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“Energie per un futuro sostenibile”

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Matera, *Palazzo Viceconte*

PRESENTATION BY

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World Energy Outlook Within “Energy Transition to NZE”

Key approaches, choices, issues, and questions about scenarios for fast pathways to NZE 2050

Adnan Shihab-Eldin

“Energies for a Sustainable Future”

25 February 2022

Palazzo Viceconte, Matera, Italy

General Observations

drivers of (short, medium and long term) energy outlooks

Global Energy Scene & Energy Transition to NZE

- **Today**, global energy scene is undergoing a major **Transition of Structural nature, referred** to: **"Energy Transition", (ET),** in terms of primary energy share, demand, supply, trade, sources, resources, etc.
- **The direction of the transition is clear**: towards less energy related GHG emissions, leading to an aspirational target of **NZ GHG emission** by, or soon after, 2050, **limiting avg. rise T to < 1.5 C**
- **The ET** is driven by several factors: economic growth, resources, technology, **but increasingly environmental policies**
- ET is characterised by **heightened uncertainties, especially following the COVID19 Pandemic, with increased volatility & disruptions going forward,**

These stem from uncertainties:

- **Global economic growth:** following a sharp decline **in 2020**, on account of COVID19, with growth returning **in 2021 @ 5.2% and** level of global GDP in 2022 expected to be modestly > 2019
- **Availability of & Access to resources: there are abundant resources**, but huge overall investment is required, **while investments per unit of new capacity decreasing:**
- **Q: will investments recover, in Non-Re following COVID19?**
- **Affordability (Price of Supply)**? With **price volatility increasing** as tensions and threat of economic and political **instability** within exporting countries rises, & **lower investments** from **lower for longer prices –**
- **But Climate Policies are leading cause now related to commitment, following COP26, & rational enabling policies to speed up the GET**

Uniqueness of the unfolding transition

- Unlike the past shifts, the unfolding transition does NOT have to take place because of:
  - resource shortages (fossil fuels remain abundant)
  - economic reasons (dominant conversions are affordable); or
  - technical imperatives (many conversions are highly efficient and reliable)
- Past transitions have MOVED UP:
  - higher energy density wood 17 MJ/kg; coal 22-3(MJ/kg; oil 42 MJ/kg
  - higher power density biomass < 1 W/m^2; fossil fuels 10^2-10^4 W/m^2
  - easier storage and transportation
- The unfolding ET MOVES DOWN:
  - lower energy density (biomass vs. fossil fuels);
  - lower power density ;
  - lack of mass-scale distance transmission

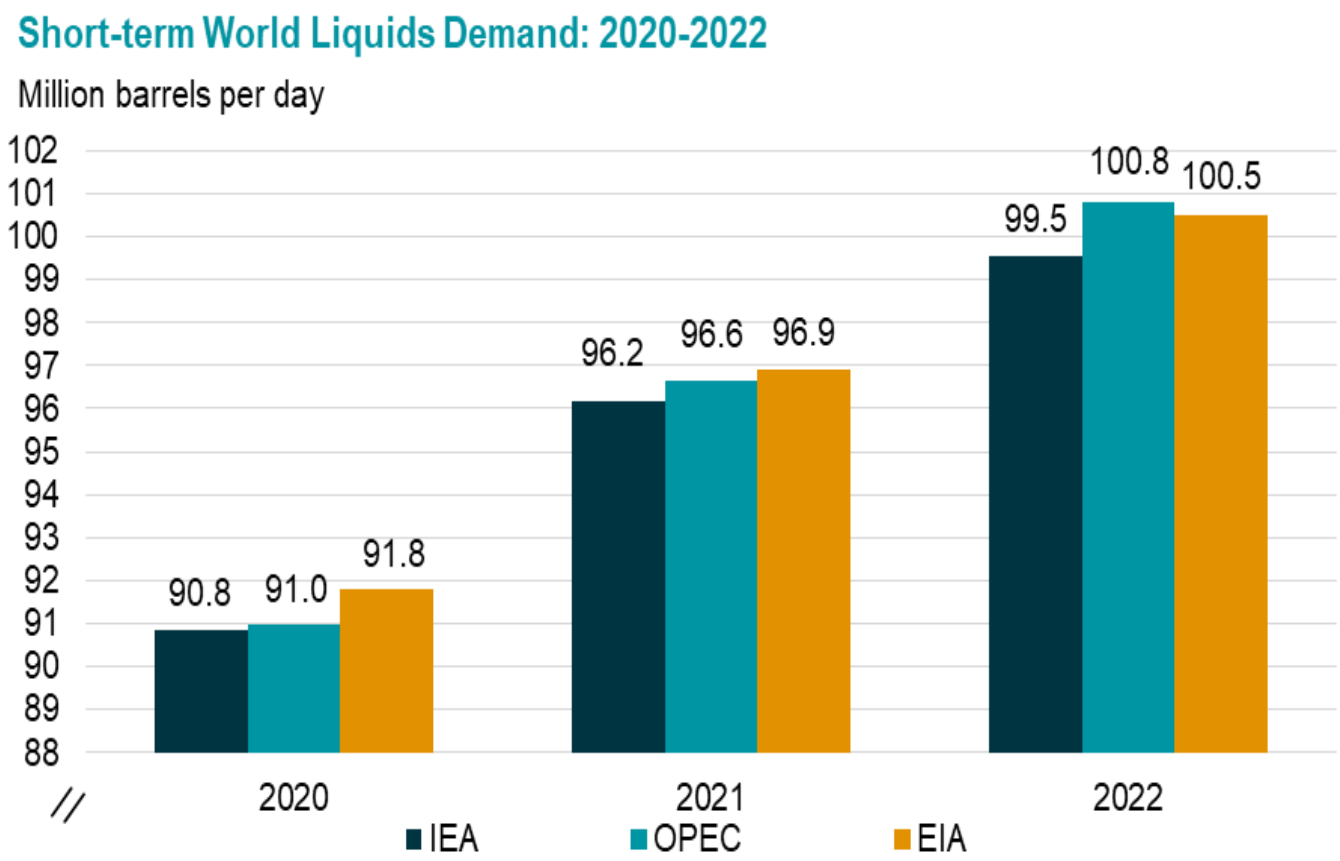
- Driver of resource & technology:
  - Supply side now less of a concern as a result of increased sources & resources (shale fossil resources, Renewable, EV, etc.)
  - but demand side uncertainty also decreasing!
  - Rising concerns now relate to stability of domestic supply network (e.g. grid power) & infrastructure (Terror threat)

Accelerated transition is needed in order to avoid excessive global warming and hence the only measure of success is global

Short-term global demand projections of IEA, OPEC, and EIA (2020-2022) are similar, with minor differences

- Rapid recovery of global energy demand, back to 2019 levels, following sharp drop and in GDP early 2020 due to onset of COVID19 pandemic

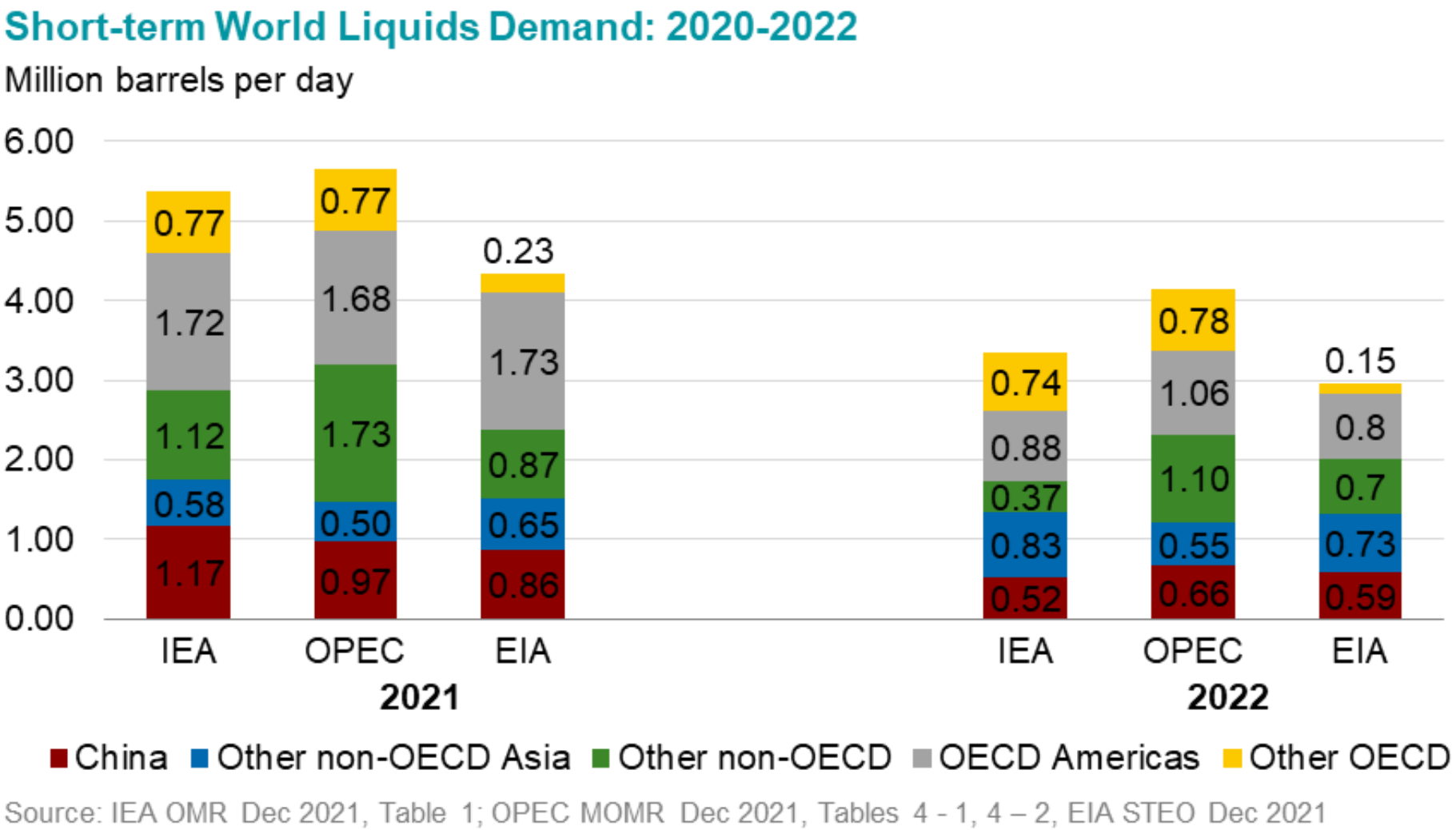
- **Minor differences in IEA's & OPEC's projections, reflecting definitions, components and methodology**



Source: IEF, IEA OMR Dec 2021, OPEC MOMR Dec 2021, and EIA STEO Dec 2021
Notes: 2020 are historical data and 2021/2022 are projections. Sums in data callouts may not total due to rounding.

Source: IEF- rff- comparison report 2022

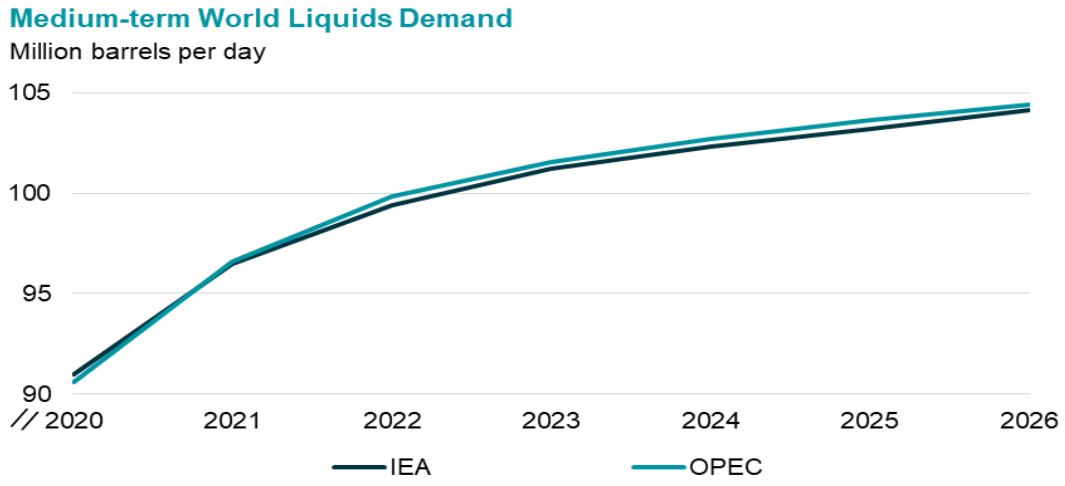
Short-term global demand growth comparison, by region, for IEA, OPEC, and EIA



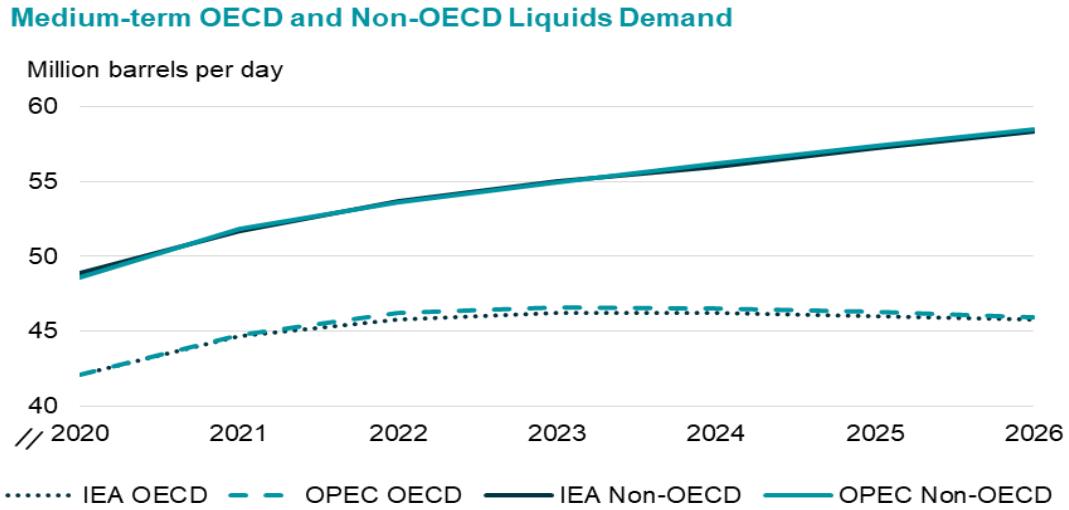
Source: IEA OMR Dec 2021, Table 1; OPEC MOMR Dec 2021, Tables 4 - 1, 4 – 2, EIA STEO Dec 2021

Source: IEF- rff- comparison report 2022

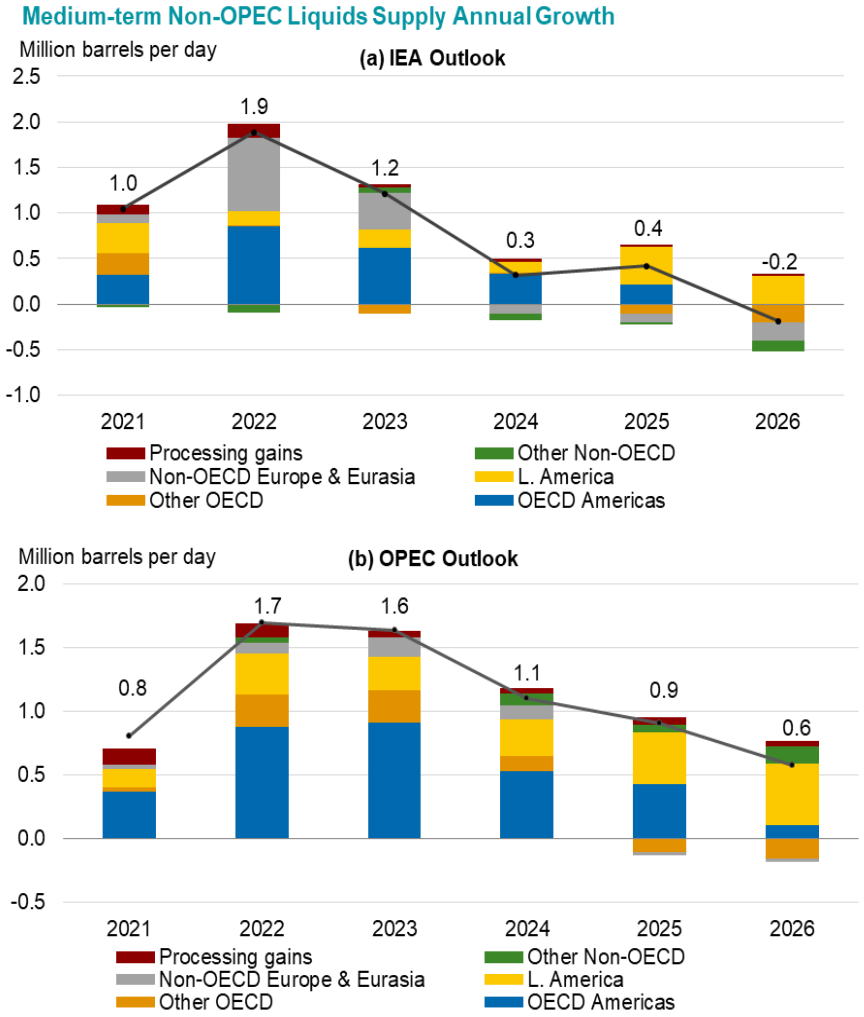
Medium Term World Liquids Demand & Supply Growth Outlook (IEA & OPEC) are similar also



Source: IEA Oil 2021, Table 2; OPEC WOO 2021, Table 3.1



Source: IEA Oil 2021, Table 2; OPEC WOO 2021, Table 3.1



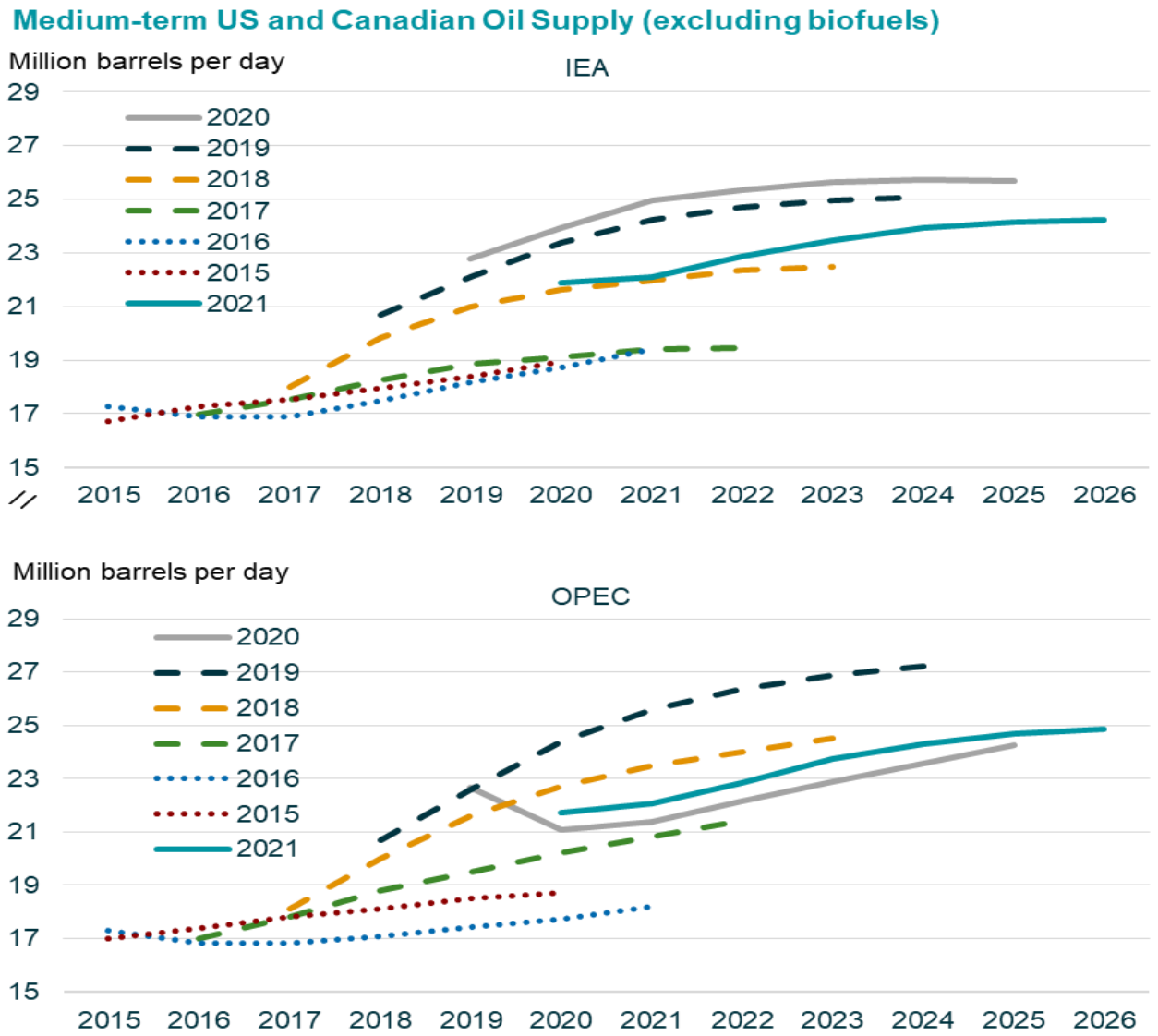
Source: Figure 10 data sources: IEA Oil 2021, Table 3, Table 5, Table 5a; OPEC WOO 2021, Table 4.1. Sums may differ due rounding.
Figure 10 notes: Other OECD is the sum of data from OECD Europe and Asia Oceania; Other Non-OECD is the sum of data from Middle East & Africa and Non-OECD Asia.

Source: IEF- rff- comparison report 2022

Projected Medium-Term (5-y) Role of North America liquid supply growth continues, starting in 2015, through 2026

- Projected role continued to show increase starting in 2015 until 2019
- Following the pandemic, divergence between IEA and OPEC in projected role level and rate of growth
- **Starting 2020, OPEC shows a drop with slower growth of role**
- IEA sees reduced level, with slight decrease in role growth rate.

Source: IEF- rff- comparison report 2022



Source: IEA Oil 2021 Table 3; OPEC WOO 2021 Tables 4.1 and 4.2, Figure 4.7. IEA Oil 2020 Table 3; OPEC WOO 2020 Tables 4.1 and 4.2, Figure 4.7. IEA Oil 2019 Table 3; OPEC WOO 2019 Tables 4.1 and 4.2, Figure 4.7; IEA Oil 2018 Table 3; OPEC WOO 2018 Tables 4.5 and 4.10; IEA Oil 2017 Table 3; OPEC WOO2017, Table 4.1; IEA MTOMR 2016 Table 3; OPEC WOO2016, Table 4.1

Long Term world Energy Outlook: Different Approaches to address ET yield major differences in most aspects

- Some, like IEA's NZE and IRENA's set the target and work backward to find out pathways , including policies, technology innovation and investments needed

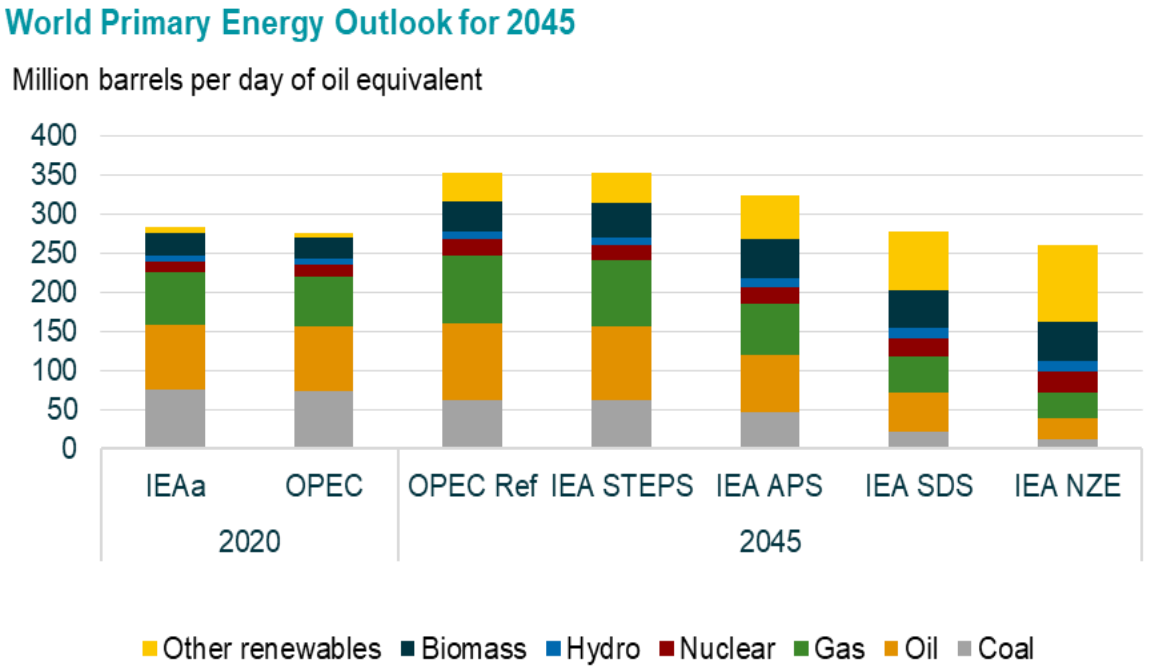
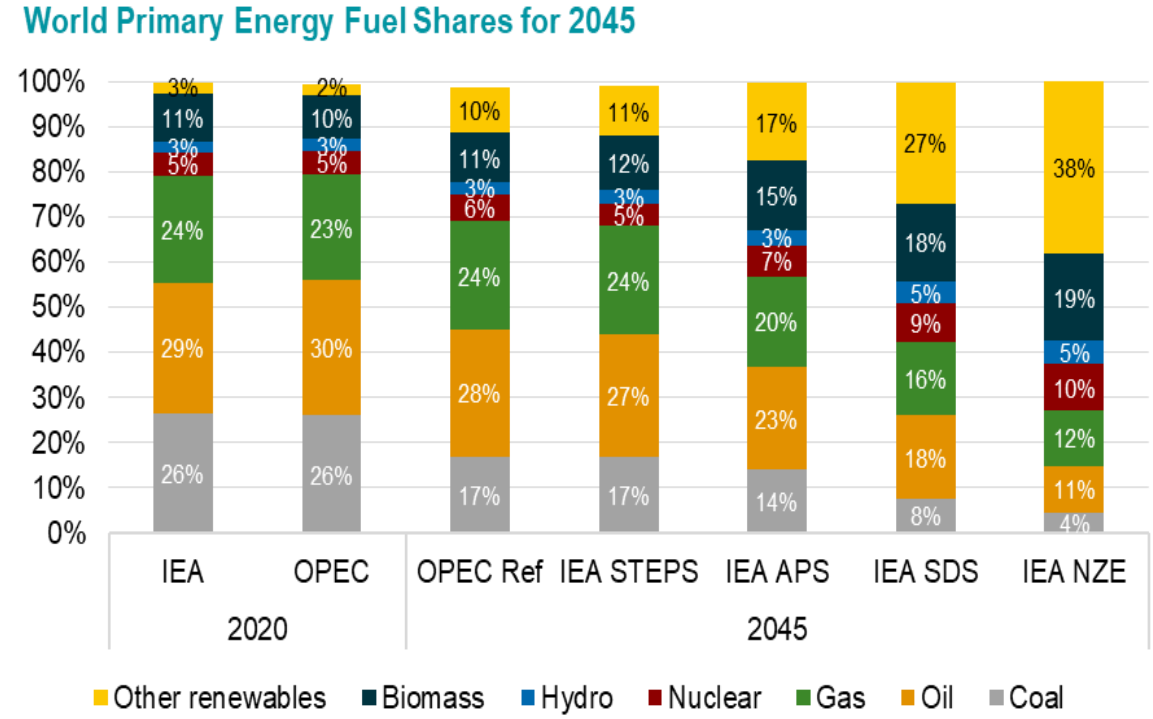


Figure 14 data sources: IEA WEO 2021, Annex Tables; OPEC WOO2021, Table 2.1 for Reference Case.
Figure 14 note: a IEA primary energy is converted from EJ per year to mboe/d by multiplying by 0.4825 mboed/EJ.
OPEC Sensitivity Scenarios do not provide fuel-specific data for non-fossil fuels.

- Others, like OPEC's, EIA's , etc.. continue to develop scenario with assumptions about GDP growth, prices and Climate POLICIES that lead to fast transitions without fixing the end post or choice of technology or primary sources

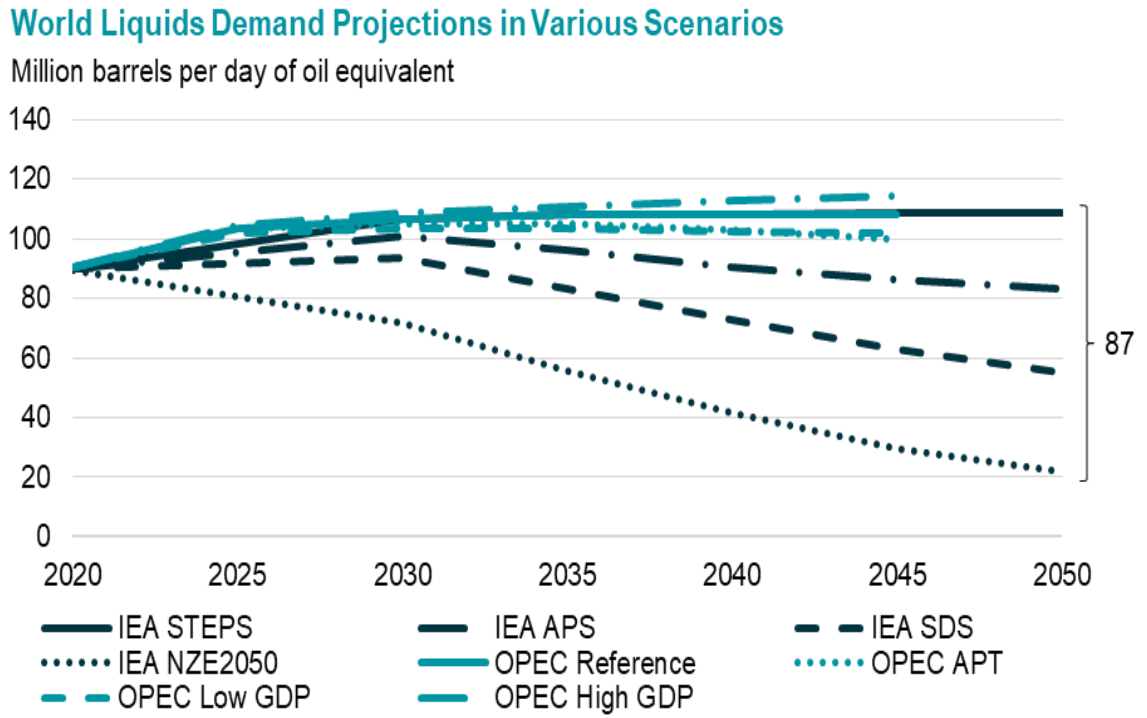


Source: See Figure 13. Sums in the data callouts may not total due to rounding.

Source: IEF- rff- comparison report 2022

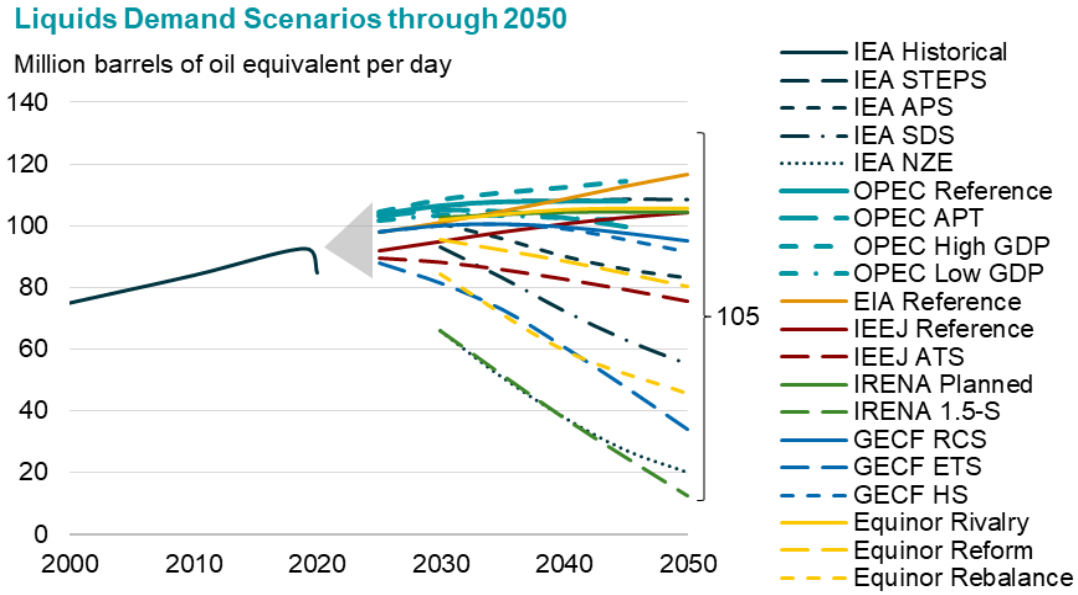
World Liquids Demand Projections in Various Scenarios (*The Non-OECD region accounts for over 60 percent of liquids demand in all scenarios into 2045*)

the gap between IEA's NZE and that of OPEC's reference for liquid demand is huge @ 87 mbd



Source: IEA WEO 2021, Annex Tables; OPEC WOO 2021, Table 3.2 for Reference Case

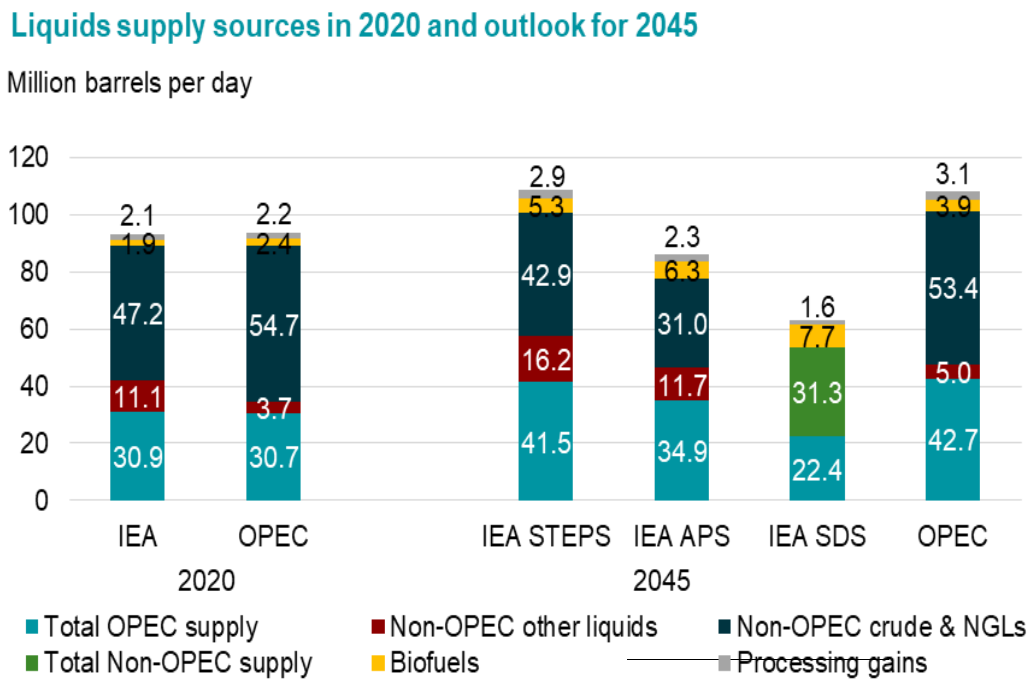
the gap between the highest scenario (EIA Reference) and lowest scenario (IRENA 1.5°C) is even larger, at 105 mb/



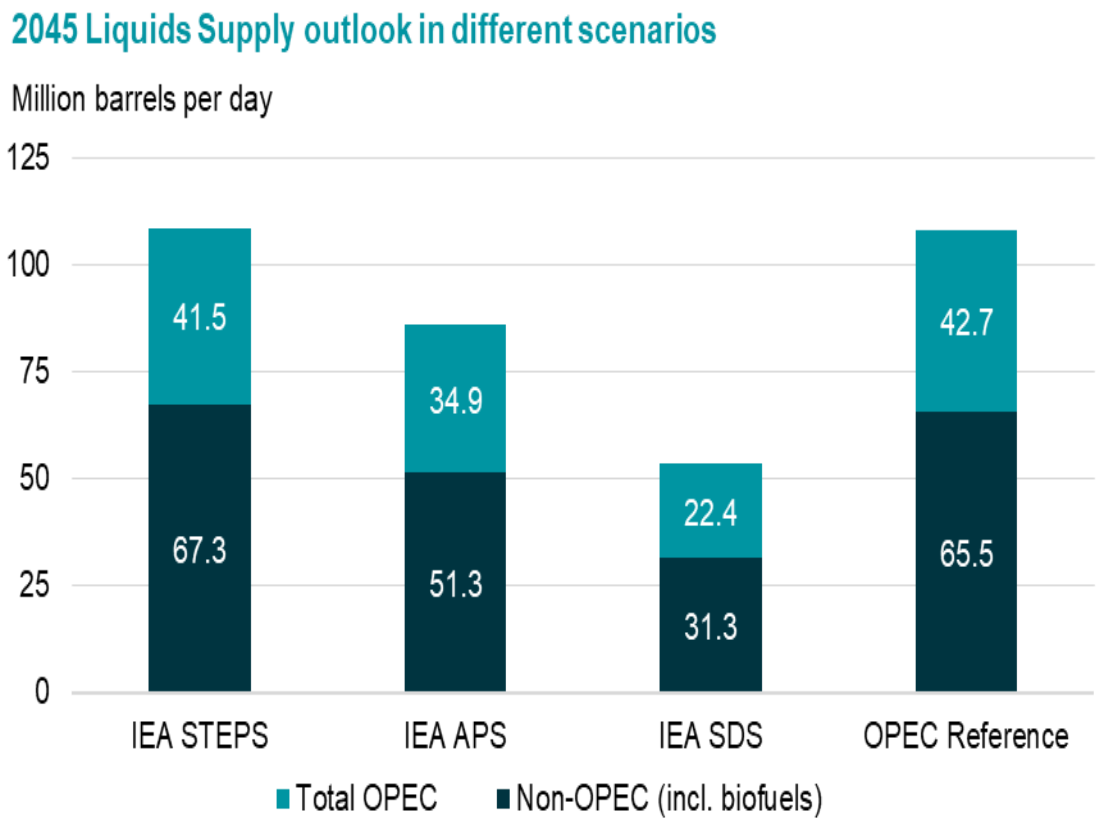
Source: IEA WEO2021 Annex Tables, OPEC WOO2021 Table 3.2, EIA International Energy Outlook 2021; IEEJ Outlook 2022, IRENA World Energy Transitions Outlook: 1.5°C Pathway and 2021 edition GECF Global Gas Outlook 2050 data provided via internal communication, Equinor Energy Perspectives 2021 Data Appendix. Because most outlooks do not provide projections from 2020 through 2025, the grey shaded area represents the range of implied natural gas demand during this period.

Source: IEF- rff- comparison report 2022

Liquid Supply Sources and Outlook in different Scenarios by 2045



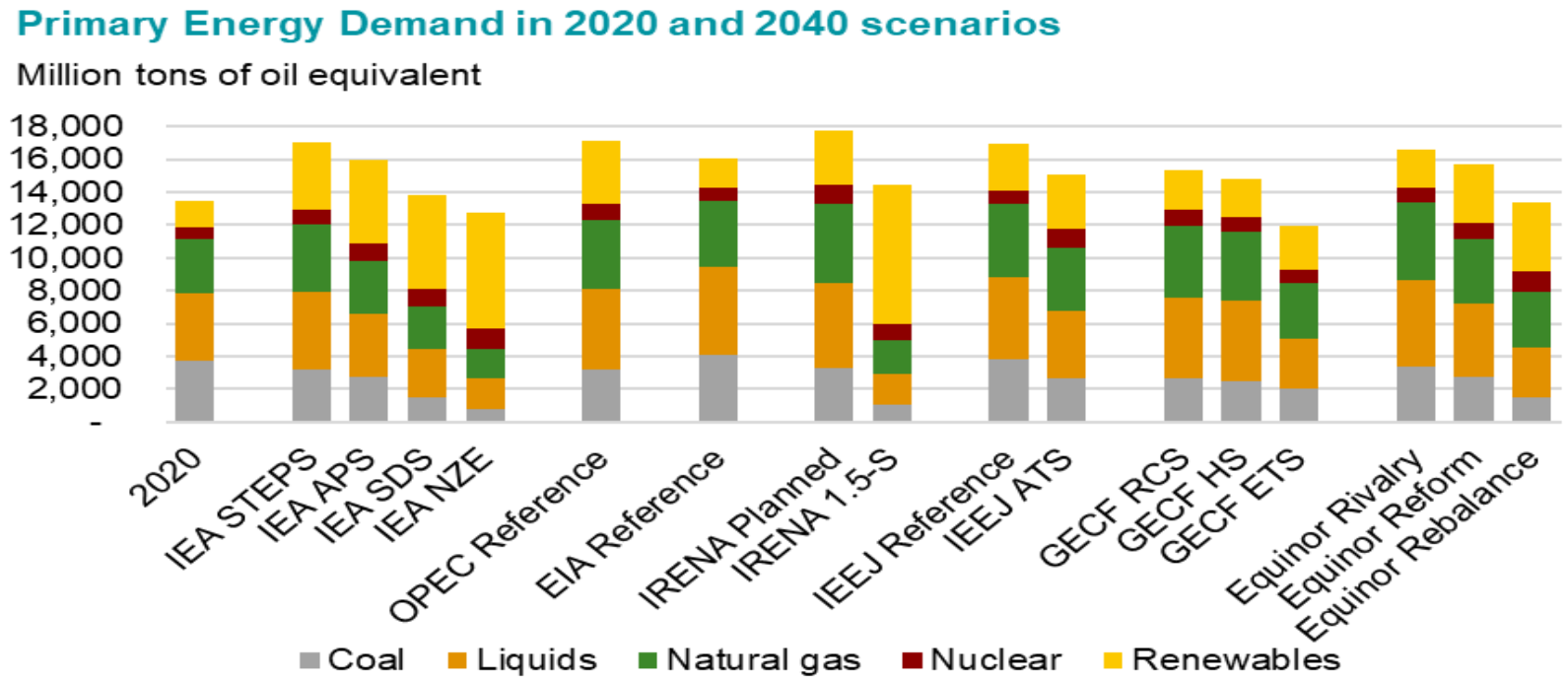
Source: IEA WEO2021 Annex Tables; OPEC WOO2021, Table 4.2 through 4.18
Note: The IEA includes LTO and oil sands in Non-OPEC other liquids, whereas OPEC includes LTO and unconventional NGLs in Non-OPEC crude & NGLs



Sources: IEA WEO2021 Annex Tables. OPEC WOO2021 Table 4.3.
Figure 21 notes: OPEC did not publish details on the composition of OPEC supplies (e.g., NGLs and unconventionals) in WOO2021. Processing gains are included for OPEC Reference scenario only.

Source: IEF- rff- comparison report 2022

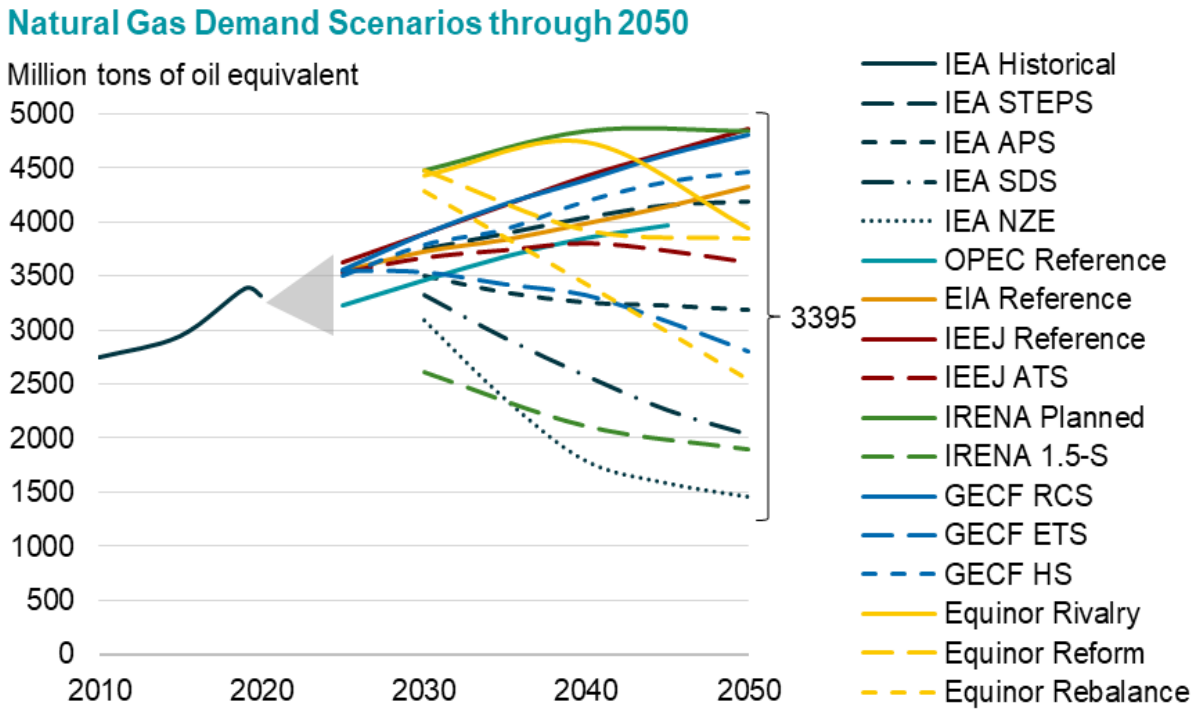
Primary Energy Demand, by source, in 2020 and 2040, for different IEA, OPEC & others' scenarios



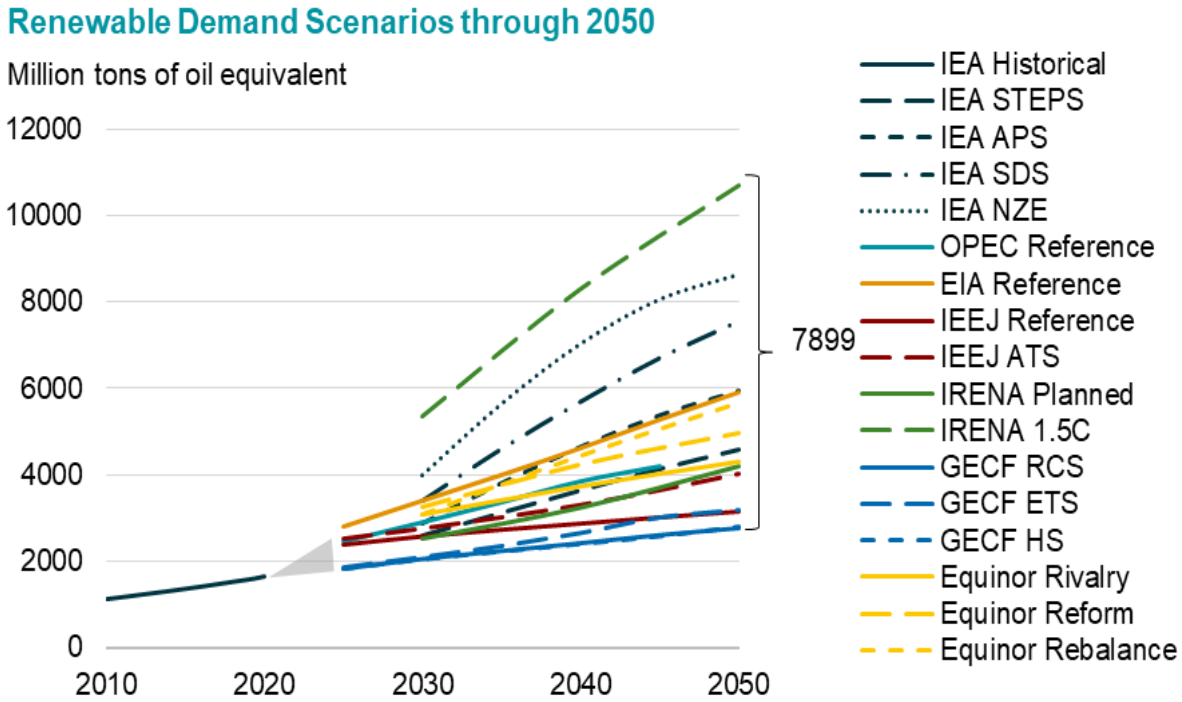
Source: IEA WEO2021 Annex Tables, OPEC WOO2021 Table 2.1, EIA International Energy Outlook 2021; IEEJ Outlook 2022, IRENA World Energy Transitions Outlook: 1.5°C Pathway and 2021 edition GECF Global Gas Outlook 2050 data provided via internal communication, Equinor Energy Perspectives 2021 Data Appendix.
Figure 22 notes: "Renewables" include hydro, biomass, and other renewables such as wind, solar, and geothermal. OPEC liquids is only primary energy demand for oil.

Source: IEF- rff- comparison report 2022

Huge differences between the projections for highest and lowest natural gas demand (3395 mtoe) in 2050, and even more huge for Renewable (7899 mtoe)



Source: IEA WEO2021 Annex Tables, OPEC WOO2021 Table 2.1, EIA International Energy Outlook 2021; IEEJ Outlook 2022, IRENA World Energy Transitions Outlook: 1.5°C Pathway and 2021 edition GECF Global Gas Outlook 2050 data provided via internal communication, Equinor Energy Perspectives 2021 Data Appendix. Because most outlooks do not provide projections from 2020 through 2025, the grey shaded area represents the range of implied liquids demand during this period.



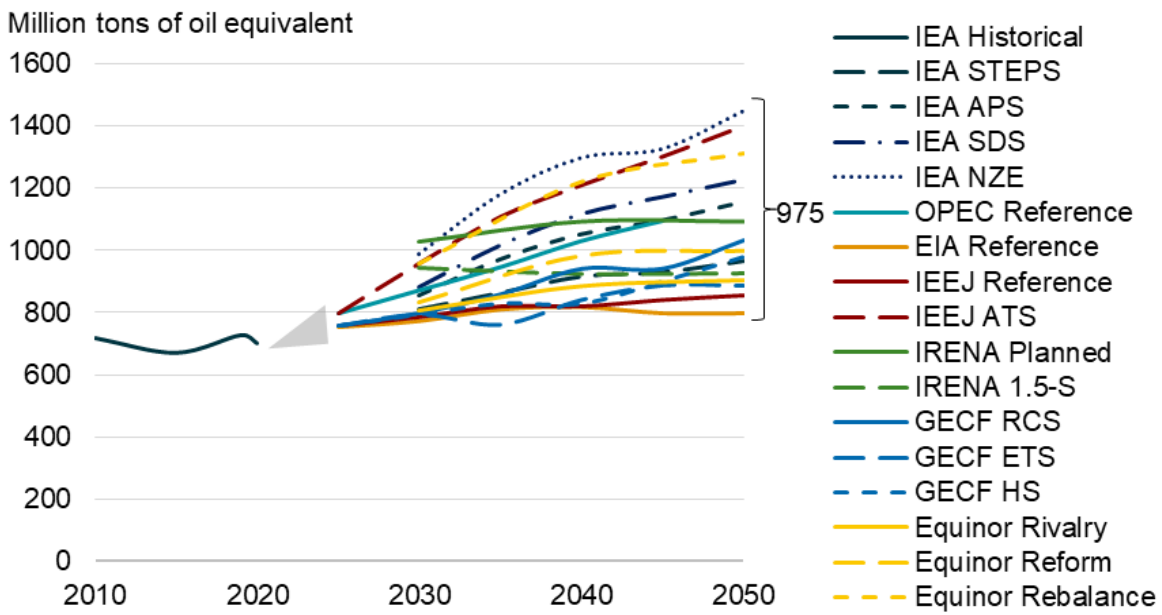
Source: IEA WEO2021 Annex Tables, OPEC WOO2021 Table 2.1, EIA International Energy Outlook 2021; IEEJ Outlook 2022, IRENA World Energy Transitions Outlook: 1.5°C Pathway and 2021 edition GECF Global Gas Outlook 2050 data provided via internal communication, Equinor Energy Perspectives 2021 Data Appendix. Because most outlooks do not provide projections from 2020 through 2025, the grey shaded area represents the range of implied liquids demand during this period.

Source: IEF- rff- comparison report 2022

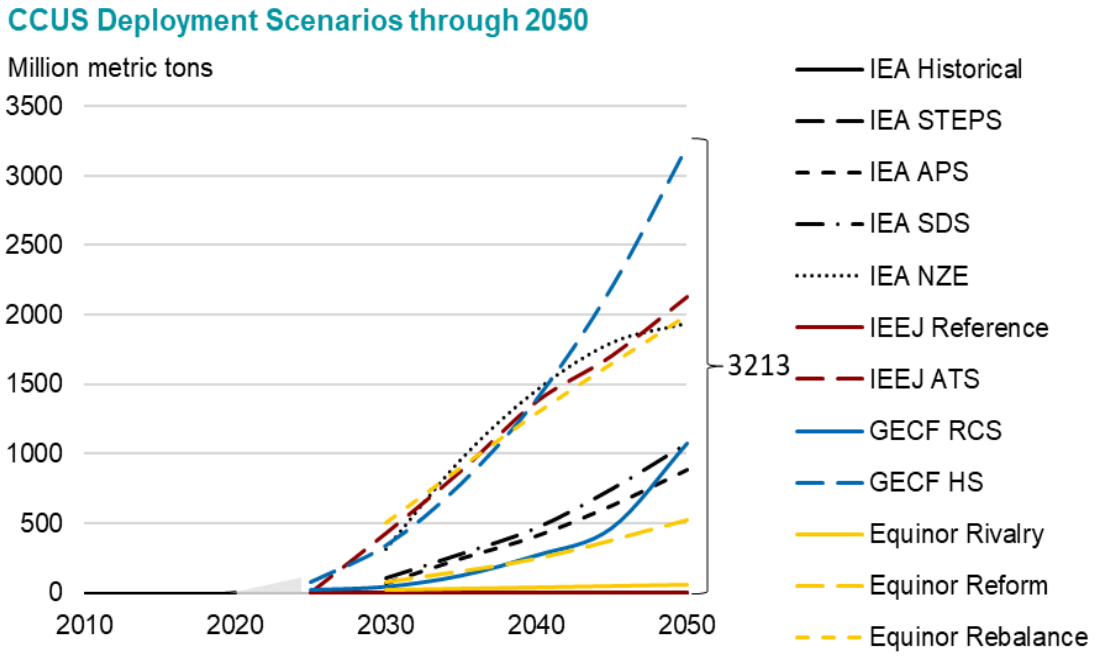
Large difference between the projections for highest & lowest Nuclear Demand (975 mtoe) in 2050, and even larger difference for needed deployment of CCUS (3213 m metric tons)

Figure 23: Nuclear demand grows much more rapidly under climate and technology scenarios

Why nuclear and CCUS are important in fast NZE pathways



Source: IEA WEO2021 Annex Tables, OPEC WOO2021 Table 2.1, EIA International Energy Outlook 2021; IEEJ Outlook 2022, IRENA World Energy Transitions Outlook: 1.5°C Pathway and 2021 edition GECF Global Gas Outlook 2050 data provided via internal communication, Equinor Energy Perspectives 2021 Data Appendix. Because most outlooks do not provide projections from 2020 through 2025, the grey shaded area represents the range of implied liquids demand during this period.

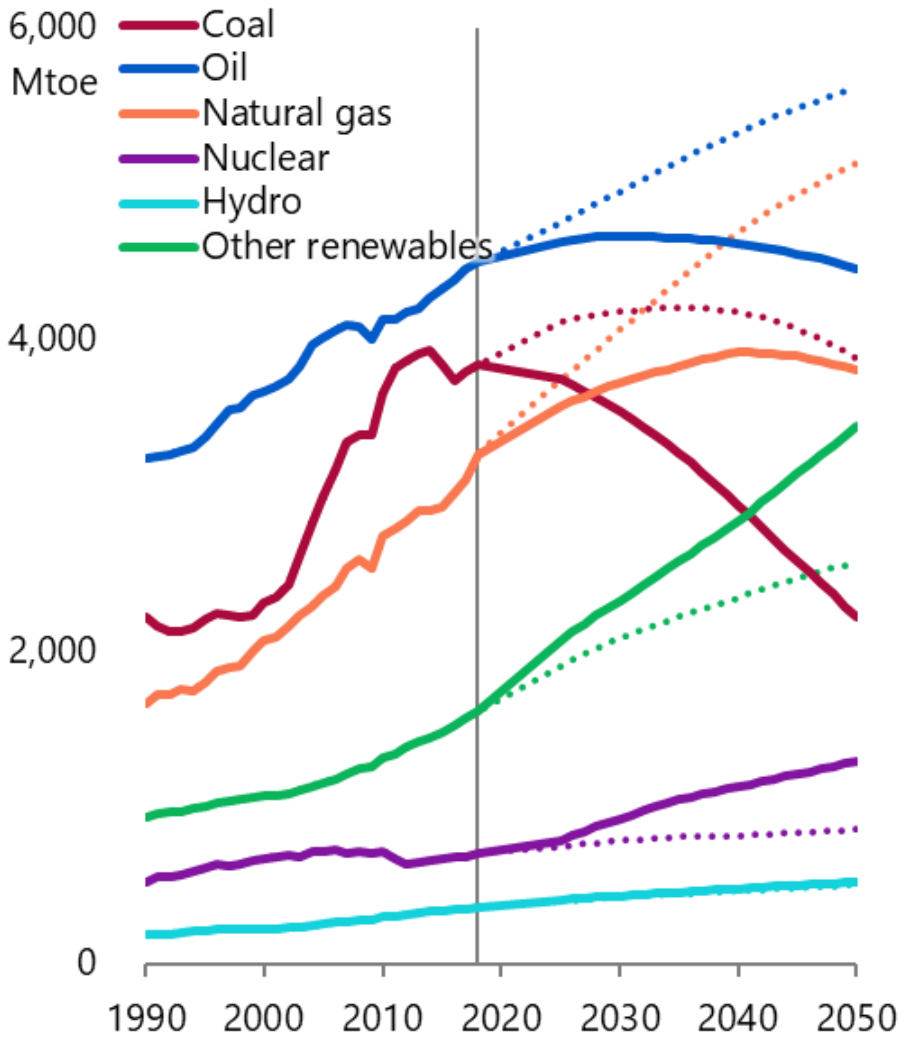


Source: IEA WEO2021 Annex Tables, EIA International Energy Outlook 2021; IEEJ Outlook 2022, IRENA World Energy Transitions Outlook: 1.5°C Pathway and 2021 edition GECF Global Gas Outlook 2050 data provided via internal communication, Equinor Energy Perspectives 2021 Data Appendix. Because most outlooks do not provide projections from 2020 through 2025, the grey shaded area represents the range of implied liquids demand during this period.

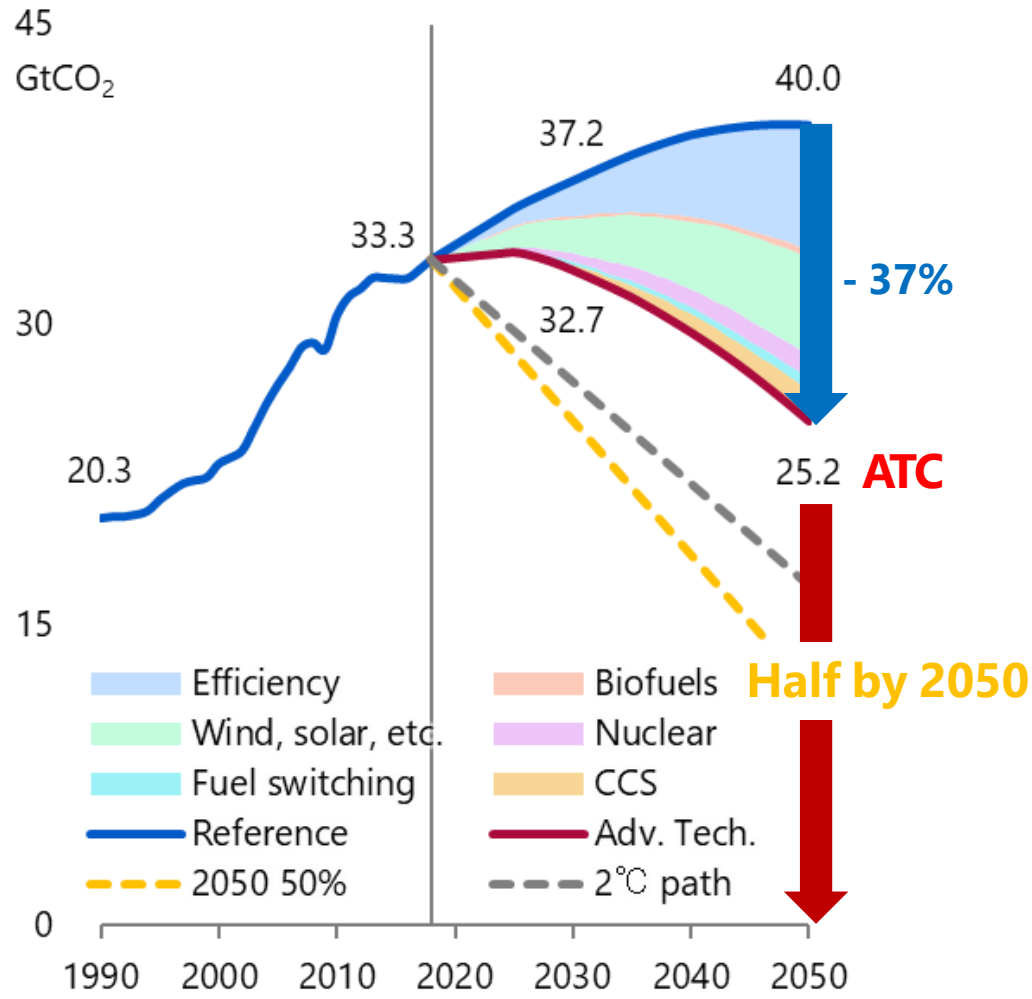
Source: IEF- rff- comparison report 2022

Advanced technologies and strong policies reduce CO_2 emission

❖Primary Energy By Source

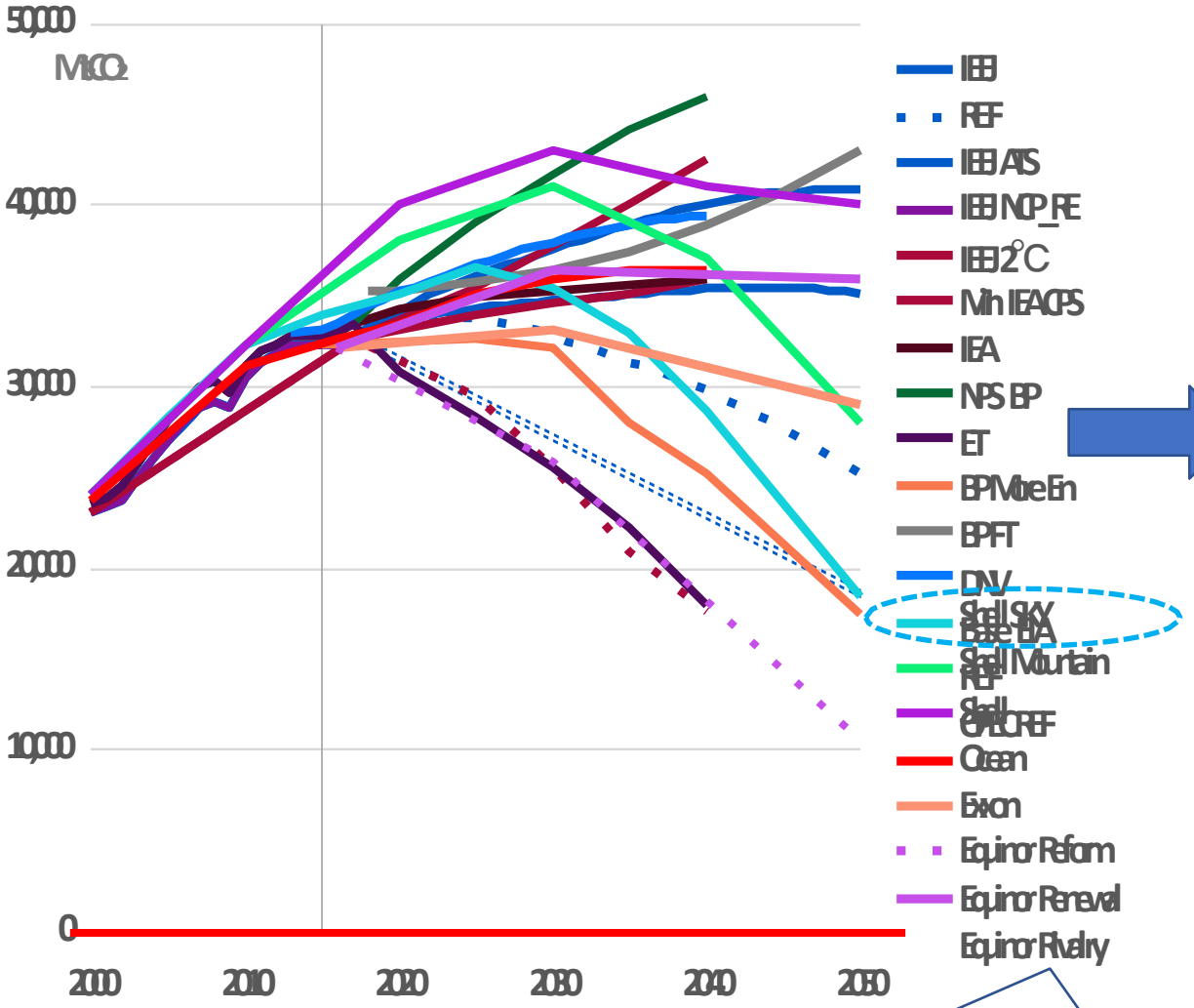


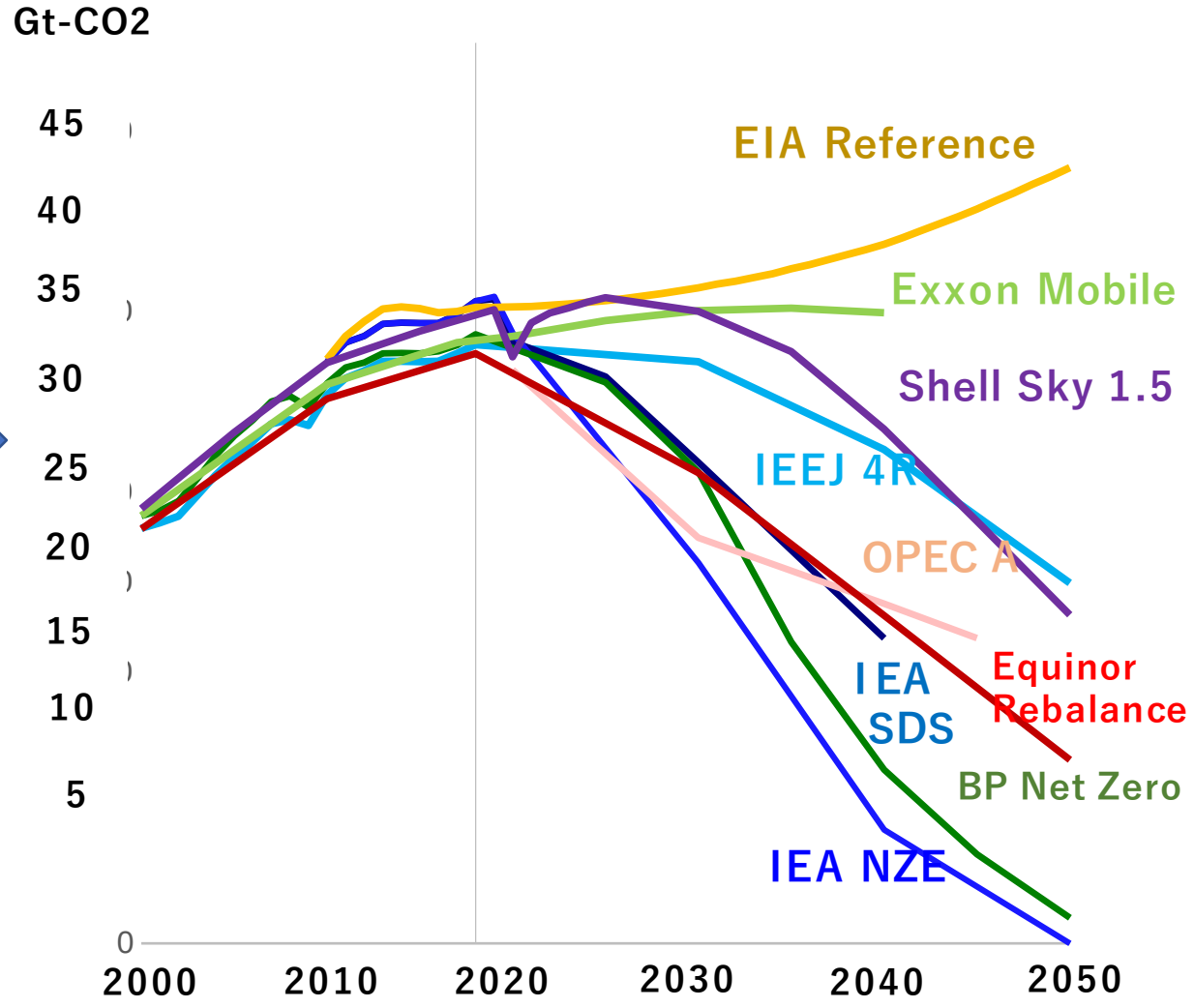
❖ CO_2 Emission By technology



Source: IEEJ Outlook 2021 (Oct. 2020)

Dash for energy transition towards decarbonization





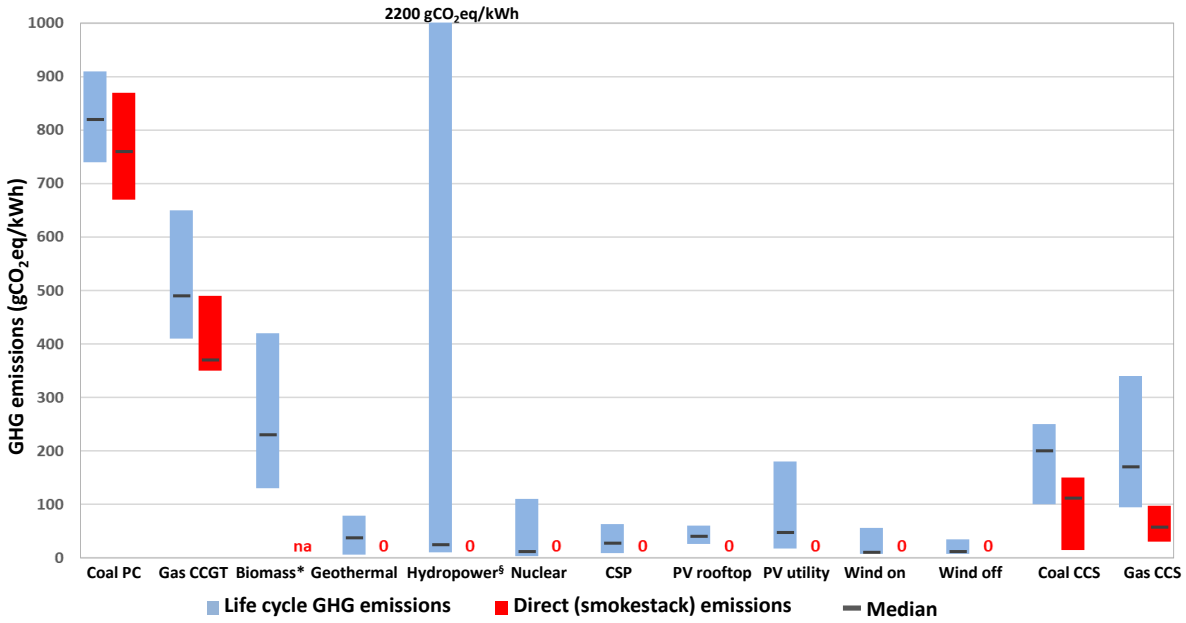
Net Zero Emission

As of March 2020

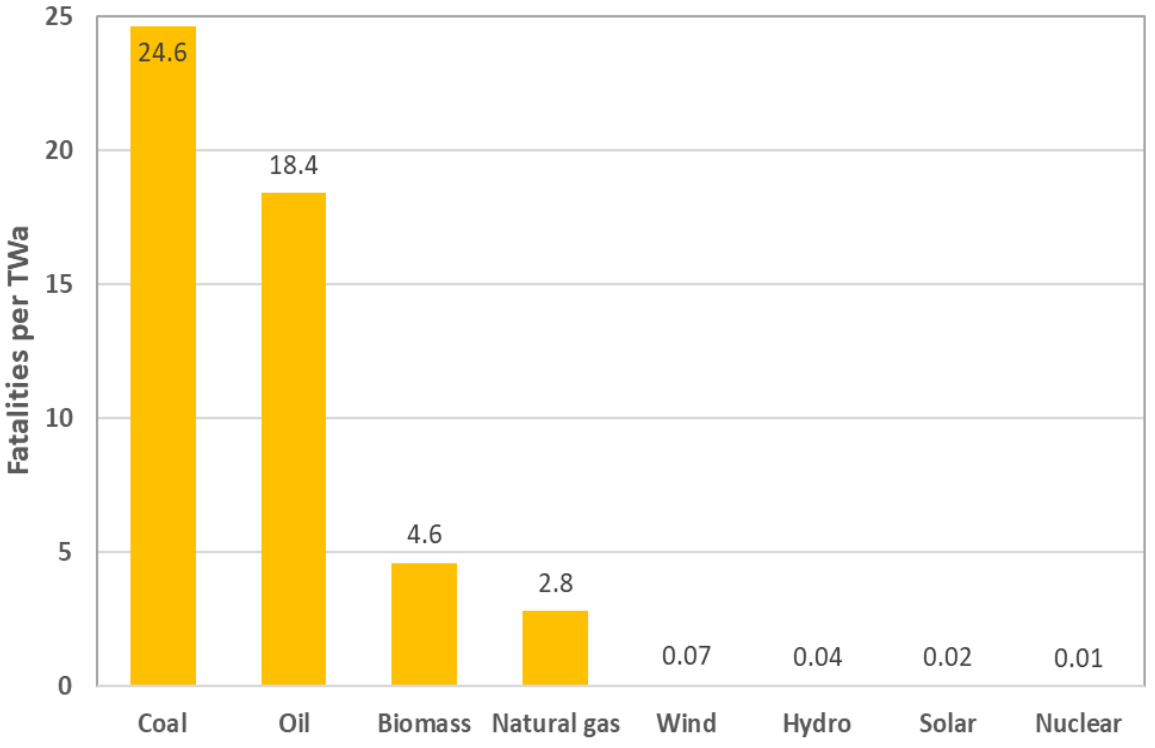
As of May 2021

Compiled from original sources by IEEJ

All low carbon technologies that could contribute competitively, on LC basis: cost, net emission and Health Risk, should be pursued (as called for by the CCE framework endorsed by G20 in Riyadh, 2020)



*Biomass CO_2 emissions from combustion are assumed to be absorbed again when it regrows again.
§The global median GHG of hydropower is 24 gCO_2-eq/kWh. Hydro reservoirs can release up to 2,200 gCO_2-eq/kWh due to decomposition of flooded organic material.



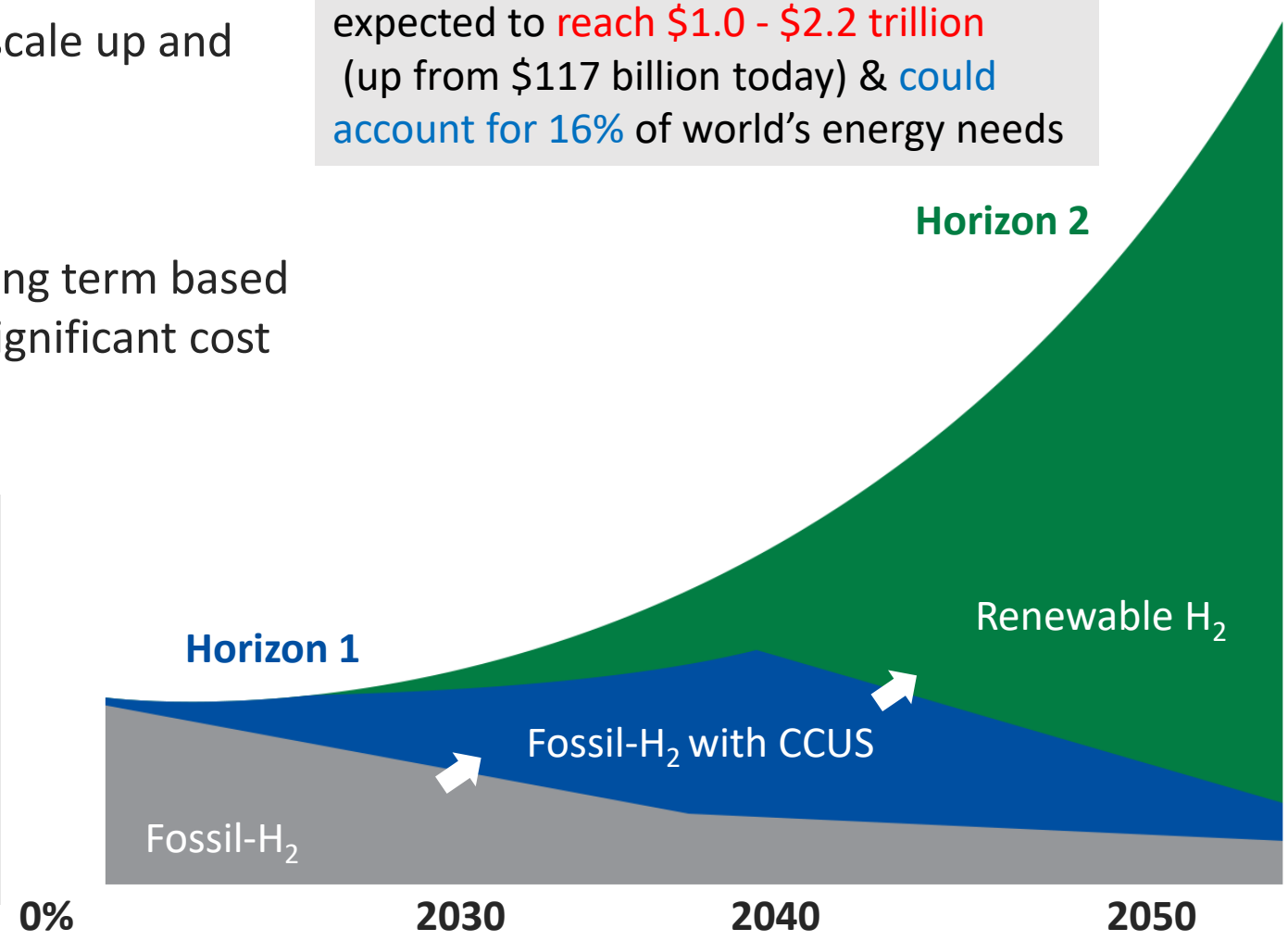
Window of Opportunity to proceed with clean hydrogen production in MENA/GCC in capturing a share of future large & exponentially growing clean Hydrogen markets

Horizon 1:
Blue hydrogen is needed to kickstart the scale up and prepare the infrastructure.

Horizon 2:
Green hydrogen will dominate over the long term based on successive/disruptive innovation and significant cost reduction.

By 2050, value of the H_2 market is expected to reach $1.0 - $2.2 trillion (up from $117 billion today) & could account for 16% of world's energy needs

- Large uncertainty about share of Blue Hydrogen through 2050 (and beyond), stemming from large uncertainties of technological innovation, maturity & cost competitiveness of blue vs. green
- Policy bias (ideology?) favoring only green H by some (EU) creating challenging obstacles against MENA realizing its potential



Closing Remarks

Based, in part, on articles appearing in several issues of Oxford Energy Forum, published by OIES in 2021, and author's analysis and views

Key issues, and questions about fast pathways to NZE 2050 - I

- Will total global energy use actually drop ~8% by 2050? with 2 billion more population!
- Will ET proceed fast & just enough?
  - With Regional differences remaining large. & ET not yet as high on the governments' nor people's Agenda in many parts of world
  - wouldn't China, India, SE Asia, etc.. need more time to NZE, & chose to use more nuclear, blue & green H & HC?
- How realistic the huge drop in fossil fuels use to 25% of its present value?
    - A significant level of minimal demand for fossil fuel WILL LIKELY remains in 2050
- How realistic & What are implications of "no investment in new fossil fuel supply"? market instability ,supply shortages & price volatility?

- Is it technically feasible that global electricity become all Re by 2040? What about the cost of storage & flexibility as share of Re increase ~ > %30
- How fast will Electrification, hydrogen, on SS side, & digitization on DS need to proceed? How many giga solar & wind farms needed/y?
- Who will pay the huge $5 Trillion/y investments by 2030? (tax/rate payers in AEs?
- Will the people in AEs vote for governments to spend huge amounts or vote them out? Especially huge transfers needed by many EMDEs –w/o it, their pathway to net zero not likely-
- How "Just" (equitable burden sharing) is the transition? Who pays for the legacy CO2? India says: you created the problem, you want us to solve it, give us the money!
- Will required behavioral changes materialize soon enough? Case of COVID19
- What about developing geoengineering solutions, as insurance, ready to deploy if all fail?

Other observations, questions & controversies

- In many parts of the world, **the ET is not high on the governments' and people's Energy Agenda** as **affordability & security**
- **ET is not happening yet as it should, certainly not fast nor just enough**
  - **Many countries are not likely to meet their 2030 targets** let alone the 2050
- **Enforcements! can it be expected?**: will the courts step in to force governments and companies to meet legally binding commitments and pledges?
- **NZE pathway relies on unprecedented international co- operation** among governments, especially on innovation and investment.

- **For many developing countries, the pathway to net zero without international assistance is not clear if not likely.**
- **Fast ET will cost** huge amounts, **~ $5 Trillion annual investment,** including huge technical and financial support & transfers to EMDEs
  - Will international transfer be enough - India says: you create the problem, you want us to solve, give us the money!
  - **Who will provide the huge annual investments** by 2050? (& rate payers?
- Without greater international co-operation, global CO2 emissions will not fall to net zero by the 2050
- **Perhaps the most controversial** parts are the key questions of how Just (equitable burden sharing) an behavioral changes needed!
- **What about the people**? Will they vote for governments to spend huge amounts or vote them o
  - example: People & governments, actions and funding, to deal with more imminent catastrophe: **COVID19**

Pace, coverage, governance & new winners/losers

- Energy transition is likely to be a **very uneven journey**
  - **Europe is moving fast** towards a clean energy economy
  - **Asia and Africa will** continue to rely heavily on fossil fuels for the foreseeable future
  - **Fossil exporters racing** to secure markets for clean decarbonized HC fuels (e.g.blue hydrogen)

- The transition need **new** energy governance structure, **driven by strong government policy and proactive support to technology innovation and financing; There is a need & opportunity for new multilateral governance (nuclear, CCUS and hydrogen,.**

- **Pace of energy transition highly uncertain** but expectations and perceptions are changing faster than potential changes in energy mix expectations ahead of changes in energy mix

- ET **will produce winners and losers** and alter the existing geopolitical relationships
  - **How to identify winners and losers?**
  - What are the implications of winning/losing?
- Winners: China and the EU
- Loser: Russia?
- What about the US? US foreign policy?
- What about MENA and other major oil developing exporters?
- **Old geopolitics revolved around access to resources and trade flows, but energy transition is about electrons and assumed to offer more security/self sufficiency**
  - changes in the balance of geopolitical power and their significance?

Technology mastering and dominance battles of the ET

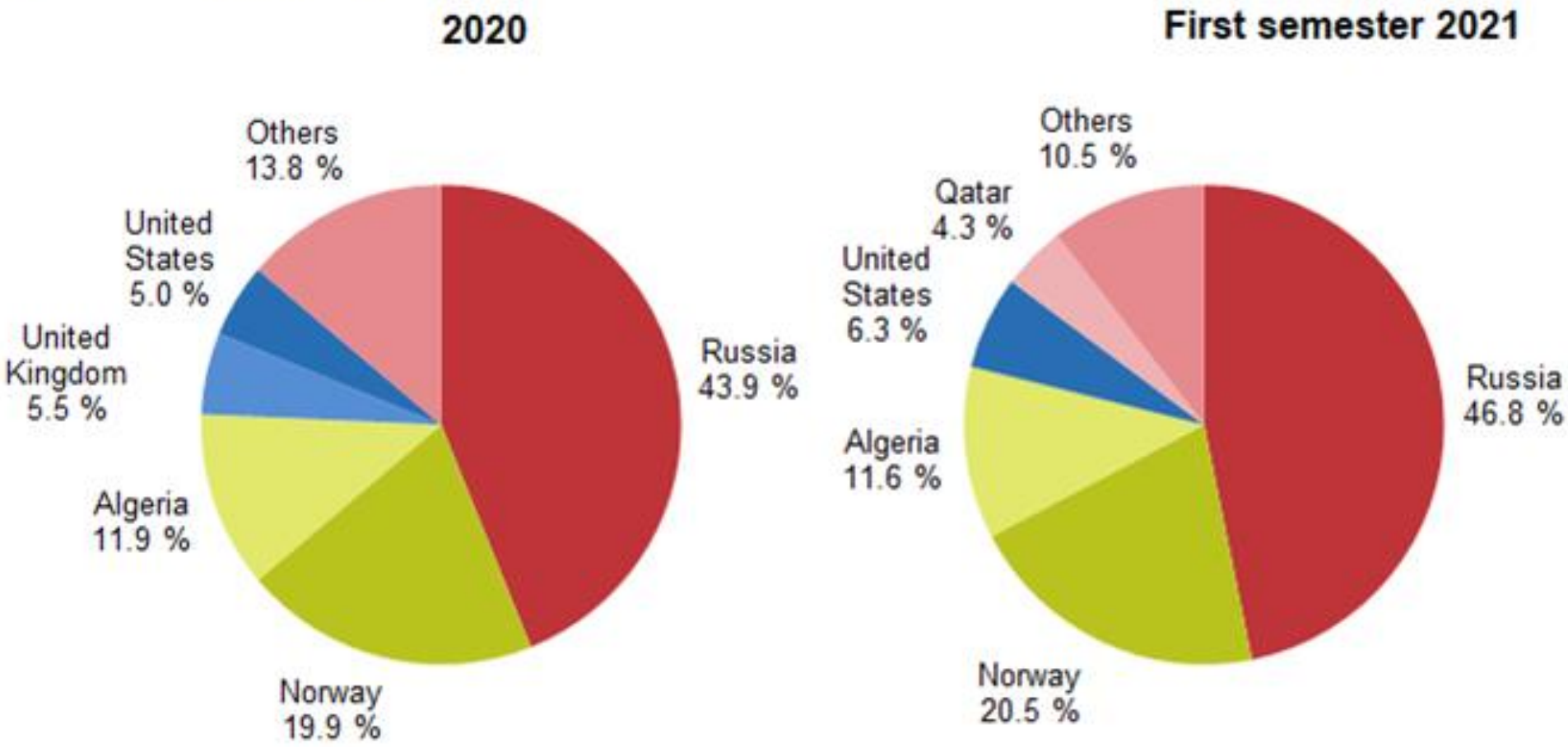
- **Nuclear Option - WHY:** exports of new innovative SMRs and related NFC shifting supplier profile, Russia and China are dominant with distorting effects on terms of commercial competition leading to weaker nuclear governance. – **need stronger int'l safety regime,**
  - ***Generous* financing** for nuclear exports as well as intergovernmental agreements with SNF Take back have helped **Russia** become world's dominant nuclear supplier.
- **Countries are now vying to control the key energy technologies** of the future, just as the US rise to global dominance in 20th century was tied to oil
- **Dominance in lithium-ion batteries and their supply chains** mean controlling balance of industrial power for remainder of this technological cycle.
- **Chinese companies** are pursuing technological breakthroughs in potentially game-changing technologies , essential in climate change mitigation
- **China**'s 'energy technology innovation system' has contributed to its clean energy leadership.
- **Europe** encouraged auto and battery conglomerates to team up as EVs were gaining momentum.
- **Germany's** green hydrogen push is an attempt to outcompete China and not repeat the experience of losing its PV industry.
- **A new map of hydrogen trade is set** to emerge - based on bilateral relationships as countries chose to become importers and exporters of hydrogen.
- **Hydrogen** is a battleground for technological and economic supremacy between the established and rising powers of this world: including currently cheaper blue vs more expensive green hydrogen favored by EU

Postscript data and observations on EU's oil & gas imports from Russia

Implications on prolonged potential sizable disruption of imports from Russia

Extra EU imports of natural gas from main trading partners, 2020 and first semester 2021

(share (%) of trade in value)

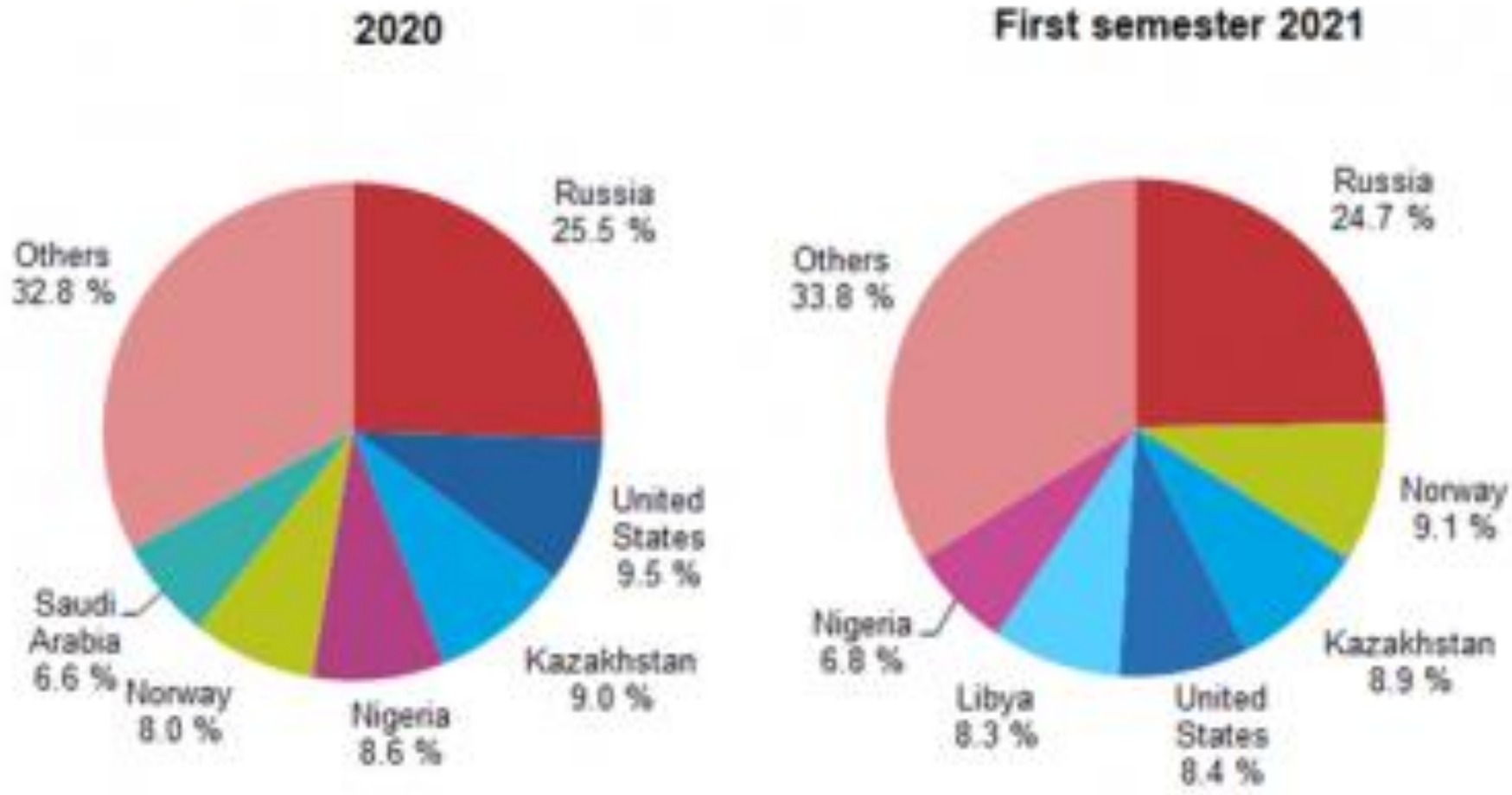


Source: Eurostat database (Comext) and Eurostat estimates

eurostat

Extra EU imports of petroleum oil from main trading partners, 2020 and first semester 2021

(share (%) of trade in value)

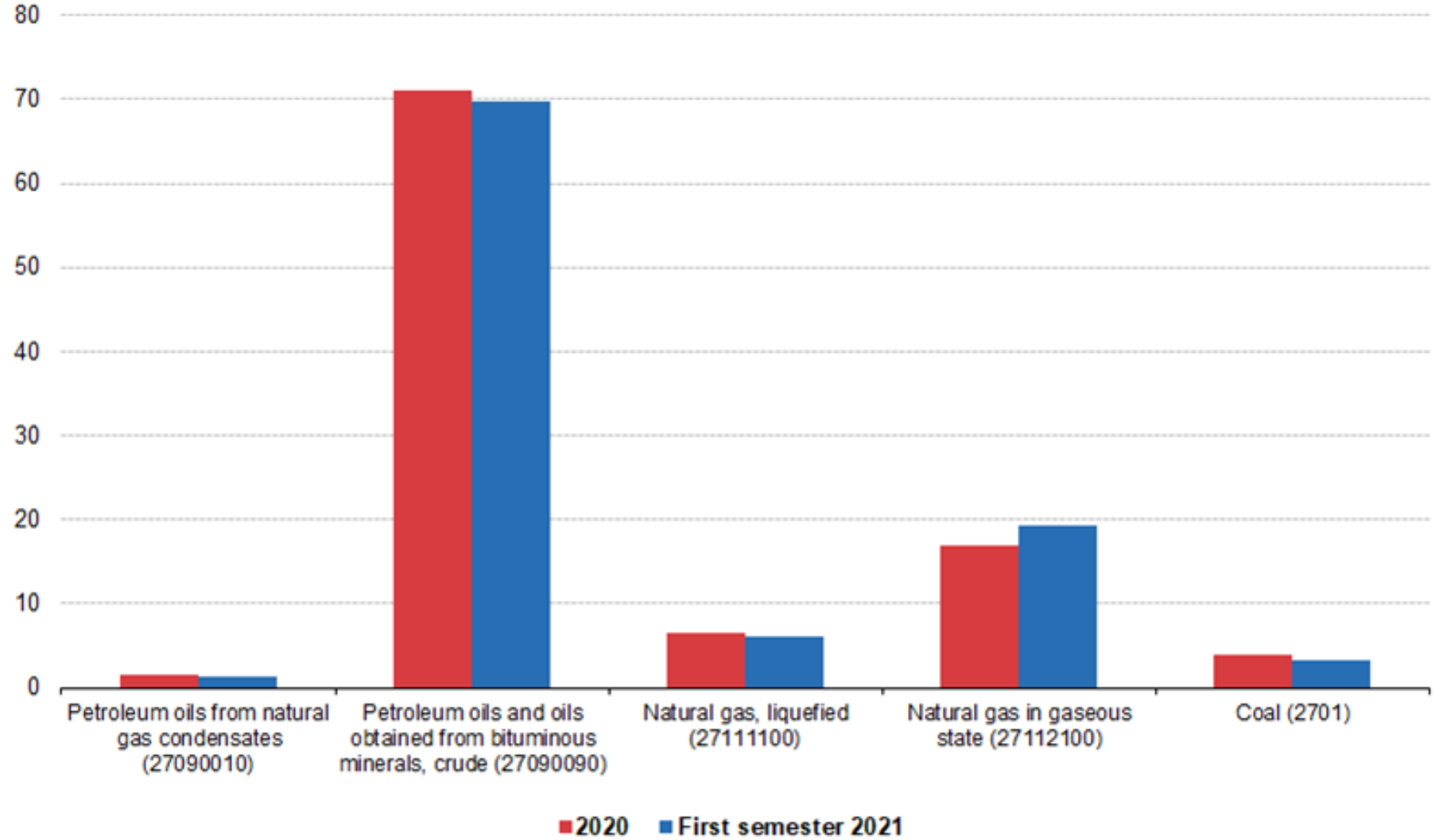


Source: Eurostat database (Comext) and Eurostat estimates

eurostat

Share of each product in Extra-EU imports in energy, 2020 and first semester 2021

(share (%) of trade in value)



Source: Eurostat database (Comext) and Eurostat estimates

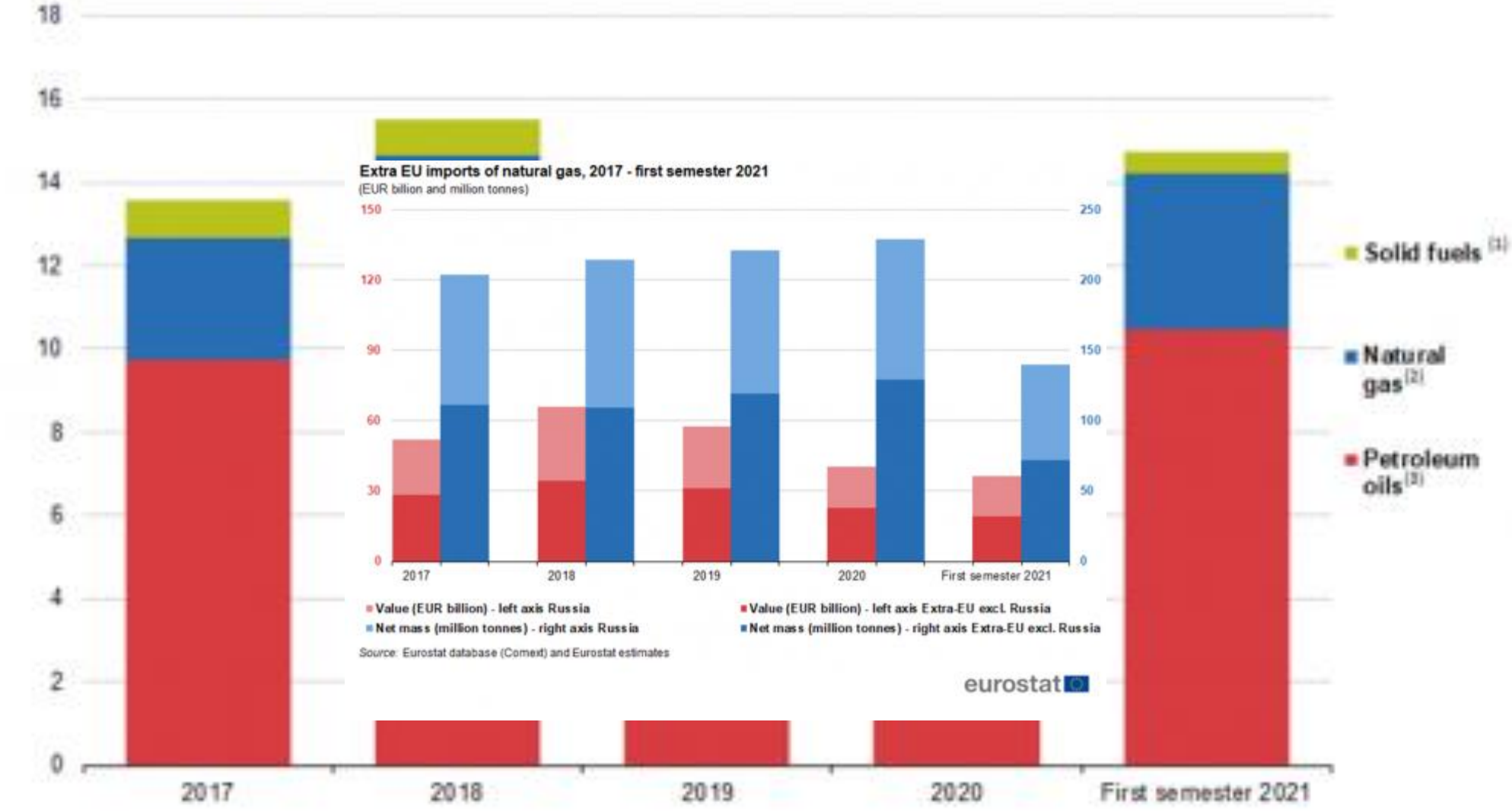
eurostat

Main extra-EU partners for imports of natural gas, first semester 2021
(shares %)

< 10
10 – < 20
20 – < 30
>= 30
Data not available

Share of energy products in total EU imports, trade in value, 2017 - first semester 2021

(share (%) of trade in value)

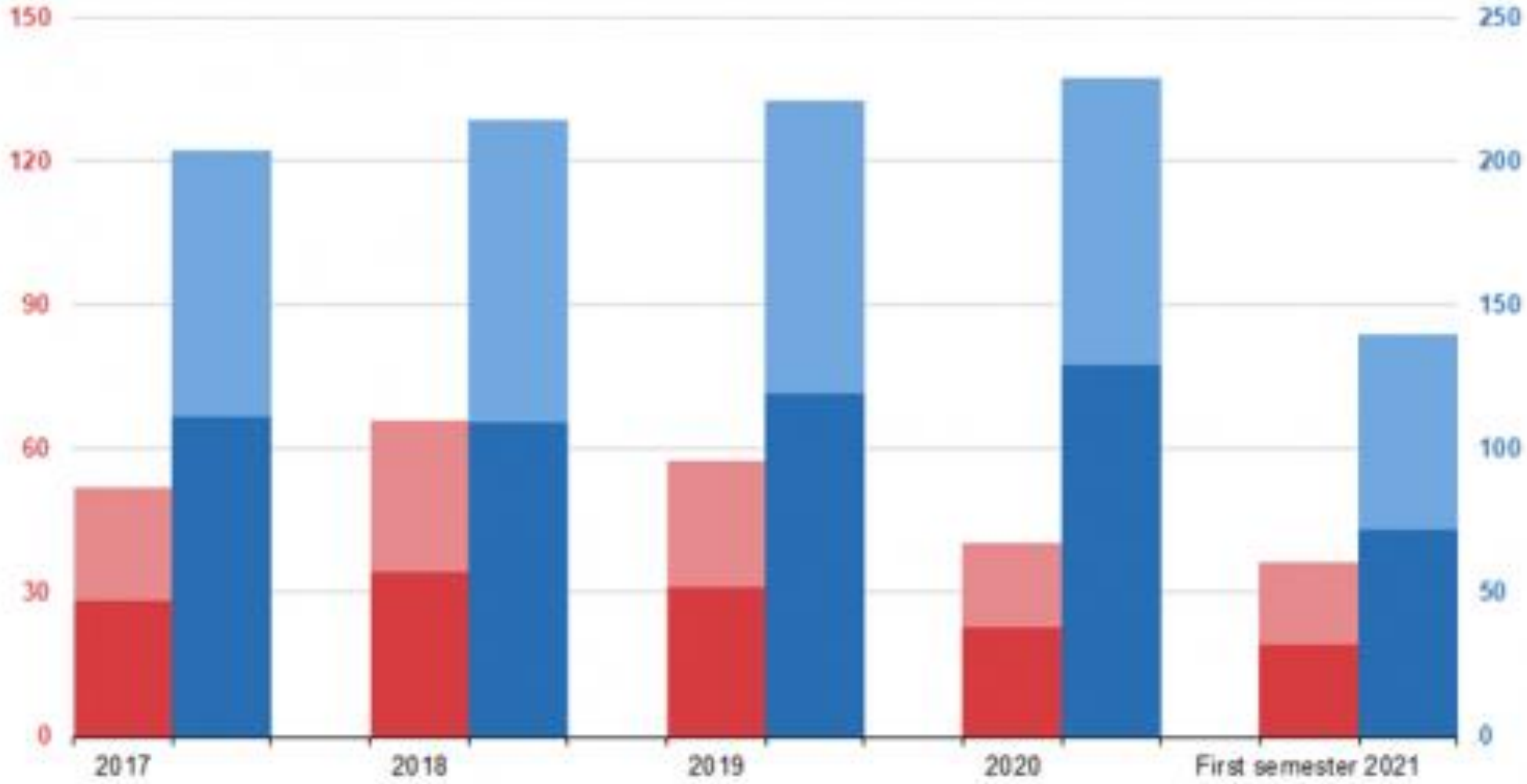


(1) Product codes: 27090010 and 27090090
(2) Product codes: 27111100 and 27112100
(3) Product codes: 2701, 2702, 2703, 2704
Source: Eurostat database (Comext) and Eurostat estimates

eurostat

Extra EU imports of natural gas, 2017 - first semester 2021

(EUR billion and million tonnes)



Source: Eurostat database (Comext) and Eurostat estimates

eurostat


MOUNT KILIMANJARO
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Thank you