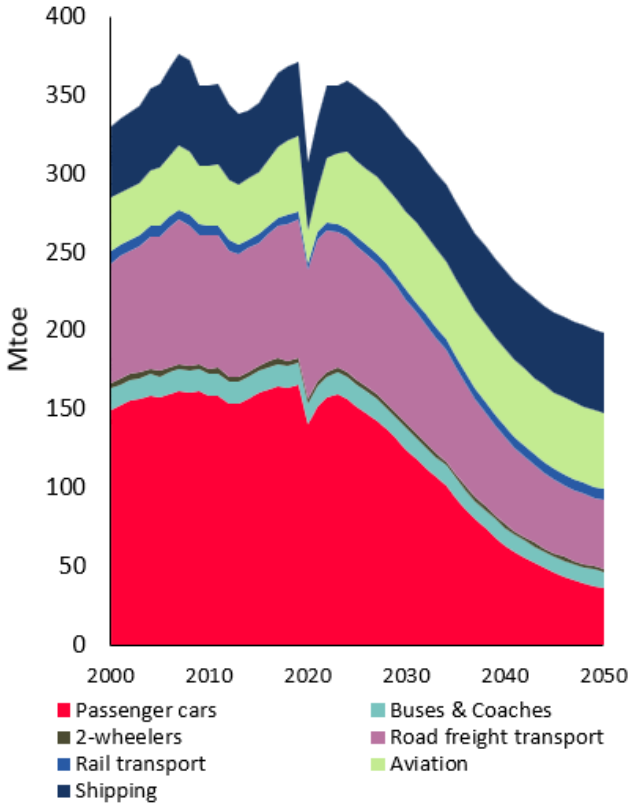
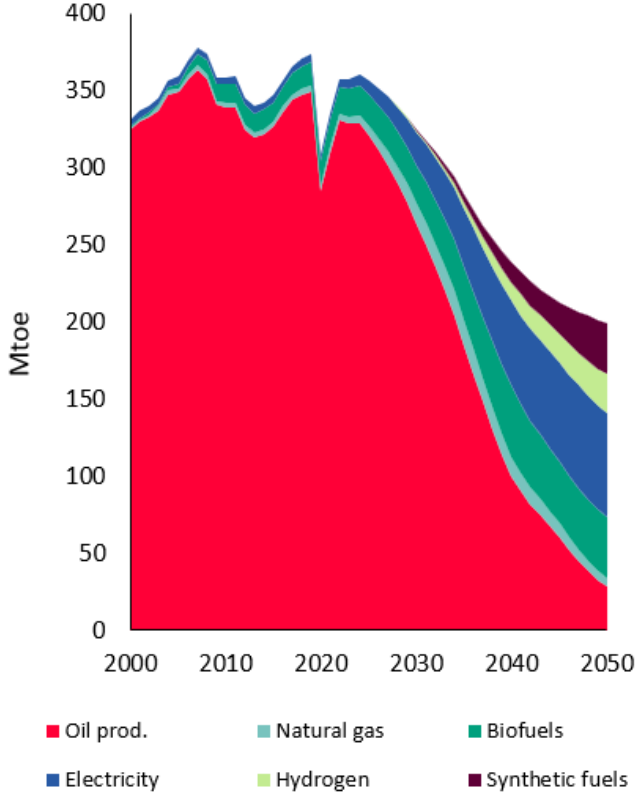


Figure 47. Energy demand in transport by fuel[46]



Buildings

Figure 69. Net emissions in residential and services sectors[61]

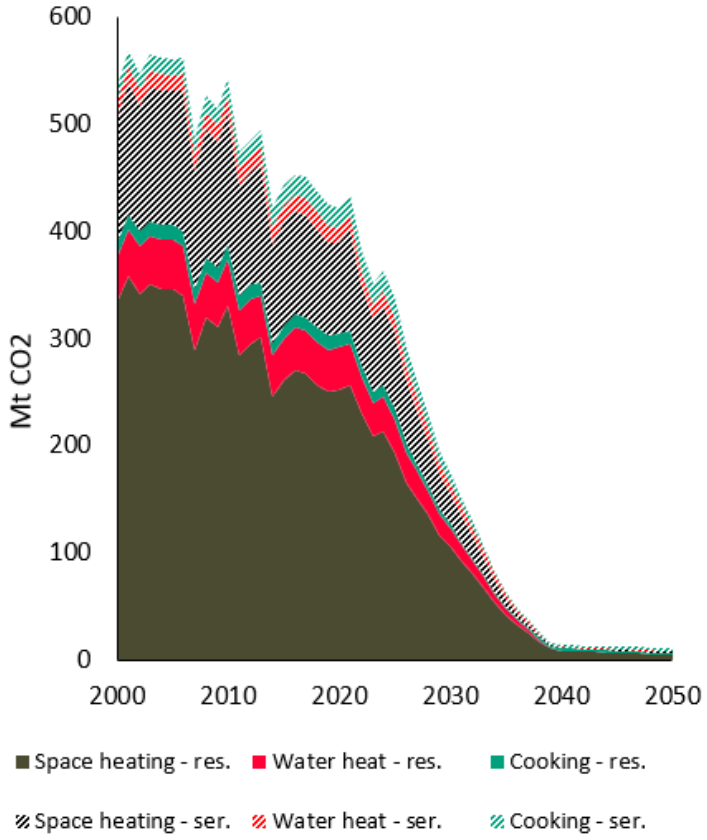


Figure 67. FEC in residential and services sectors by energy service type[59]

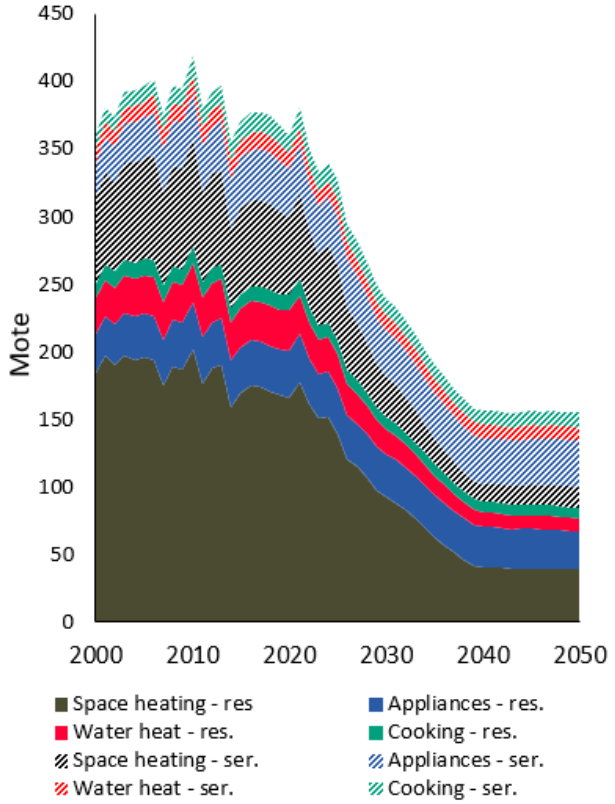


Figure 68. FEC in residential and services sectors by fuel[60]