



Future Energy Leaders Visionario

The World in 2050: MAP Phase Analysis Presentation

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Introduction

Future Energy Leaders Visionario

Led by Global Future Energy Leaders (FELs), the World Energy Council's community of exceptional young energy professionals, the FEL Visionario pilot project will inform and support the Council's World Energy Scenarios work by providing insights into the latest global energy and emissions projections.

The project aims to deliver the Council's humanising energy vision by bridging inter-generational gaps in thinking and incorporating socio-economic perspectives into the (often) technocratic realm of energy and emissions scenarios.

Project Overview

Objectives

- Provide insight into latest global energy and emissions projections
- Inform and support the Council's World Energy Scenarios work

Phases

- MAP: Review of energy and emissions scenarios globally
- GAP: Identify gaps and uncertainties to achieve projections/desired future
- ZAP: Develop strategies/proposals to close the identified gaps

Team Leads

- Olga Bogdanova (Latvia)
- Justice Ohene-Akoto (Ghana)
- Renata Viggiano (Italy)
- Guillaume Bence-Hébert (Canada)

MAP Phase Overview

Review of energy and emissions scenarios globally

Objectives

- Examined scenarios from a quantitative and qualitative perspective
- Compared scenarios' modelling assumptions and hypotheses
- Assessed drivers for change such as policy, innovation, private sector investment, and consumers' behavioural change
- Commentary provided on scenarios results
- Assessed “Humanising Energy” aspect of scenarios

MAP Phase Overview

Review of energy and emissions scenarios globally

Scenario Categories Reviewed

- Normative : Aligned with specific vision or objective (net-zero emissions)
- Outlooks: Quantitative, expected future based on business-as-usual trends
- Plausible: Qualitative and narrative-led, based on plausible alternative futures

Future Energy Leaders Involved

The MAP phase of the project saw considerable FEL community engagement. The teams reviewed close to 30 energy and emissions scenarios.

The Visionario Team

Normative

- Ivar Baldvinsson (Iceland)
- Mihaela Hristova (Bulgaria)
- Guillaume Bence-Hébert (CAN)
- Ola Atef (Egypt)

Outlooks

- Justice Ohene-Akoto (Ghana)
- João Graça Gomes (Portugal)
- Mateusz Treder (Switzerland)
- Thaddeus Anim-Somuah (Netherlands)
- Joy Eze (Nigeria)
- Anik M. Rahman (Canada)
- Mohammed Alageel (Saudi Arabia)

Plausible

- Olga Bogdanova (Latvia)
- Renata Viggiano (Italy)
- Lucia Soriano (Colombia)
- Nora Nezamuddin (Saudi Arabia)
- Maelle Gomez (France)
- Gabrielle Menard (France)

Normative scenarios

**Aligned with specific vision or objective
(net-zero emissions)**

Normative Scenarios

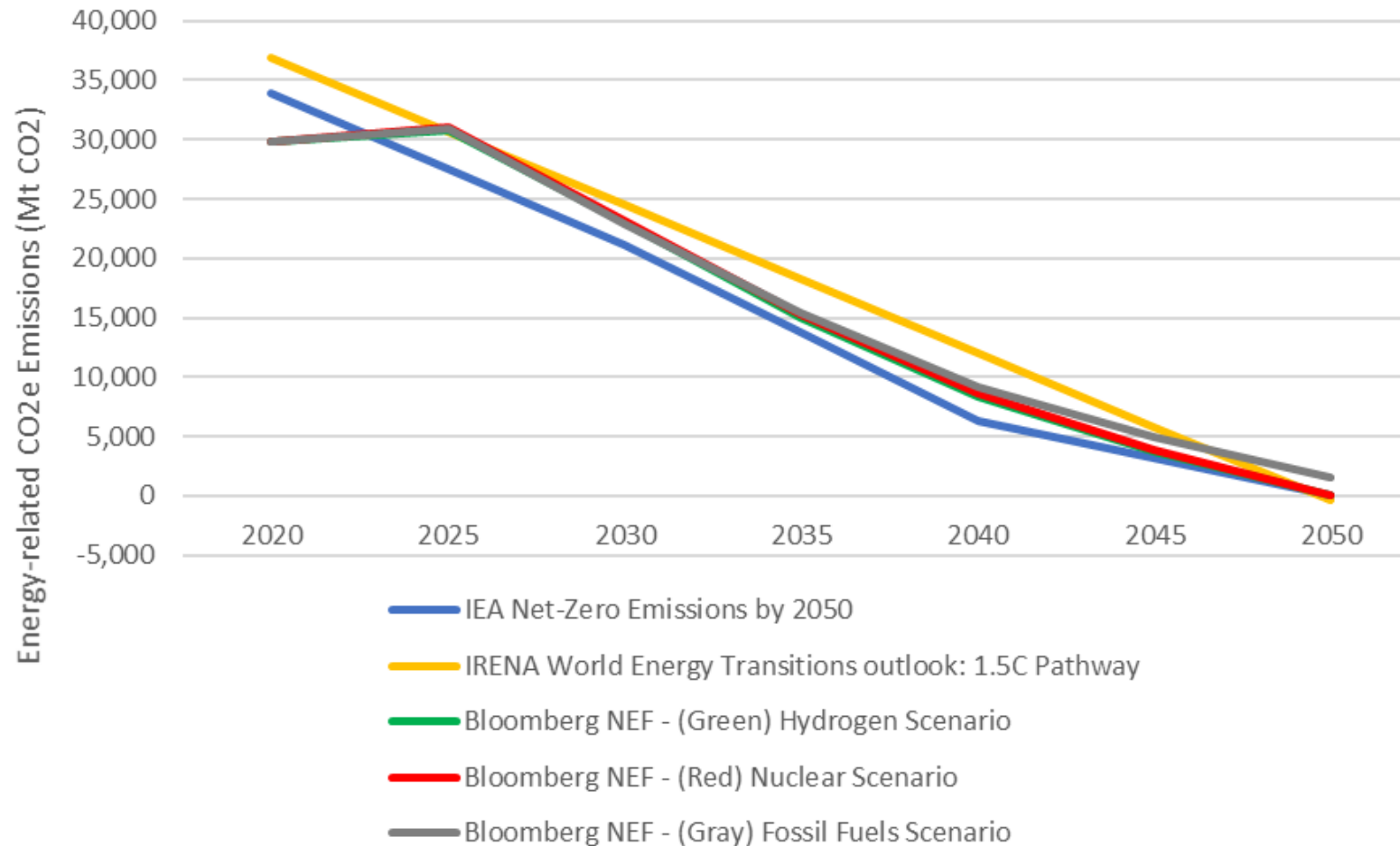
Many of the normative scenarios consist of net zero emissions projections

Institute or Firm	Scenario
International Energy Agency (IEA)	Net Zero by 2050
The International Renewable Energy Agency (IRENA)	World Energy Transitions Outlook: 1.5°C Pathway
Bloomberg NEF (BNEF)	New Energy Outlook (Green Scenario)
Bloomberg NEF (BNEF)	New Energy Outlook (Red Scenario)
Bloomberg NEF (BNEF)	New Energy Outlook (Green Scenario)
Agora Energiewende	Phasing out coal in the EU's power system by 2030
Nordic Energy Research	Nordic Clean Energy Scenarios 2050

NB:

- Some scenarios have differing timelines, geographical or thematic foci
- For consistency purposes, main analysis focused on scenarios in bold

Energy-related CO_{2e} Emissions (Normative scenarios)

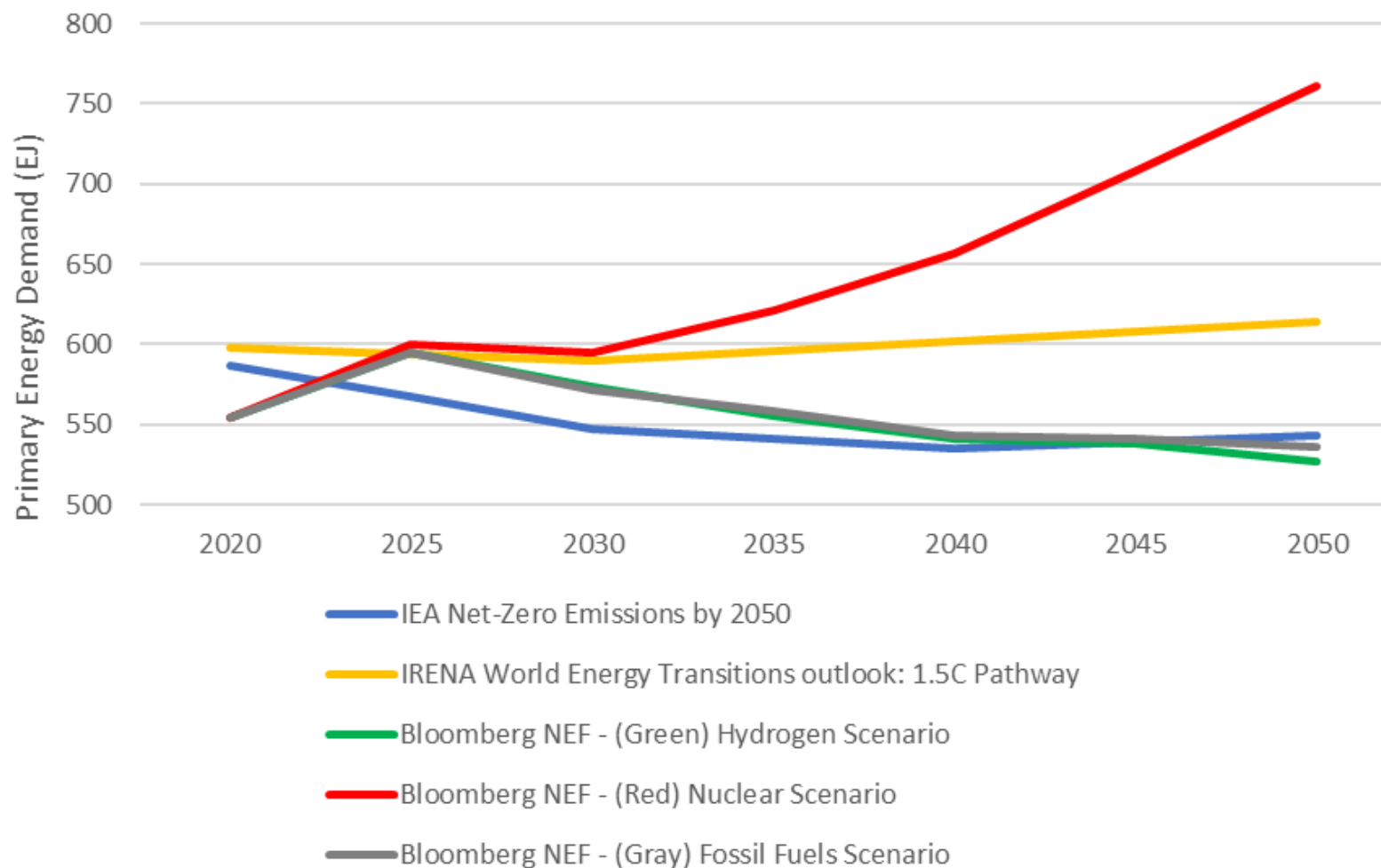


Achieving Net Zero

- ✓ Reduce (Energy intensity)
- ✓ Replace (Decarbonise)
- ✓ Remove (CCUS)

- **Most scenarios reach net zero by 2050, except Bloomberg's fossil fuel scenario**

Primary Energy Demand (Normative scenarios)

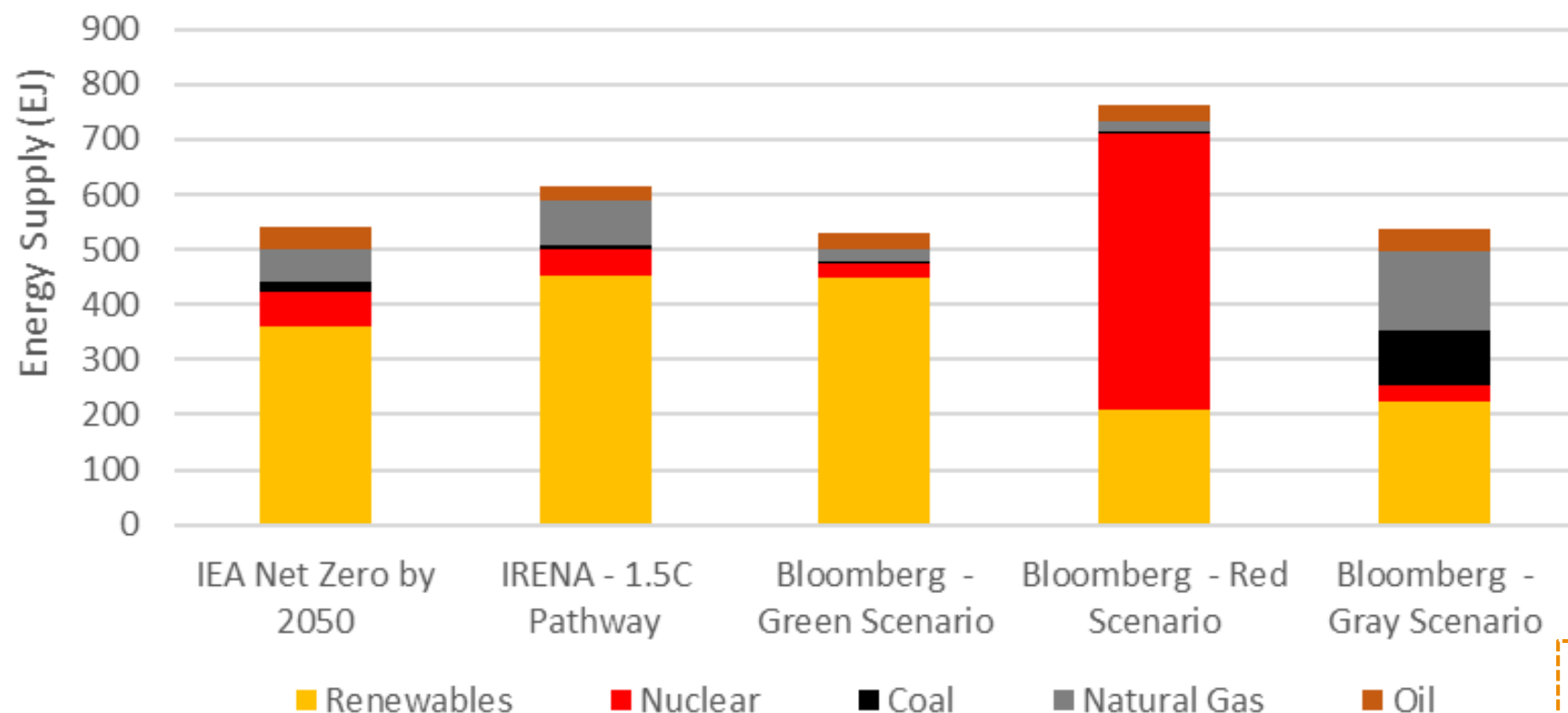


Achieving Net Zero

- ✓ Reduce (Energy intensity)
- ✓ Replace (Decarbonise)
- ✓ Remove (CCUS)

Primary energy demand tends to decrease, except IRENA and Bloomberg's nuclear scenario

2050 Primary Energy Mix (Normative scenarios)

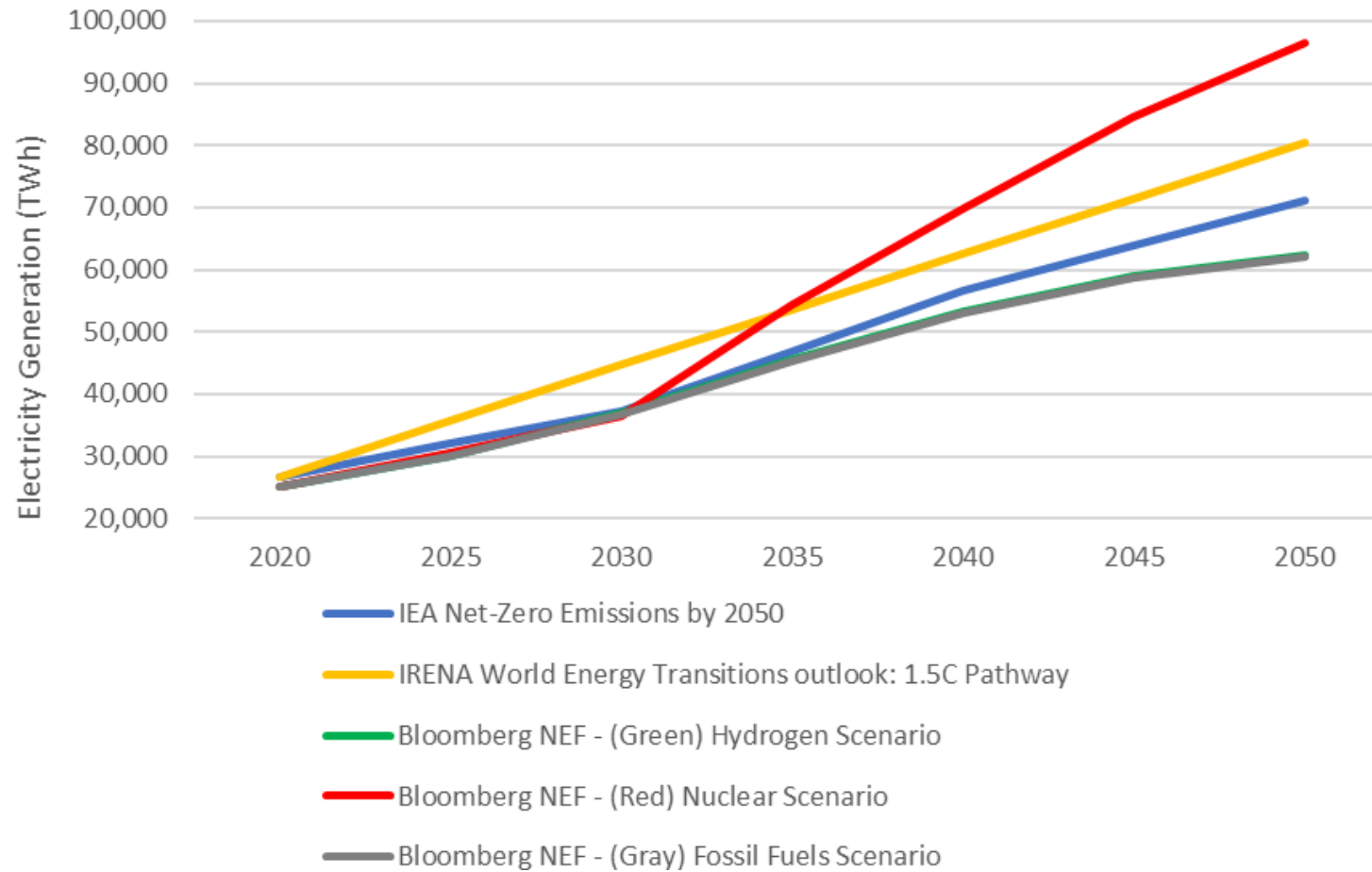


Achieving Net Zero

- ✓ Reduce (Energy intensity)
- ✓ Replace (Decarbonise)
- ✓ Remove (CCUS)

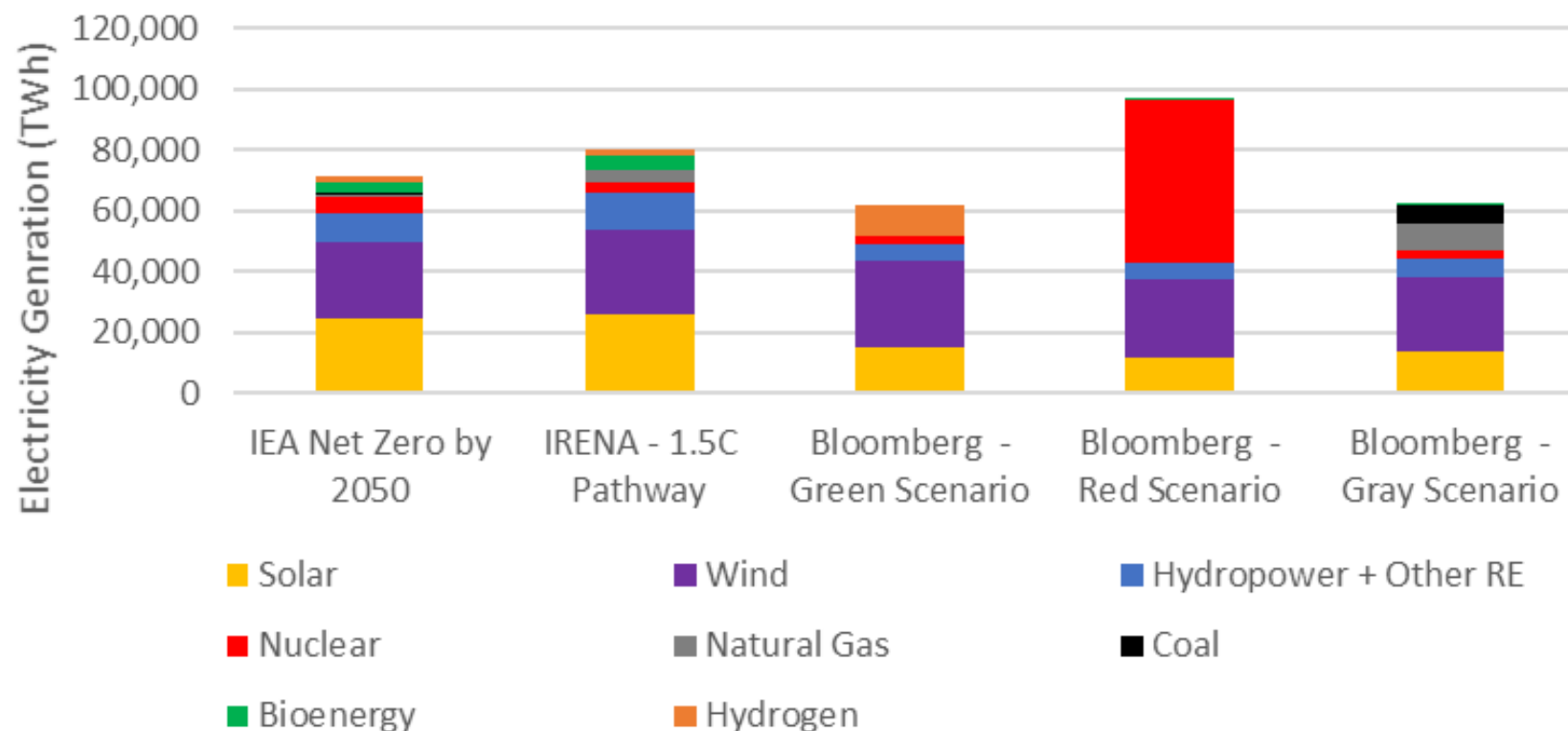
- The world in 2050 is dominated by renewable energy generation
- Fossil fuels (coupled with CCUS) are still present, particularly for harder-to-abate sectors

Electricity Generation (Normative scenarios)



Observed rising demand linked to increased electrification in industry, transport and buildings

2050 Primary Electricity Mix (Normative scenarios)



- In an increasingly electrified world, cheap renewables play a central role in decarbonization effort
- Where fossil fuels remain, CCUS usage is the norm

Main Take-aways (Normative scenarios)

1. Net-zero emissions appear to be achievable, but will rely on a combination of decarbonisation strategies
2. All scenarios project:
 - Gradual electrification of the economy
 - Decarbonisation of the electricity sector
 - Coal phase out, significant reduction in oil consumption
3. In parallel, other technologies can play a significant role
 - Electrolysers-generated green hydrogen (Bloomberg Green Scenario, IEA, IRENA)
 - Small modular nuclear reactors (Bloomberg Red Scenario)
 - CCUS, particularly for natural gas (Gray Scenario, IRENA and IEA to some extent)
 - Advanced battery technologies to complement variable wind and solar (all scenarios)
4. Harder-to-abate sectors in transport, industry & buildings will rely on hydrogen (cement, steel, chemicals), biofuels (aviation, shipping) and fossil fuels with CCUS to decarbonize

Achieving Net Zero

- ✓ Reduce (Energy intensity)
- ✓ Replace (Decarbonise)
- ✓ Remove (CCUS)

Drivers for Change (Normative scenarios)

1. IEA Net Zero by 2050

- Very goal-oriented, specific objectives highlighted every 5 years for all industries
- Economic development has a central role, with significant clean energy jobs creation
- Energy efficiency is key: world economy in 2030 is 40% larger, yet uses 7% less energy
- Investment requirements reach \$5 trillion/year by 2030

2. IRENA World Energy Transitions Outlook: 1.5°C Pathway

- Policy-guided, it promotes a hybrid solution of policies and economic development
- Economic benefits expected to outweigh initial investments two- to five-fold
- Expected \$131 trillion needed by 2050 (34% for energy efficiency, 26% for renewables, 22% for electrification, 12% for fossil fuels and nuclear).

3. Bloomberg Scenarios

- Very technology-driven, as per specific hydrogen, nuclear, and fossil fuels + CCUS scenarios
- Significant increase in recycling for steel, aluminum and petrochemicals
- Expected \$92 trillion to \$173 trillion investments in energy supply and infrastructure by 2050

Relevant Policies for Changes (Normative scenarios)

IRENA

Power Sector

- Feed-in-tariffs, premiums, auctions for renewables
- Tax incentives, subsidies and grants for renewables, R&D

Buildings & Industry

- Minimum energy performance standards
- Enhanced building codes
- Promote building retrofits
- Incentives for electrification of certain economic activities
- Guarantees of origin for green hydrogen

Transport

- Promotion of energy-efficient mobility modes (public transit, rail)
- Financial incentives for electrification

IEA

Power Sector

- Competitive auctions for wind and solar
- Fossil fuel subsidy phase-outs
- Carbon pricing and other market reforms to promote price signals
- Incentives for infrastructure investment (smart transmission, distribution grids)

Buildings & Industry

- Enhance energy codes for old and new buildings
- Foster electrification and hydrogen usage for industrial processes

Transport

- Promote hydrogen-based and biofuels for aviation, and long-haul transport
- Investment in public charging points for EVs
- Incentivize battery production facilities

Bloomberg

Power Sector

- Net-zero climate pledges
- Accelerate deployment of wind and solar PV
- Reduce and retire coal-fired power
- Support scaling up of CCUS, modular nuclear reactors, and hydrogen projects

Buildings & Industry

- Drive switch from gas- and oil-fired heating to heat pumps and electric boilers
- Increase metals and plastics recycling and secondary production
- Promote switch to electricity in low-temperature industrial processes

Transport

- Accelerate switch from ICE to EVs
- Increase biofuels production and blending mandates for aviation

Humanising Energy Vision (Normative scenarios)

Some scenarios have a more **people-centric approach** to the energy transition

1. IEA Net Zero by 2050

- Technological transfer and adequate funding for developing economies
- Ensure remaining 760 million people obtain affordable, reliable energy (SDG 7)
- Safeguard energy affordability for households (tax credits, loans and subsidies)
- Policy attention to address employment losses and minimise hardships

2. IRENA World Energy Transitions Outlook: 1.5°C Pathway

- Economic benefits also include human health benefits (air pollution mitigation)
- Behavioural policies to boost consumers' awareness for reduced consumption and participation in the circular economy

3. Bloomberg Scenarios

- Achieve fair transition for workers and communities, preserve key economic sectors

Outlook scenarios

**Quantitative, expected future based on
business-as-usual trends**

Outlook Scenarios

List of Scenarios reviewed

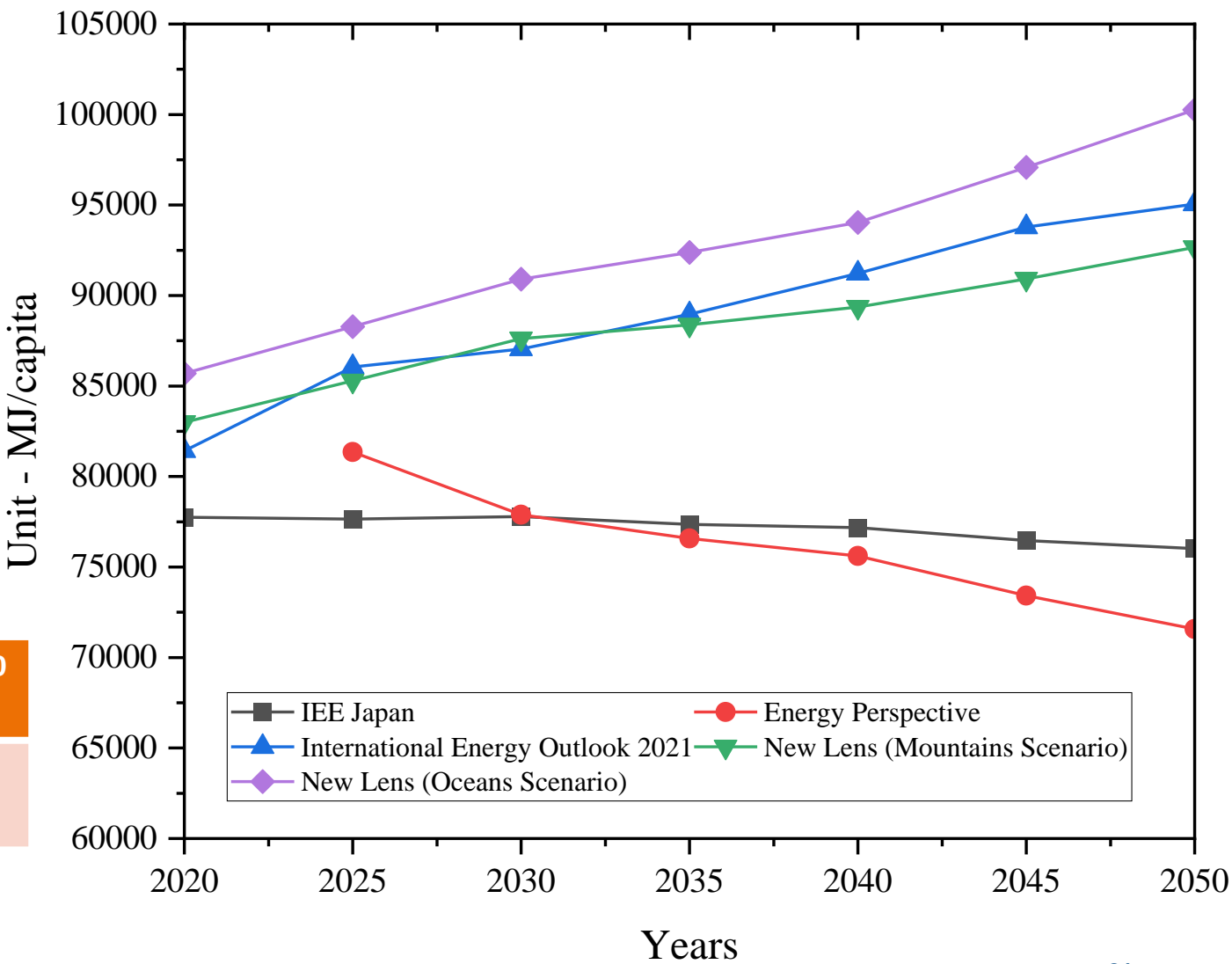
INSTITUTION	SCENARIO
EIA	International Energy Outlook 2021
IEEE	IEEE Japan
Equinor	Energy Perspective
Shell	New Lens Scenarios- Oceans Scenario
Shell	New Lens Scenarios- Mountains Scenario
Massachusetts Institute of Technology's (MIT)	Green Future Index
EU Commission	Global Climate and Energy Outlook

Per Capita Primary Energy Demand (Outlook scenarios)

- Increase of primary energy demand per capita on average of 20%.
- All scenarios increase except IEE Japan and Energy Perspective (average decrease 8%).
- Energy efficiency should be a priority in the energy transition.

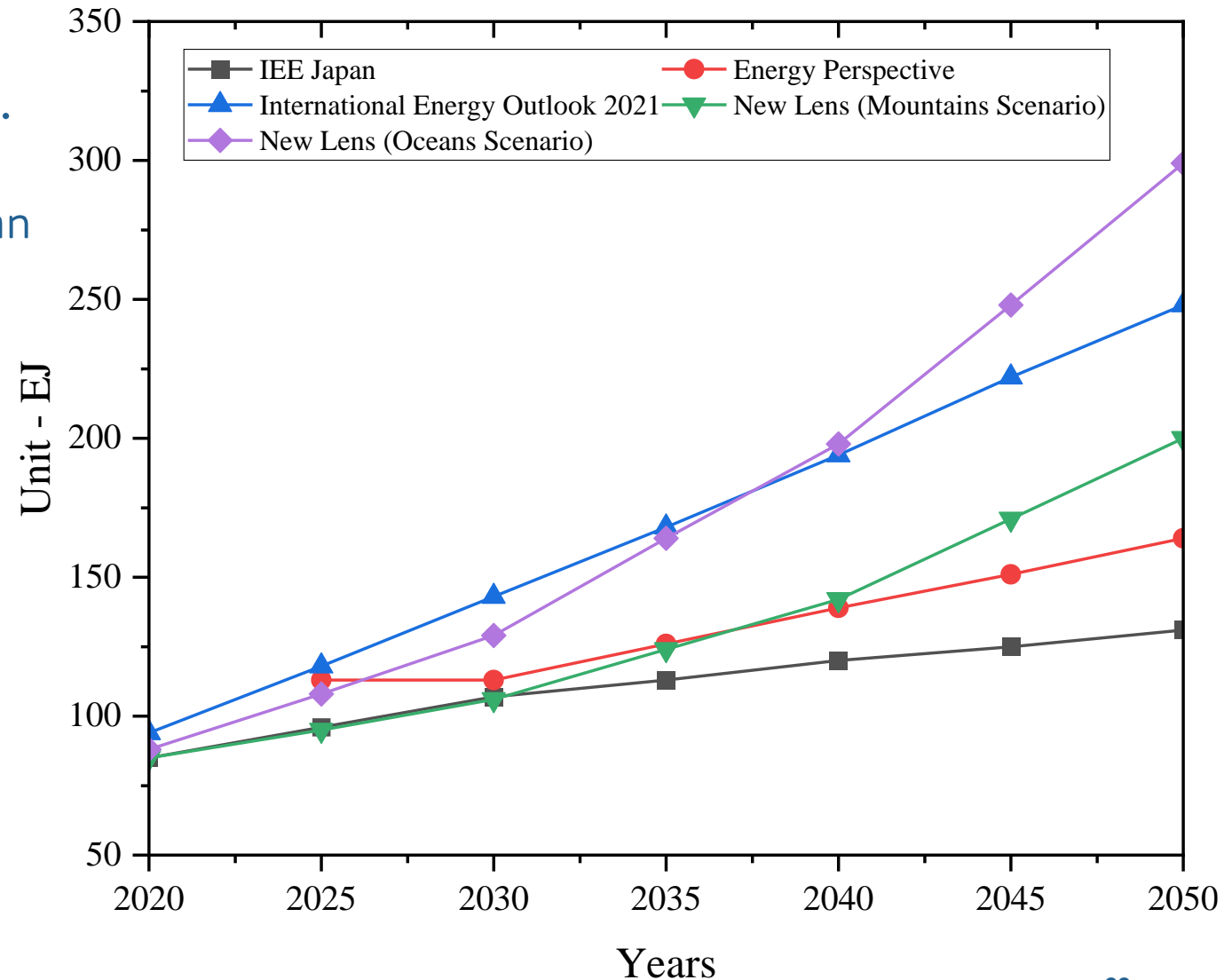
	2020R	2025	2030	2035	2040	2045	2050
Average Demand (EJ)	564	685	720	753	786	819	850

Table 1 - Average Per Capita Primary Energy Demand



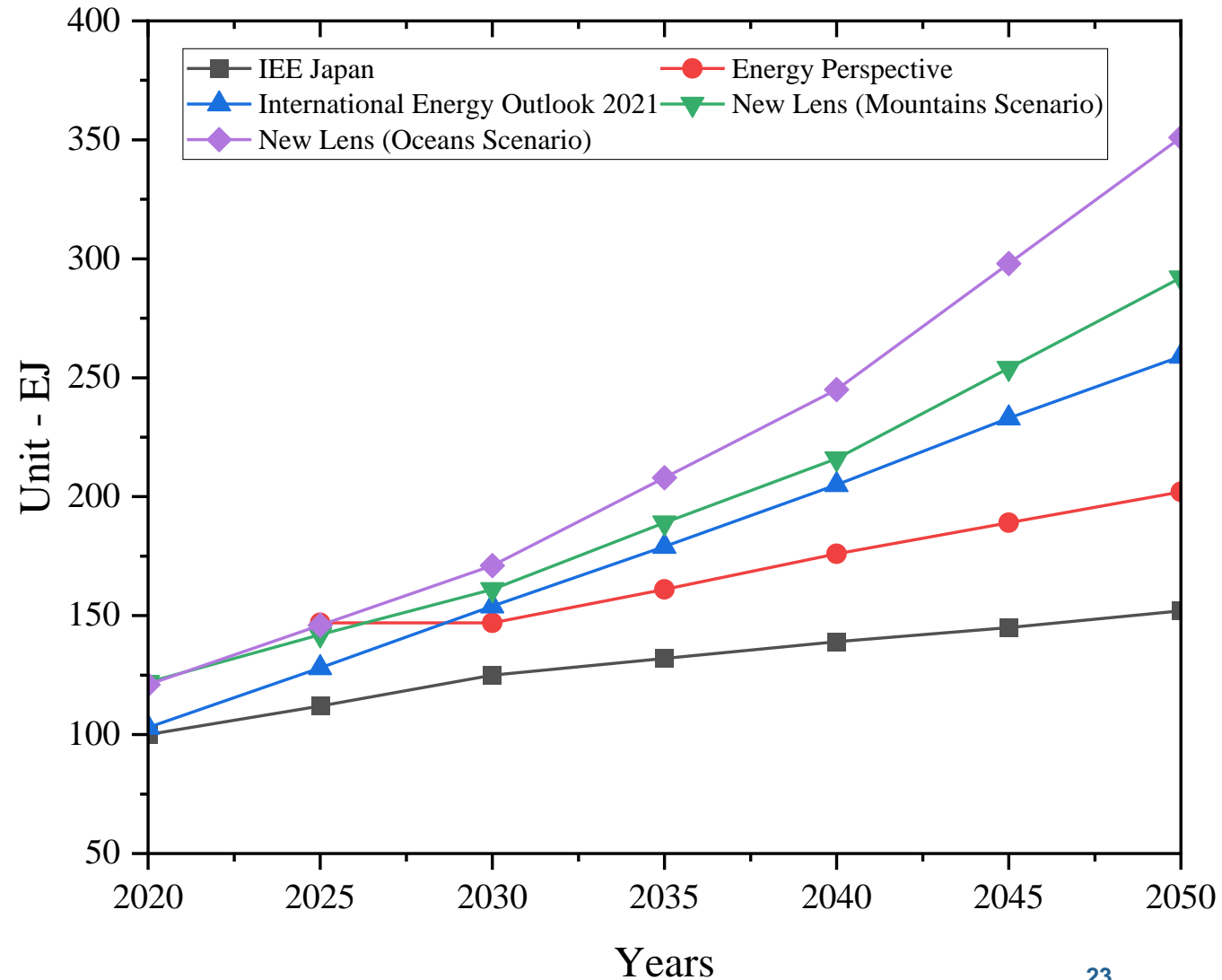
Renewables - Primary Energy (Outlook scenarios)

- Average renewable supply increase of 237 %.
- The renewable supply is increasing faster than the demand.
- Despite the increase on average renewables only account for 25 % of the primary energy supply by 2050, in the best scenario 31 %.
- The increase verified after 2040 is due to a decline in gas demand, and electrification acceleration.



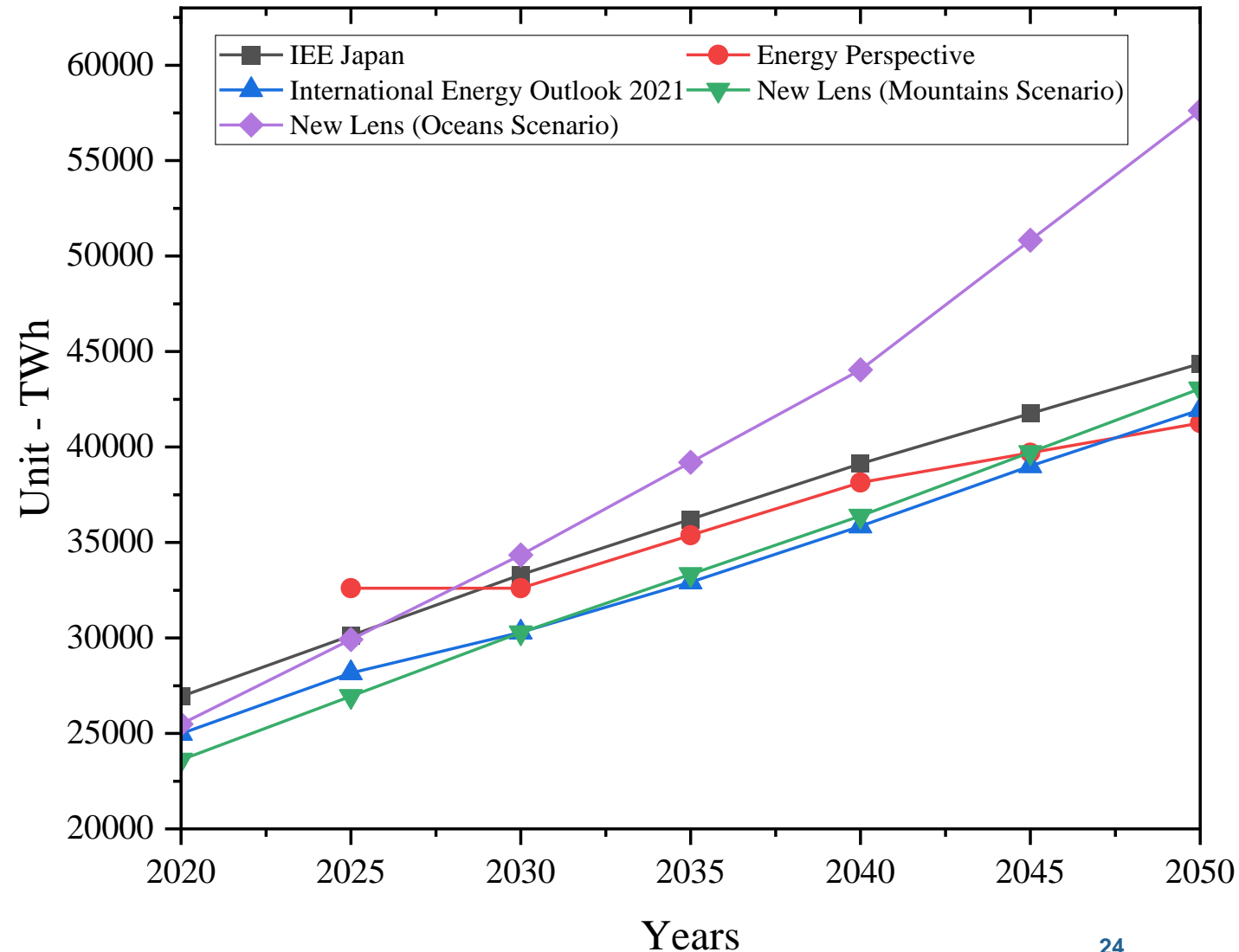
Outlook Scenarios - Low Carbon (Renewables + Nuclear)

- On average 30 % of the demand, best case 36 %.
- The trend of commissionment of technologies is below the increase of fossil fuels + demand increase.
- Transportation, industry and heating sectors need to decarbonize faster.



Outlook Scenarios - Electricity Generation

- Increase is faster than the primary demand, indicating the electrification rate is accelerating (transportation and heating).
- Results very similar in all scenarios, except New Lens.
- Electricity corresponds on average to 20% of the primary demand.



Main Takeaways (Outlook scenarios)

Energy Perspective:

- Economic growth cannot be the main driving force for all decisions.
- Particularly, richer countries will shift focus from maximizing GDP growth to optimizing other indicators - human development, happiness, social progress.
- Carbon budget shared equitably, prioritizing poorer countries and finding them opportunities.
- There's going to be a general increase in GDP.
- Slow growth in Renewable Energy.
- Lukewarm attitude towards energy efficiency.

International Energy Outlook:

- Average annual growth of 2.8% and oil price of \$95 per barrel (2020 Dollars).
- By 2050, global energy use increases nearly 50%. This will increase as a result of population and economic growth.
- Electric vehicle stock contributes to reduced emissions and represents 31% of total passenger vehicle stock by 2050.
- Renewables will be the primary source for new electricity generation, but natural gas, coal, and increasingly batteries will be used to help meet load and support grid reliability.

Main Take-aways (Outlook scenarios)

Global Climate and Energy Outlook:

- From the current trends, we are lagging behind in achieving net-zero.
- GDP is projected to grow at 2.54% per annum over 2020-2050.
- The share of e-fuels and hydrogen reach a marginal share of 1.1%.
- Global final energy demand continues to rise in the CurPol scenario at an average of 1.1%/year for the period 2020-2030.
- Current policies lead to warming in excess of 3°C. This indicates that strong action is needed by countries to deliver on their domestic targets and that reaching the Paris Agreement target of 1.5°C.

Green Future Index 2021:

- There are too many allowances, depressing the price of carbon.
- The world's ability to contain the climate emergency will largely be determined by China, the United States, and the 27 countries of the European Union.

Main drivers (Outlook scenarios)

International Energy Outlook 2021	Global Climate and Energy Outlook	Energy perspective	Green Future Index
<ul style="list-style-type: none"> -Oil prices -Technology -Law and policy -Economic growth -Population 	<ul style="list-style-type: none"> -Market forces -Technology -Renewable Energy -Energy Efficiency -GDP -Population -Energy Prices 	<ul style="list-style-type: none"> -Economic growth -Climate change -GDP -Technology -Human development -Happiness -Social progress -Energy efficiency -Renewable energy -Nationalism 	<ul style="list-style-type: none"> -Technology -Green energy -Carbon emissions -Energy transition -Green society -Clean innovation -Climate policy

Humanising Energy (Outlook scenarios)

- Shifting focus from GDP and Energy growth to human development, happiness and social progress as the main drivers will have positive effect on the demand-side.
- Carbon budget shared equitably, prioritizing poorer countries and finding them opportunities.
- Energy security over climate change is a long-term suicide plan.
- Rise in oil prices is surely going to have a heavy toll of individuals. This has a number of socioeconomic effects.
- High energy demands without consideration of energy mix is worrying. It means the adverse effect on climate change is going to be on the rise looking at the rise in demand for oil.
- Increase in GDP is positive

Plausible scenarios

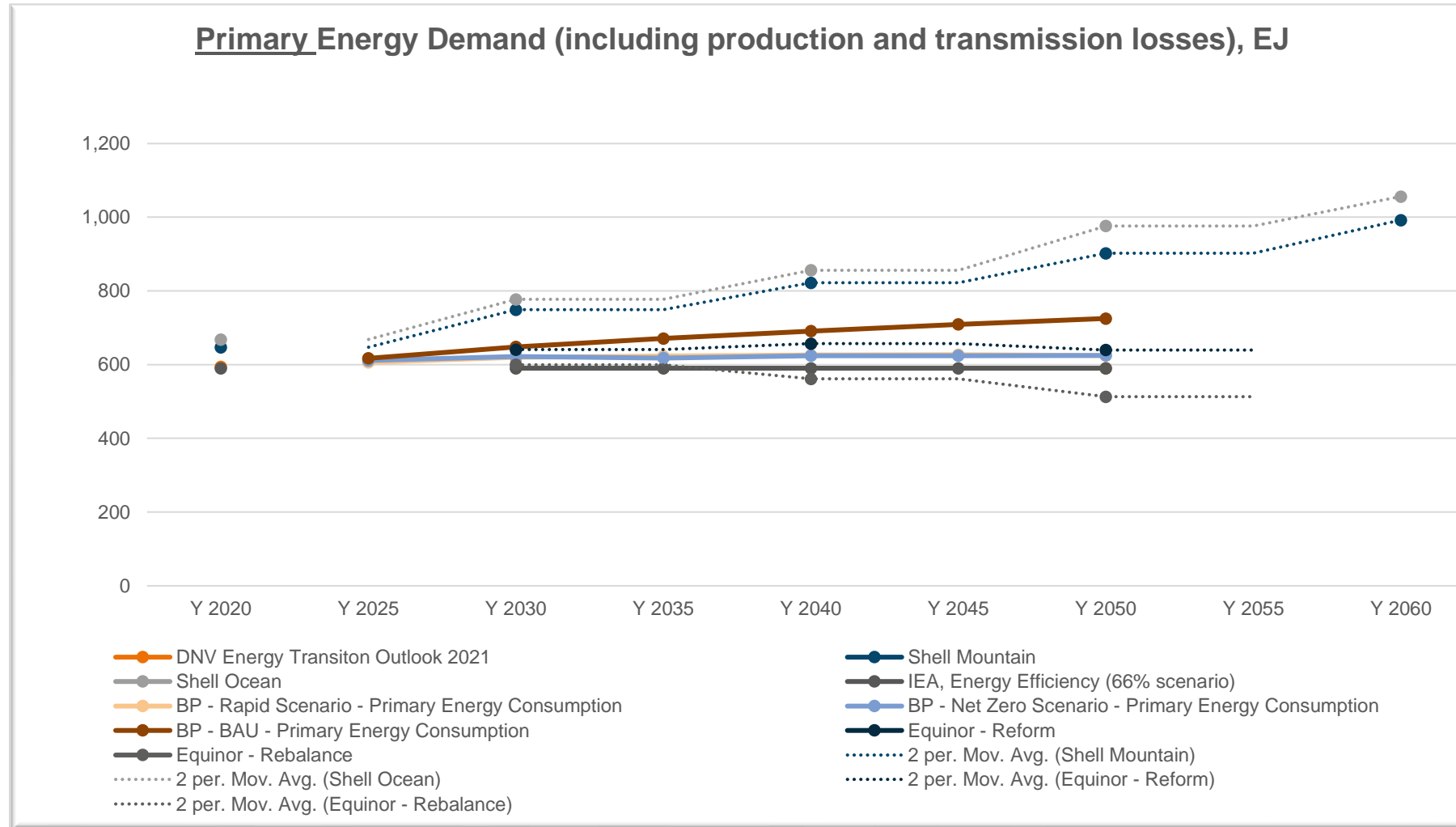
**Qualitative and narrative-led, based on alternative
futures that might happen**

Plausible Scenarios

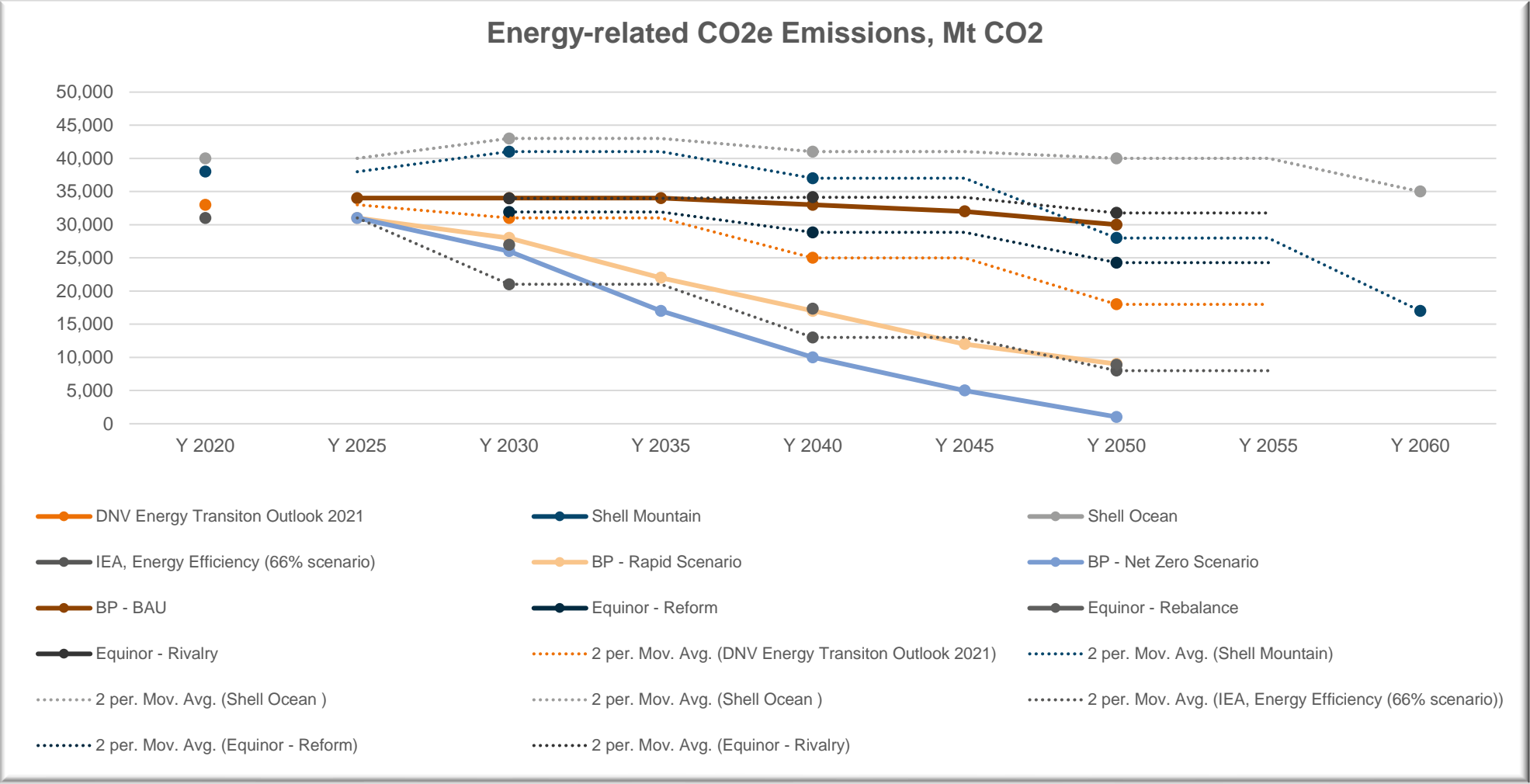
13 Scenarios Reviewed

Institution	Scenario
DNV	Energy Transition outlook 2021Scenario
Shell	Mountain
Shell	Ocean
IEA	Energy Efficiency (66% scenario)
BP	Rapid Scenario - Primary Energy Consumption
BP	Net Zero Scenario - Primary Energy Consumption
BP	BAU - Primary Energy Consumption
Equinor	Reform
Equinor	Rebalance
Equinor	Rivalry
NGFS	Net Zero 2050
McKinsey	Global Energy Perspective 2021
PwC/WEC	Hydrogen Demand and Cost Dynamic

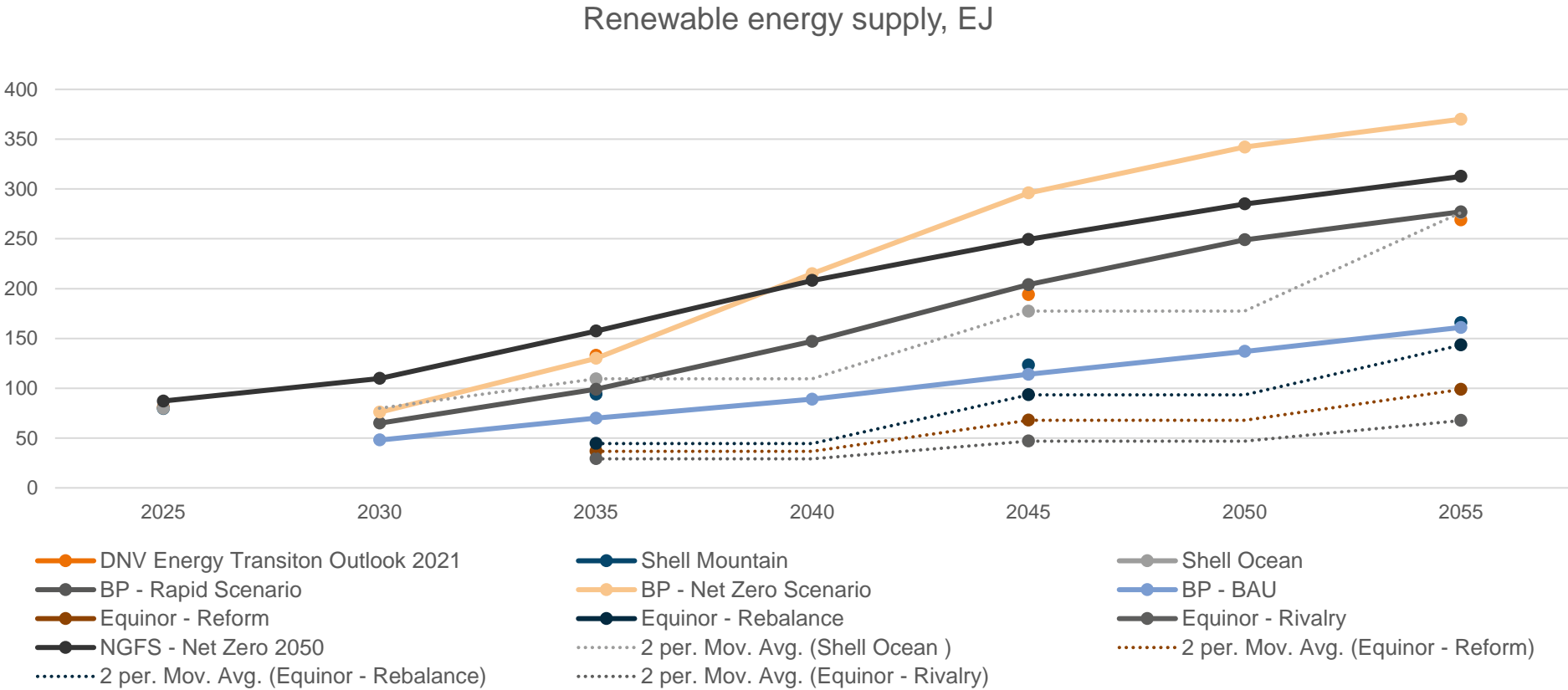
Primary Energy Demand/ Energy-related CO_{2e} Emissions (Plausible scenarios)



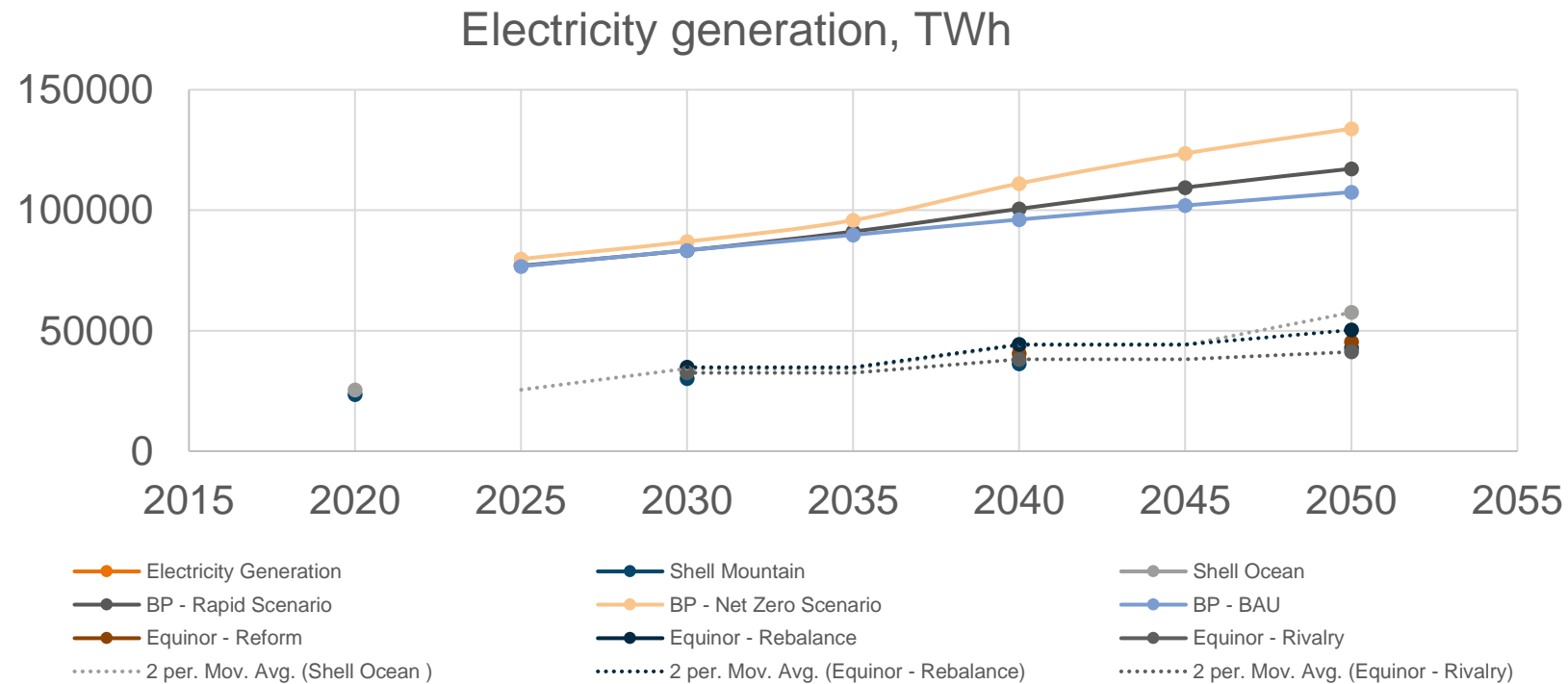
Primary Energy Demand/ Energy-related CO_{2e} Emissions (Plausible scenarios)



RES energy supply, Electricity generation (Plausible scenarios)



RES energy supply, Electricity generation (Plausible scenarios)



Key take aways (Plausible scenarios)

- **Primary energy growth** is demonstrated by 5 scenarios (Shell Ocean, BP Rapid, BP Net Zero, NGFS, Equinor Rebalance), **decrease** is highlighted by 3 scenarios (DNV, Shell Mountain and Equinor Rivarly) and 2 scenarios stay at the same level (IEA, Equinor Reform)
- **Primary energy mix** in all the scenarios shows **increase** in RES, **drop** in Oil energy and keeps dominance for natural gas
- The scenarios **Shell Mountain, Ocean and DNV Energy** show stable trends decreasing oil supply; With even higher ambition BP Rapid, BP Zero Show significant decreases **tending to 0** in the 2050 year
- **Renewables**, particularly Solar and Wind, face **exponential growth** in power generation in the next 40 years

Main drivers (Plausible Scenarios)

DNV	Shell Mountain	Shell Ocean	McKinsey	PwC/World Energy Council	BP Net Zero	Equinor	IEA
Energy Efficiency	Supply side investments and policies (i.e. compact city development)	Biomass, CCS, and solar play a key role in reducing GHG emissions	Stimulus Packages shape future energy systems	Available infrastructure for electrolysis	Rapid growth in wind and solar power, electric vehicles, biofuels, and low carbon	REFORM: Little development in hydrogen and CCUS	International public finance, private investments
Power-to-X; Storage; Connectivity; Demand Response; Carbon Pricing; Solar+Storage	Tight/shale gas and coal bed methane (CBM) make up 'gas backbone' as gas takes central stage	Liquid fuels and coal play key role in energy mix	Electricity demand increase though direct electrification and the uptake of green	Carbon pricing	Carbon pricing	REBALANCE: Technology allows for drop in CO2	Reducing Risks for investors
Hard to abate sectors go for hydrogen, e-fuels, bio-fuels	Efficient CCS technology and renewables	End user efficiency		Standardisation and mass production to lower the cost of electrolyser	Hard-to-abate sectors go for hydrogen, e-fuels, biofuels	RIVALRY: No coal to gas switch; oil demand highest among 3 scenarios (especially in transport)	Flexibility: batteries, demand, response and low-carbon flexible power plants, supported by smarter and more digital electricity networks
Electrification Hydrogen, Electrolysis	Coal in emerging economies with CCS	Heavy Industry sector efficiency (by 80%) Residential energy efficiency (by 60% in 2060, by 90% in 2100)			Electrification of road transport (EVs) Hydrogen produced by electrolysis	RES: continues to grow but at slower pace	

Top drivers (Plausible scenarios)

- Renewables (mostly solar, wind)
- Electrification
- Hydrogen, electrolysis
- New!** ▪ Investments
- Energy efficiency
- CCS
- New!** ▪ Connectivity, demand response (humanising energy)
- New!** ▪ Also mentioned: storages, carbon pricing, digitalization

Conclusions

- Normative, plausible scenarios and outlooks as **main drivers** highlight electrification, decarbonization and energy efficiency.
- **Humanizing energy** concept becomes more visible in scenarios in comparison to the scenarios' analysis performed by WEC in 2019
- **New players in scenarios:** connectivity, demand response, investments, storages, carbon pricing, digitalization
- Scenarios have **different approaches** (policy-driven, market driven or technology driven), however their prospects demonstrate that energy transition is realistic task

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