

# SOME GLOBAL ENERGY SCENARIOS: NOT NORMATIVE BUT DESCRIPTIVE APPROACH

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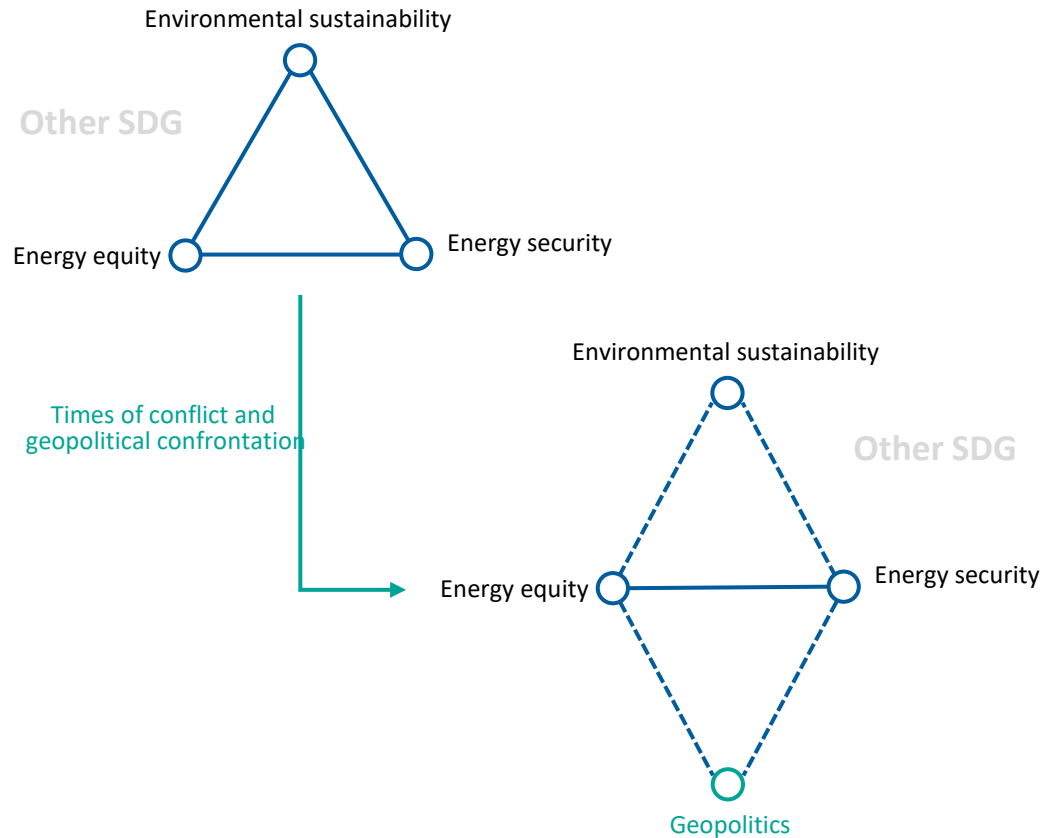


Moscow, 2024

# Policies and scientific and technological progress will largely determine the future of the energy sector

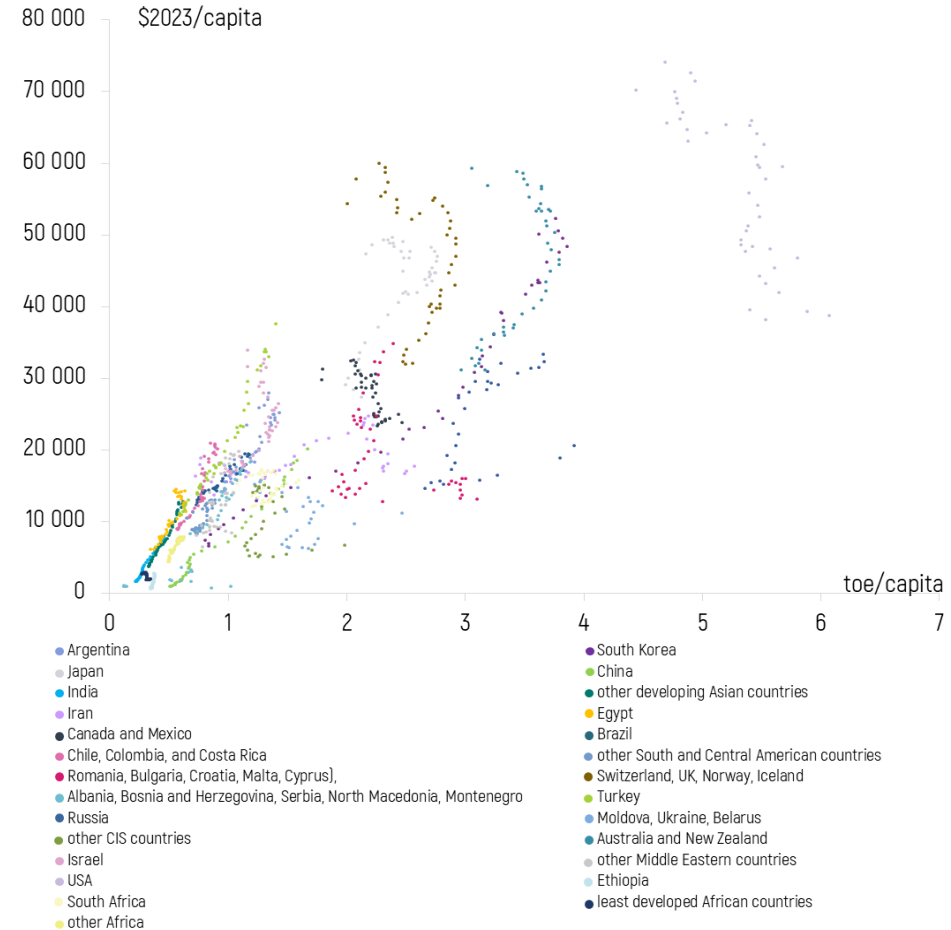
In times of conflict and geopolitical confrontation, the classical **trilemma** (energy equity - environmental sustainability – energy security) turns into a **quadrilemma** where geopolitics comes to the forefront.

Key energy policy targets



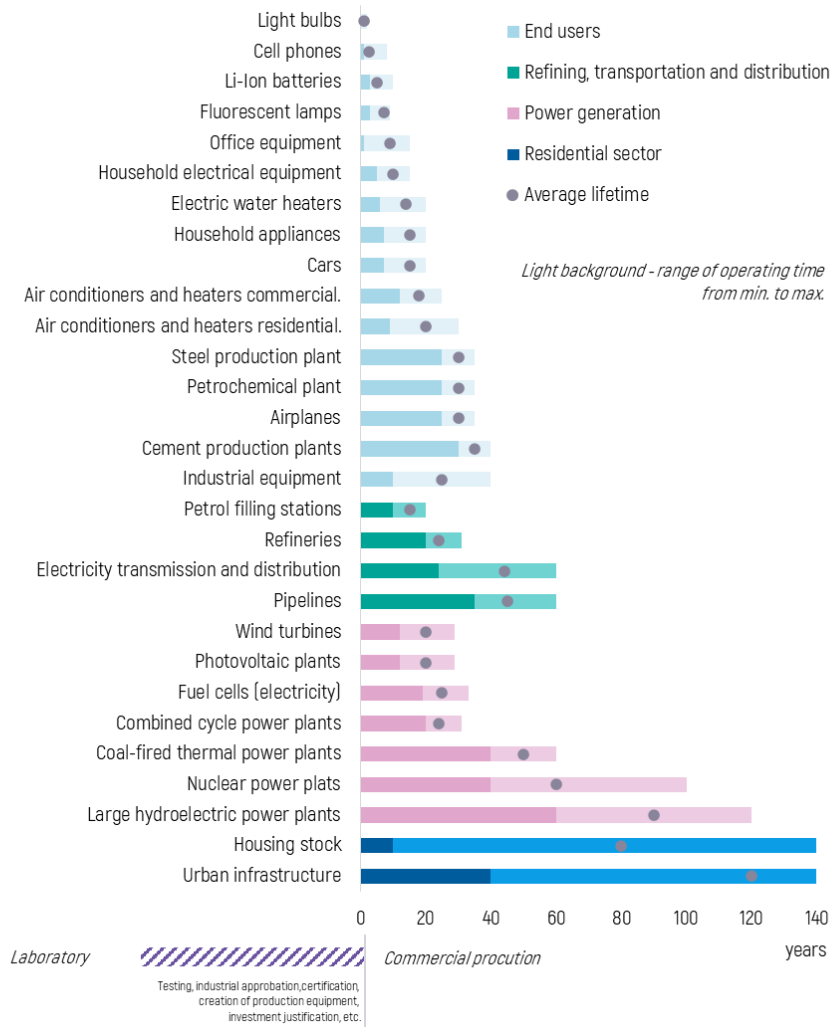
More than **half of the world's energy demand is not satisfied** due to insolvency. Until 2050, the gap between potential energy demand and actual energy consumption is expected to remain almost **twofold**.

Per capita final energy consumption and per capita GDP from 1980 to 2021 by country and country groups



# Technologies don't takeover of markets overnight

## Timelines for upgrading equipment and infrastructure

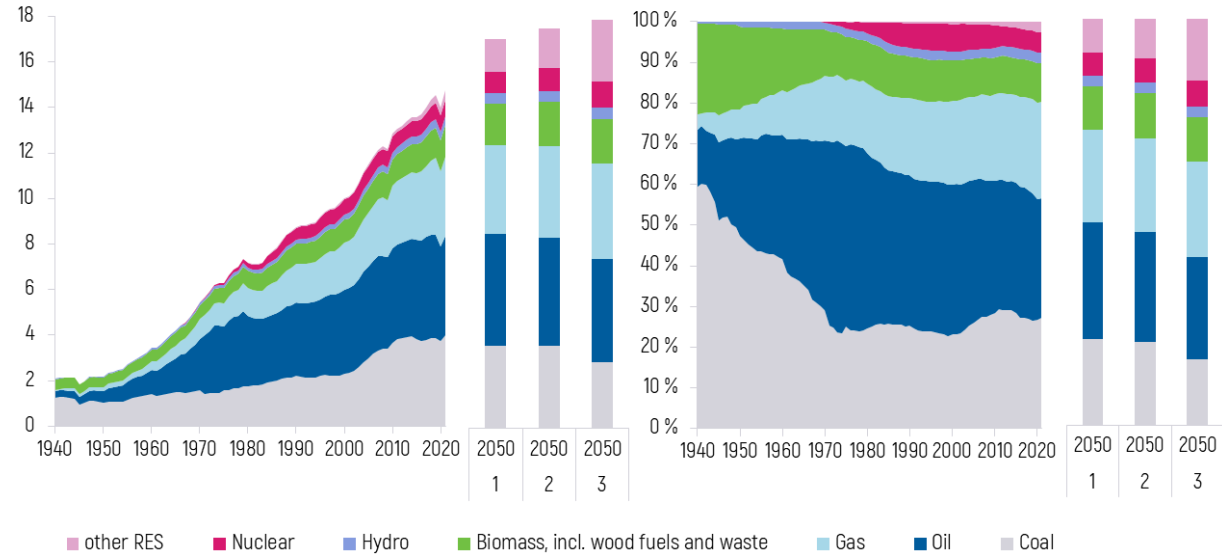


- A new type of battery in cell phones from the moment of commercialization will take over the market (will be used in more than 50% of equipment) in 2-3 years, a new type of oil refining unit - in 25-30 years, a new type of nuclear power reactors - in 60 years;
- Before commercialization, it is still necessary to pass the stages of testing, industrial approbation, justification of investments, creation of production facilities, etc.

# The growth of primary energy consumption is slowing down, with a “peak” possible by 2050

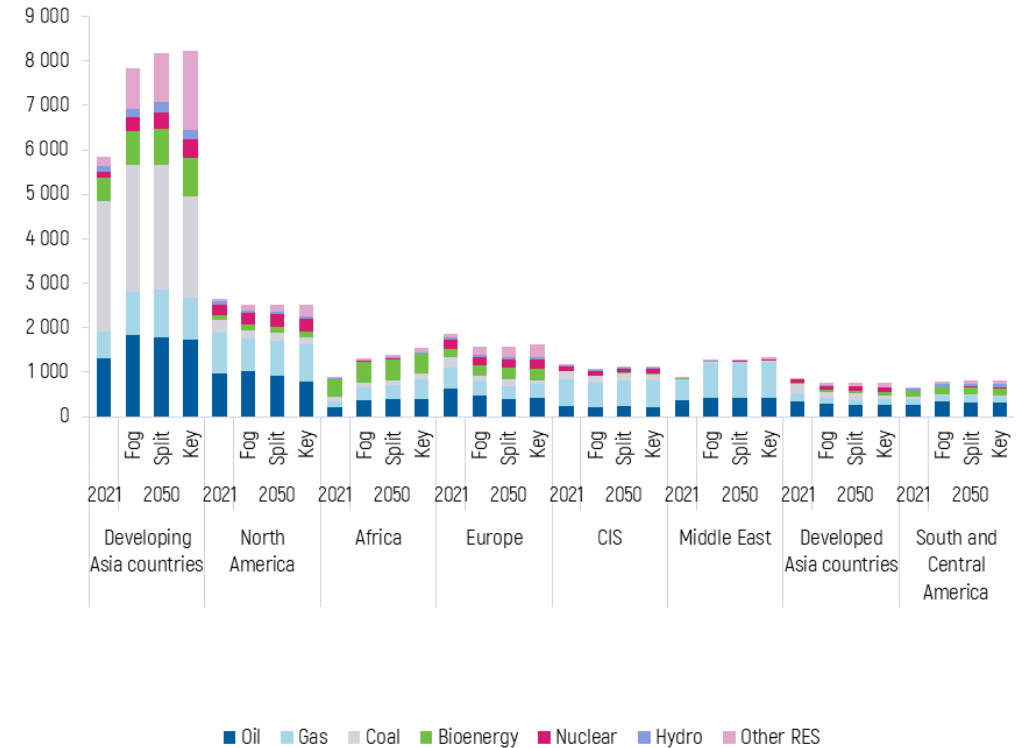
**Global energy consumption dynamics, forecast and breakdown by fuel type from 1940 till 2050**

billion toe



Scenarios: 1 - Fog 2 - Split 3 - Key

**Primary energy consumption forecast by world region by energy type**  
mtoe

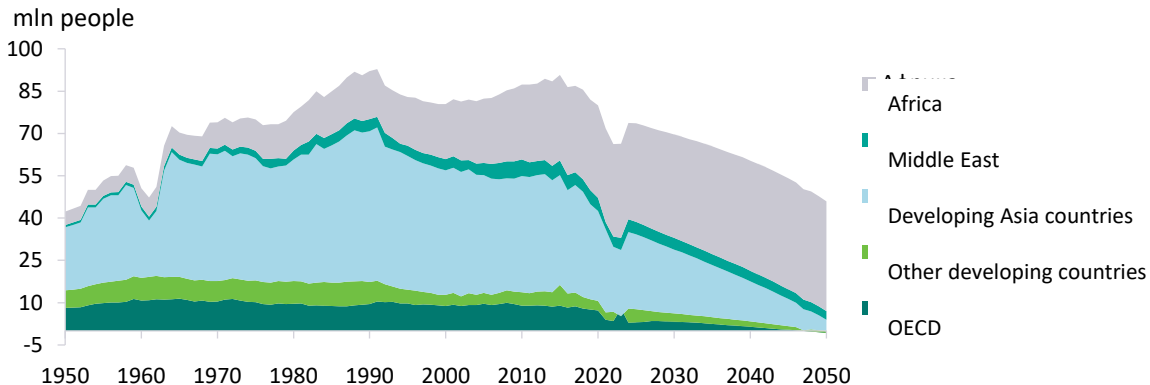


Throughout the timeframe to 2050, the global energy industry will resemble a car on 4 wheels - “oil”, “gas”, “coal” “renewable and carbon-free sources”. Each of these will be important. But, unlike in previous periods, “gas” and “renewable and carbon-free sources” will now take the lead axle.

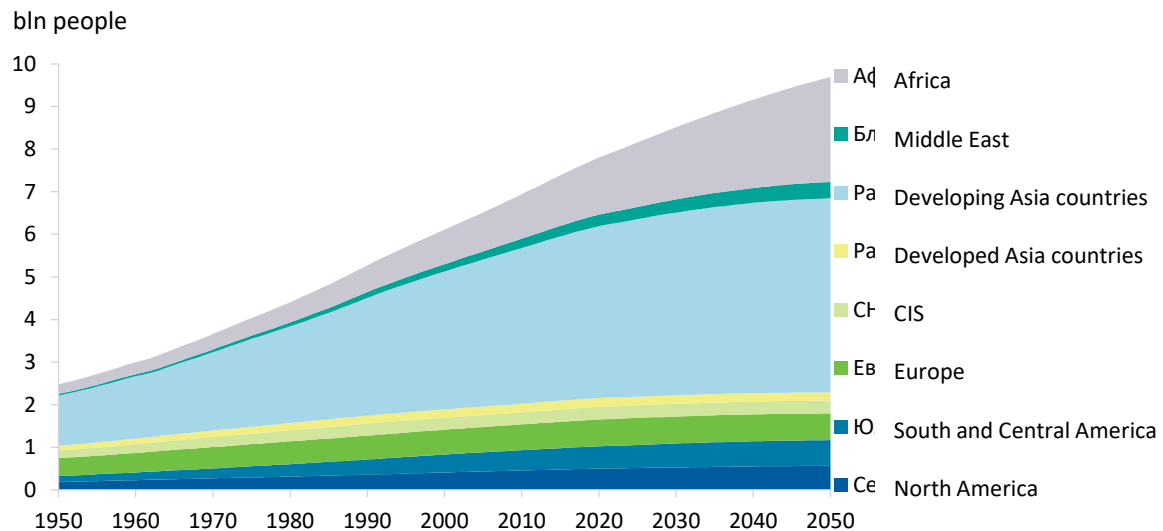


# Economic and population growth is slowing down

Population growth forecast by country groups



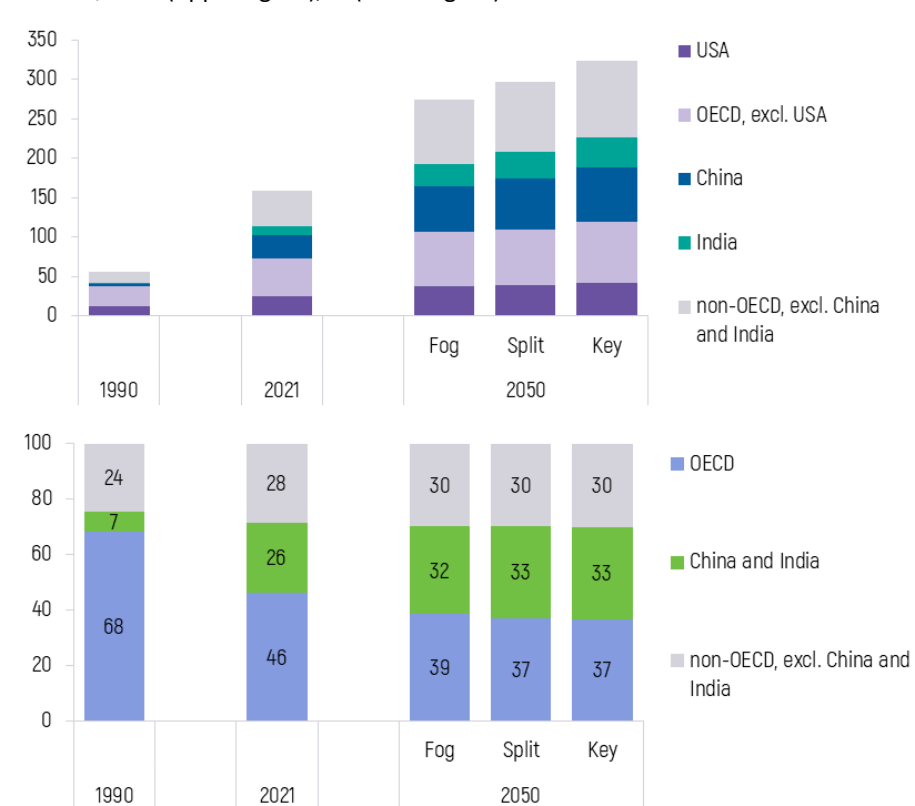
Population forecast by region



In the next 30 years, due to rapidly changing labor conditions, smart policies for education, income redistribution, and social support will be more important than ever before.

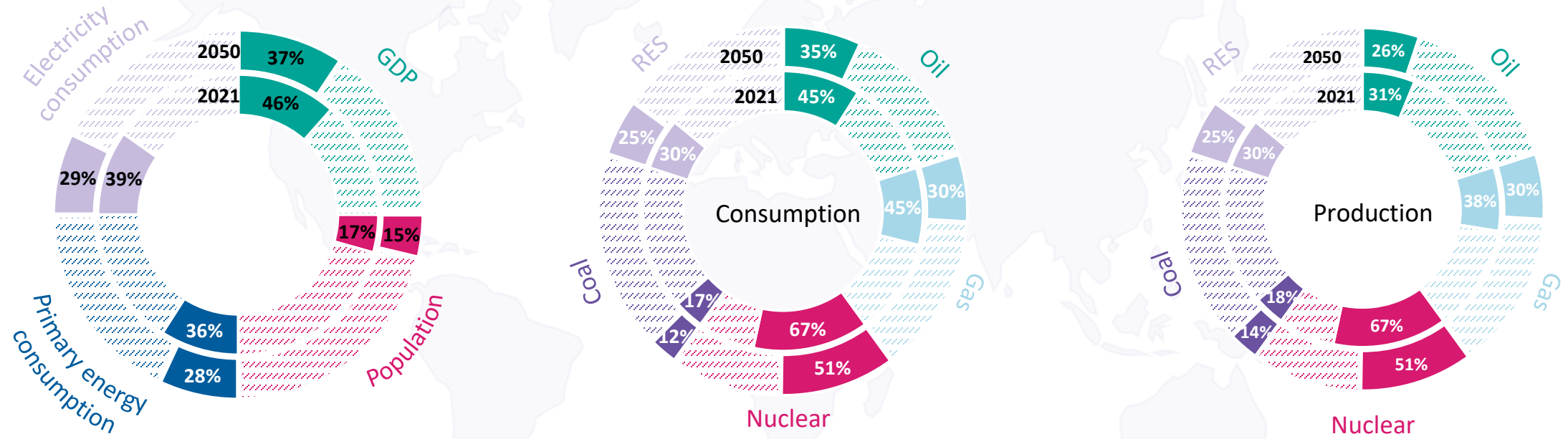


GDP (PPP) forecast by country groups by scenario



# OECD. Once dominant player loses significance

OECD share of world performance in 2021 and 2050 (average of scenarios)

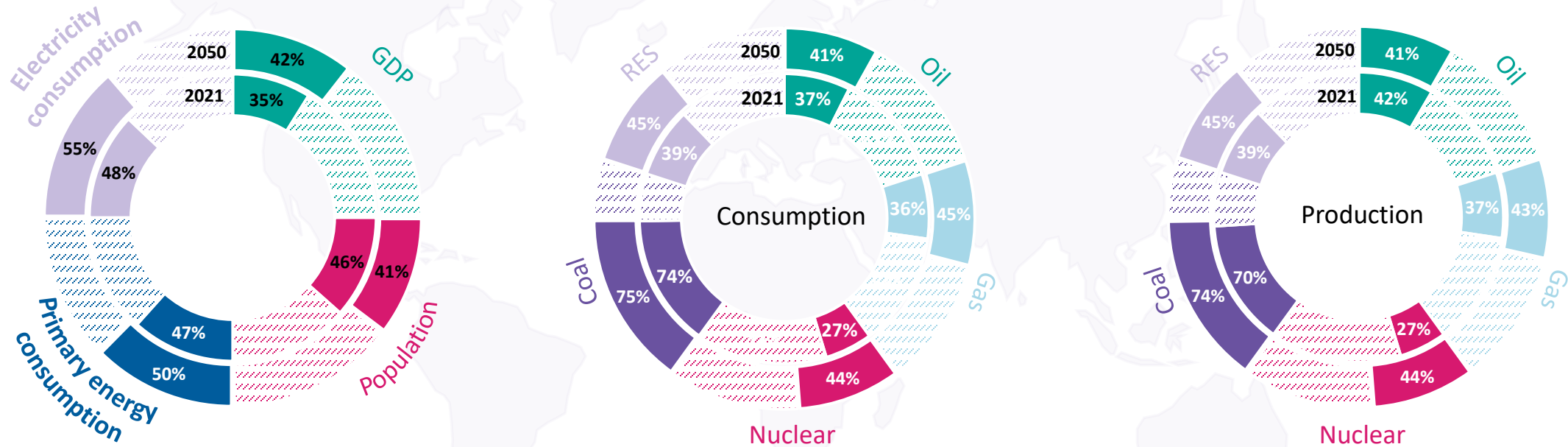


The role of the OECD in the world economy, energy and all fuel markets is decreasing by 2050. At the same time, within the association, the main centers of energy exports will be concentrated in North America and Australia, and the centers of imports - in Europe, Japan and South Korea.



# BRICS will account for 50% of global energy consumption and production by 2050

BRICS share in world performance in 2021 and 2050 (average of scenarios)



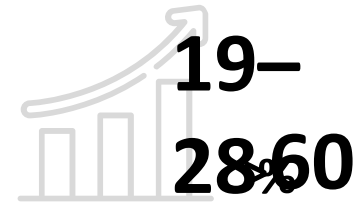
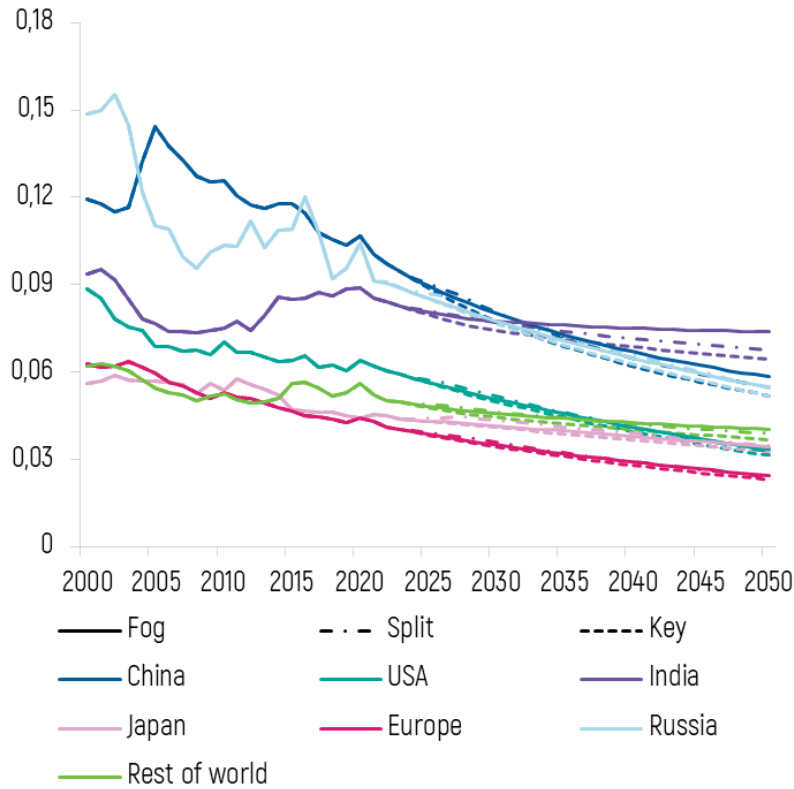
Note: BRICS composition for 2021 and 2050 is shown as of 2024.

With the major oil and gas producers joining BRICS in 2023, the role of the association in the hydrocarbon market has increased significantly.



# Demand for manufactured goods drives global energy demand

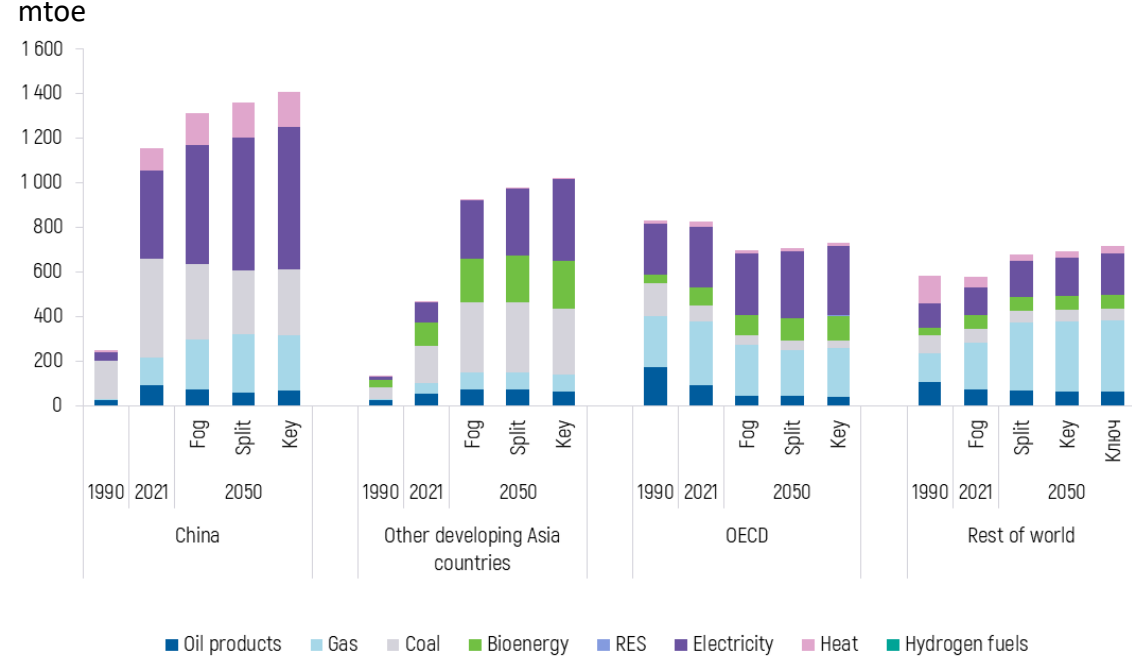
Energy intensity of industrial output in some countries and country groups  
toe/1000 \$2021



Growth of energy consumption in industry by 2050

The share of the “world's factories” - China and developing Asia - in industrial energy consumption in 2050

Energy consumption in industry by fuel



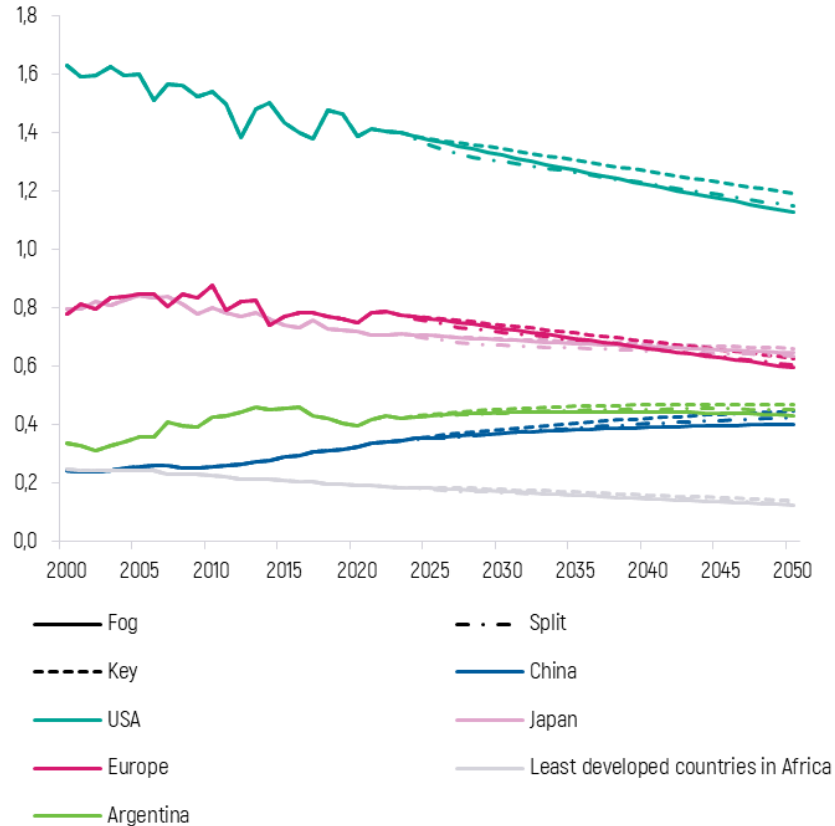
High-temperature processes are powered by traditional fuels - coal and gas. Switching to alternatives is possible for certain technologies, but is limited by high costs. Electrification is the main trend in the medium- and low-temperature industry.





# Demand in commerce and household use is highly dependent on per capita income

Per capita energy consumption in commerce and households in some countries and countries groups toe/capita

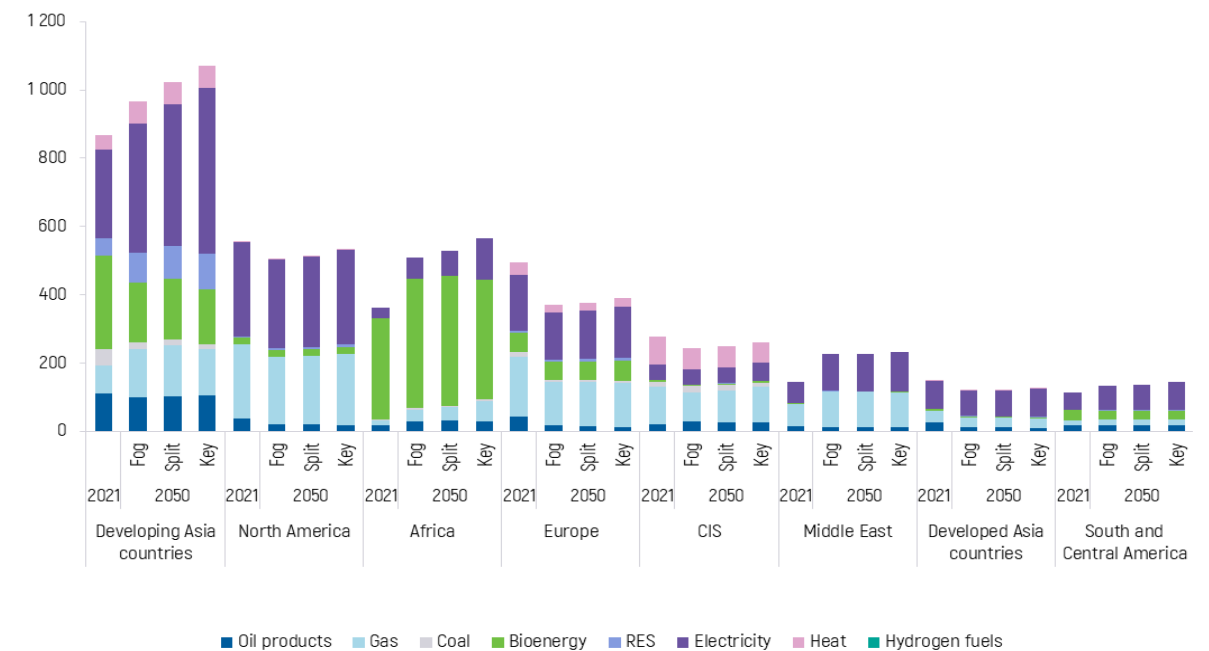


**37%** The share of electricity grows by 2050 as the comfort level of the world's affluent population increases

**49%** The share of traditional biomass remains high by 2050: in none of the scenarios is the world able to overcome energy poverty

**22%**

Energy consumption in commerce and households by fuel type mtoe



For high-income countries, further improvements in energy efficiency lead to reductions in per capita energy consumption, and high energy price levels encourage energy saving. And in a number of low-income countries, prices act as a severe constraint and prevent mass access to energy.



# Increasing prosperity and mobility needs require more and more energy

14-

The share of non-oil fuels in the marine bunkering sector by 2050



19%

99-



Energy demand in aviation will be met by petroleum products due to lack of alternatives by 2050

65-69%



Energy demand from railroads will be covered by electricity by 2050

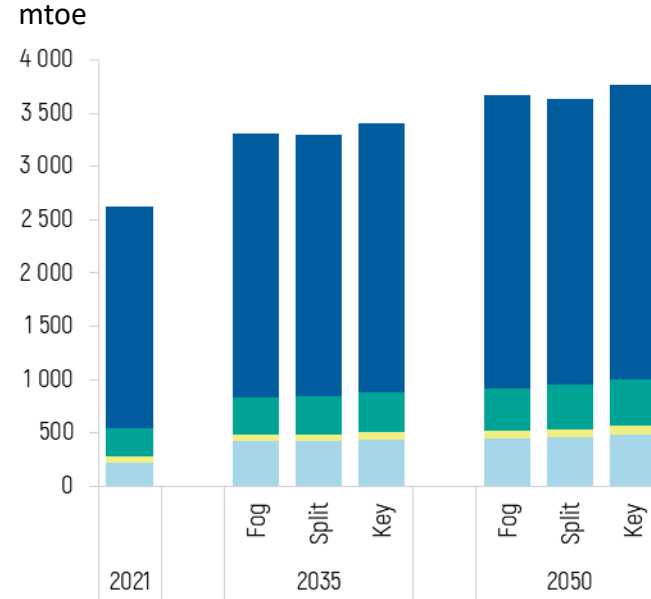
13-

Demand in road transportation will be covered by alternatives to petroleum products



27%

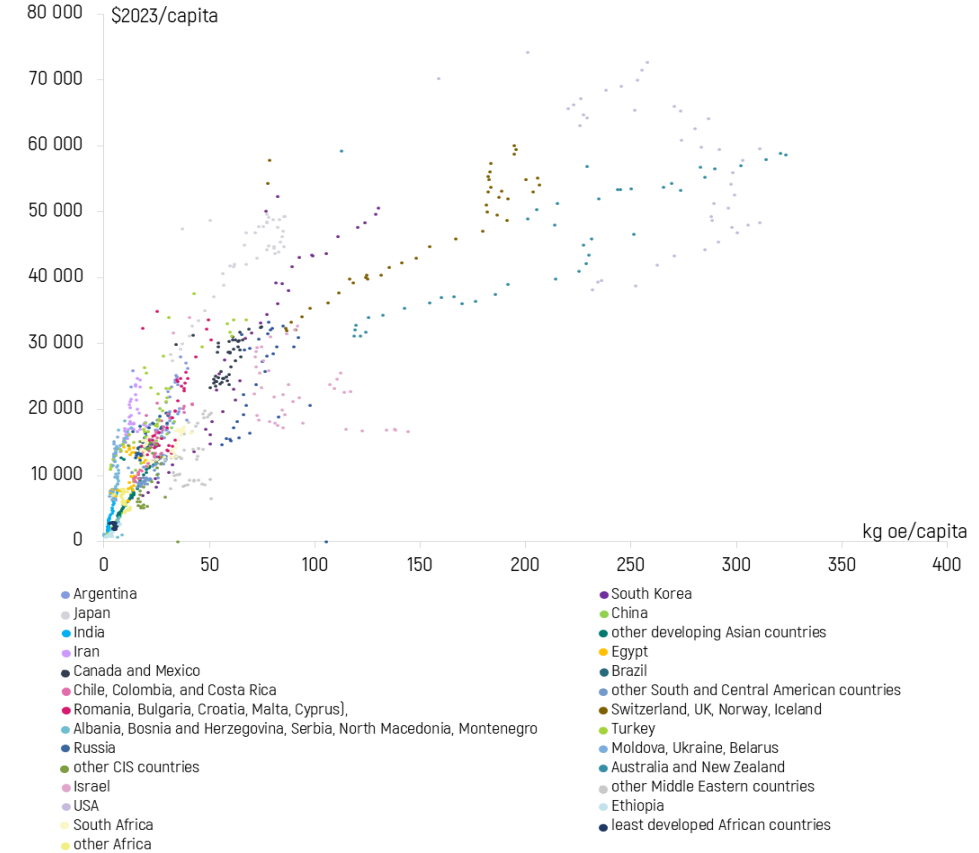
Energy demand forecast by transportation sector



Legend for Energy demand forecast by transportation sector:

- Air transport (light blue)
- Marine transportation (teal)
- Railway transportation (yellow)
- Road transportation (dark blue)

Per capita energy consumption in aviation and per capita GDP from 1980 to 2021 by country and country groups

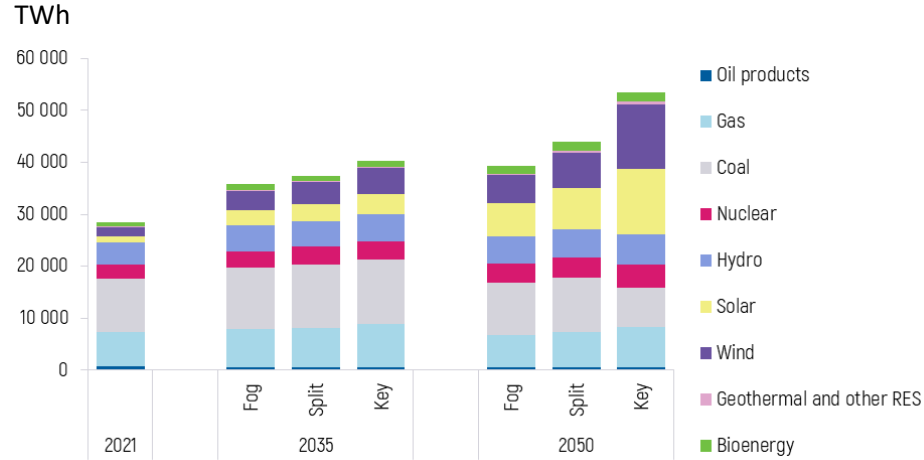


Scientific and technical progress, changing consumer behavior and environmental policies have set the basis for the transition to a new technological era in the transportation sector, which will be based on active inter-fuel competition, the development of driverless solutions and compact vehicles with various functionality

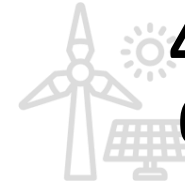
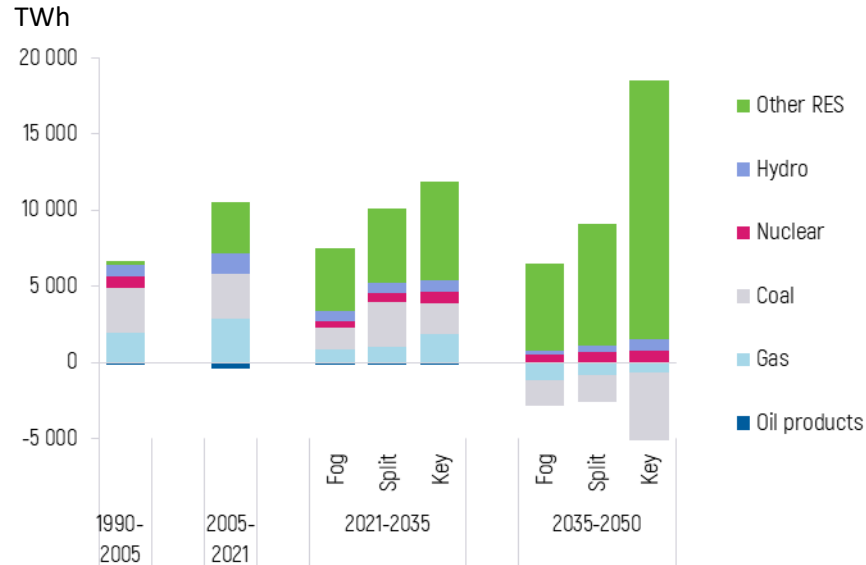


# Electricity generation is growing strongly with a dramatic re-shaping of the energy mix. Accelerating low-carbon agenda brings back interest in nuclear power

Global electricity consumption by fuel type



Global electricity consumption growth breakdown by fuel type



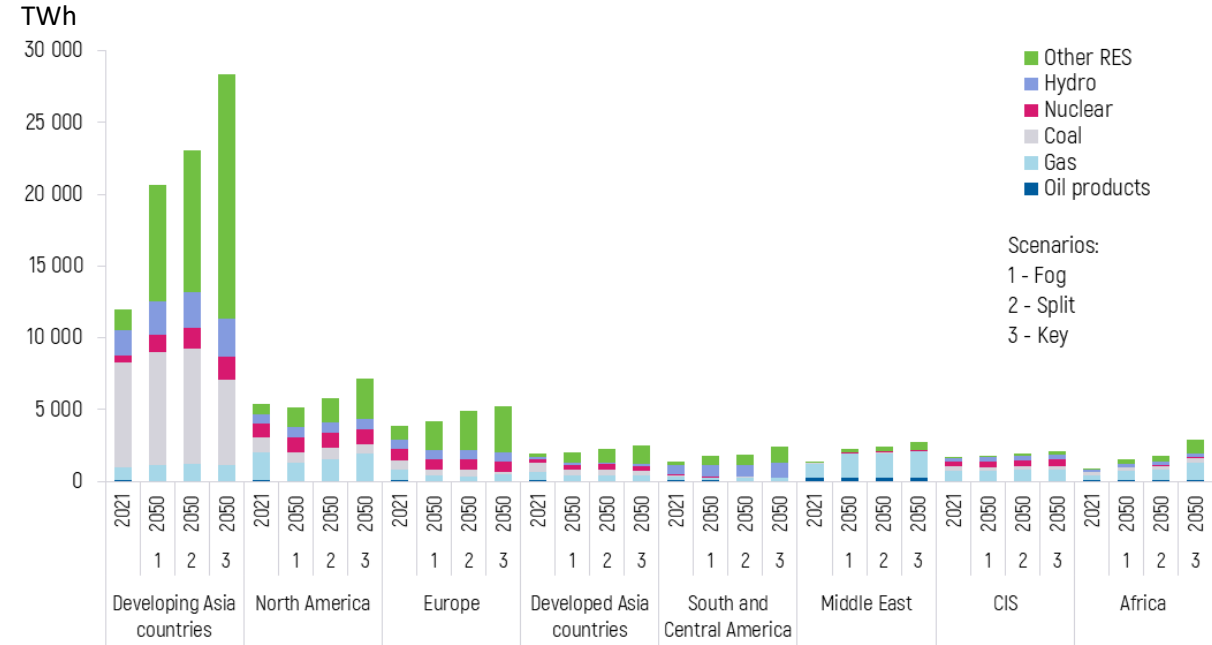
**40-90%** Electricity consumption growth by 2050

**62-**

**66%**

RES will provide the increase in electricity generation in 2021-2035, in 2035-2050 – almost the entire increase

Global electricity production by region and fuel type

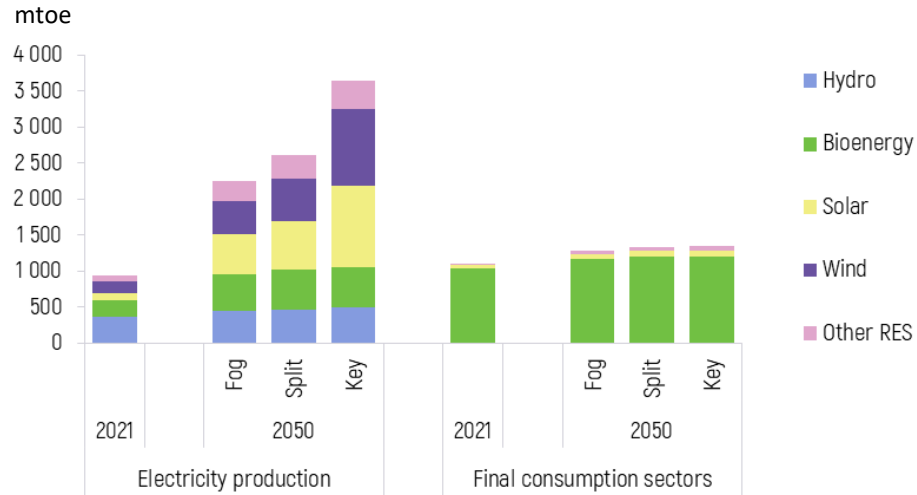


- There will be no universal recipe for electricity supply in the next 30 years.
- Each country will need to find its own reasonable solution to the generation structure, taking into account its priorities, financial capabilities, natural and climatic features and availability of energy sources.

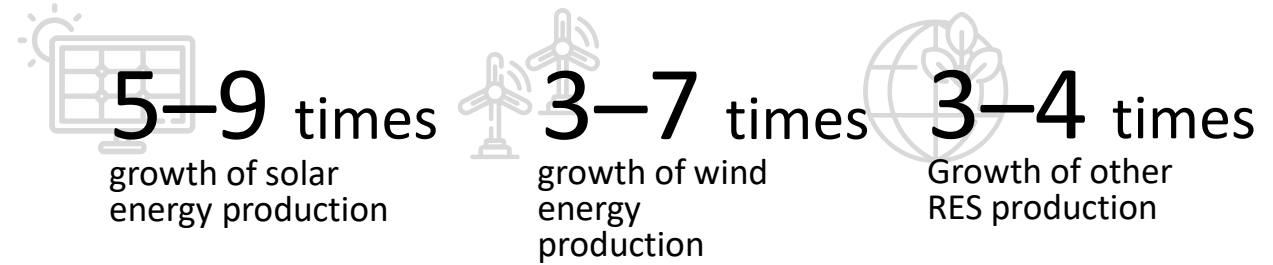
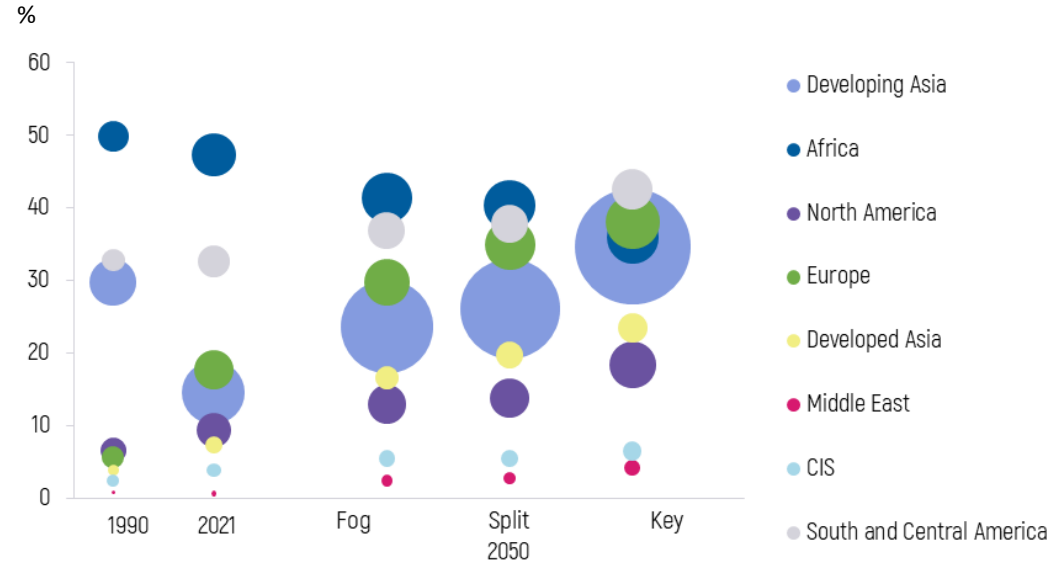


# The entire increase in renewable energy consumption is expected to take place in power generation

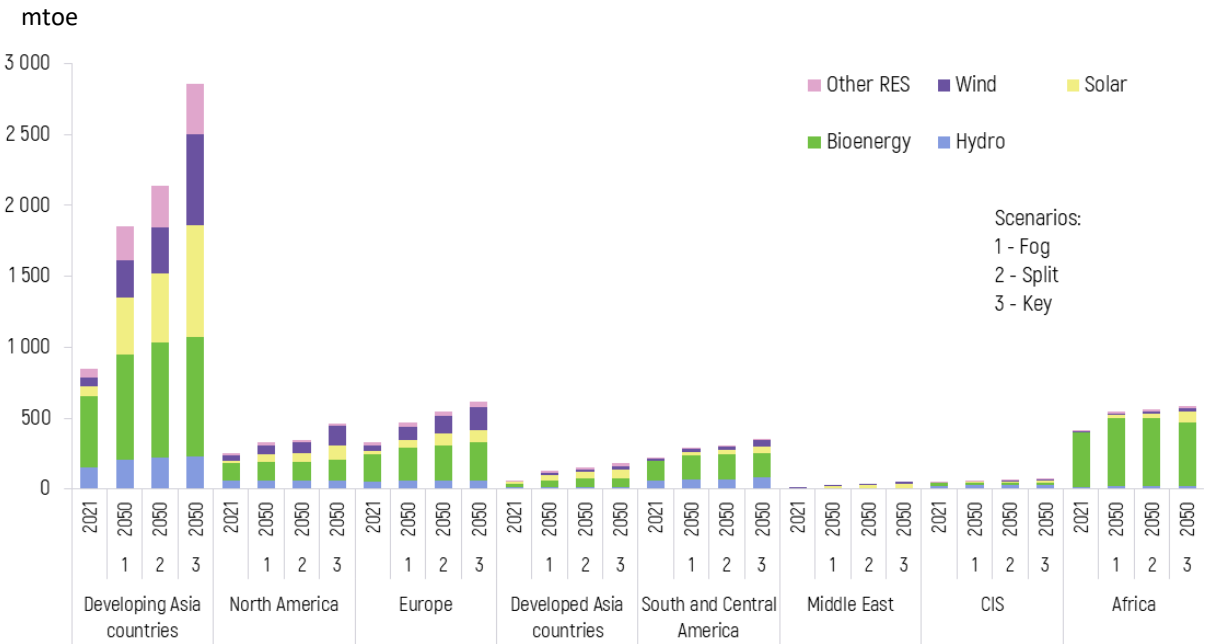
Global renewables consumption by sector by type



Global renewables consumption by region



Main types of renewables by region by scenario in 2021 and 2050

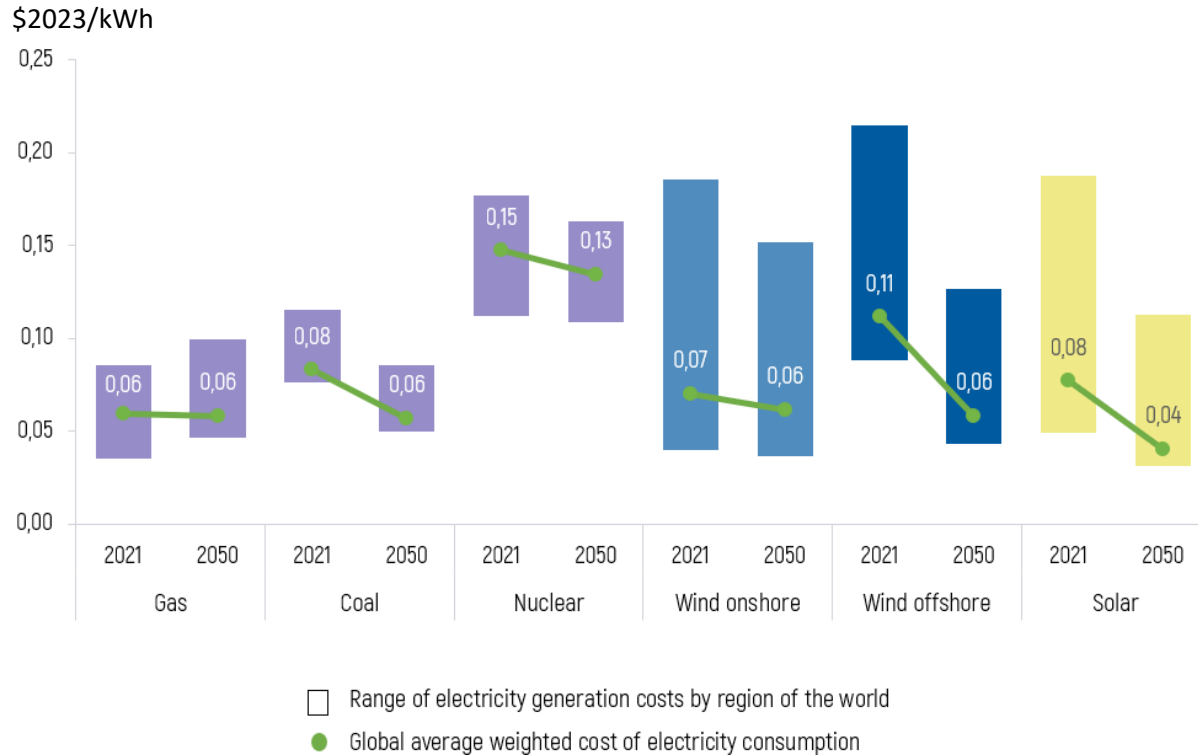


The share of renewables in the energy mix will decrease only in Africa due to a shift from firewood to more efficient energy sources. In other regions, it is steadily increasing.

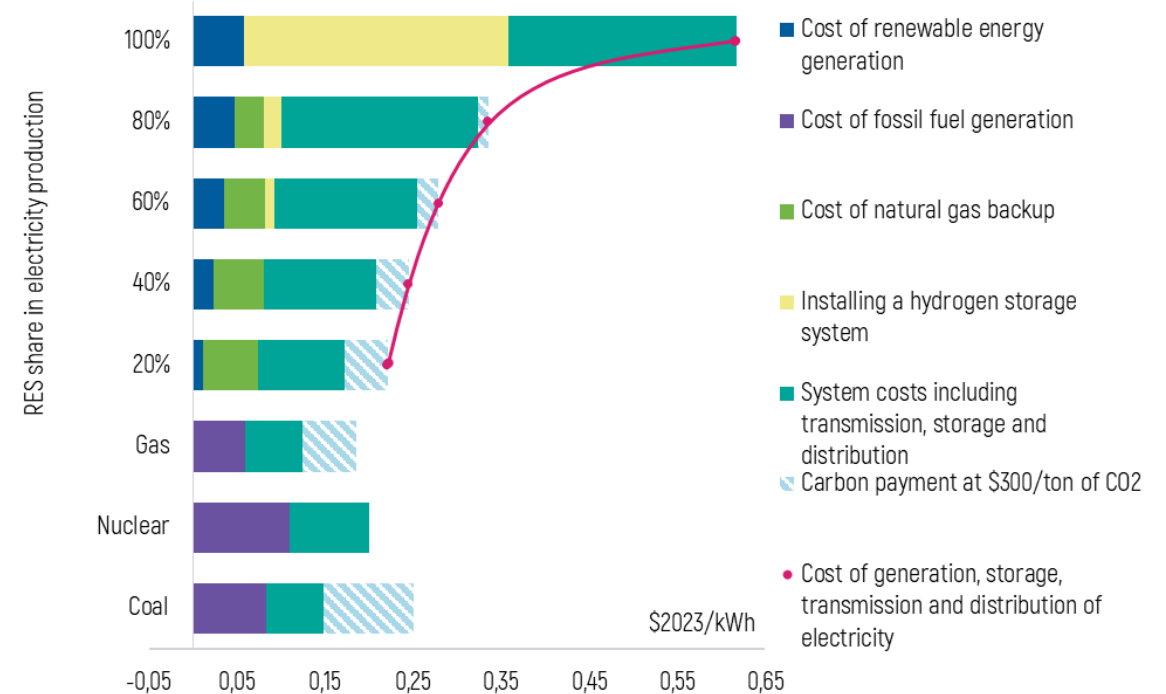


# Renewables are within the zone of competitiveness with thermal generation

Forecast of change in the cost of electricity generation (LCOE) by source in 2050 compared to 2021



Schematic change in the full pre-tax cost of electricity supply, taking into account the cost of generation, system effects, payment for CO2 eq.



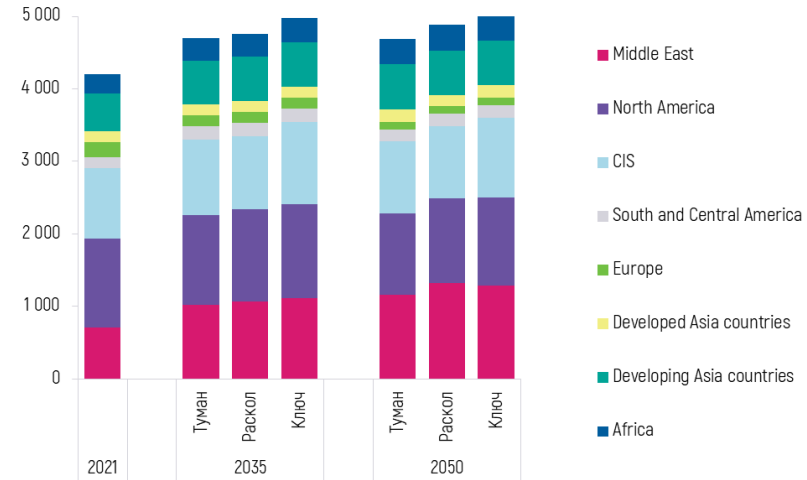
The transition from gas and coal-fired generation to 100% RES utilization will lead to a 3-5 times increase in the cost of electricity supply, taking into account all system effects and increased risks of system sustainability. But there may be acceptable compromises combining different types of generation



# Fossil fuel markets

Global gas production by scenario by region

bcm

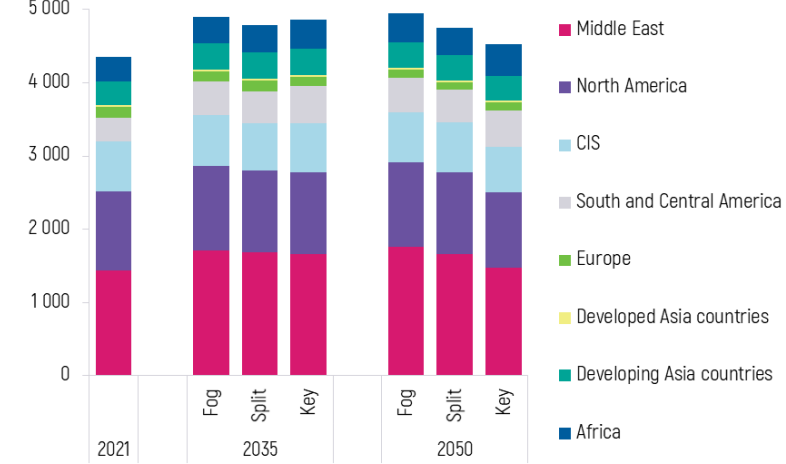


**~70%**  
of global gas production will be provided by three regions

- ~ 26% Middle East
- ~ 24% North America
- ~ 21% CIS

Global oil production by scenario by scenario

mtoe

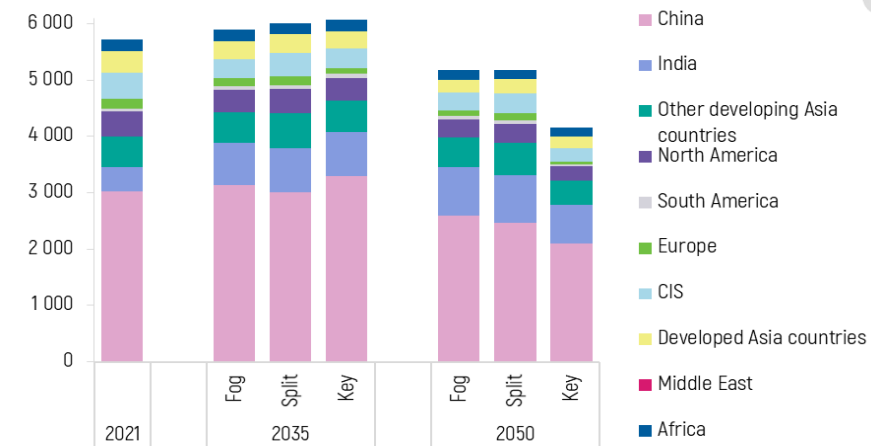


**~70%**  
of global oil production will be provided by three regions

- ~ 35% Middle East
- ~ 23% North America
- ~ 14% CIS

Global coal production by scenario by region

mtce

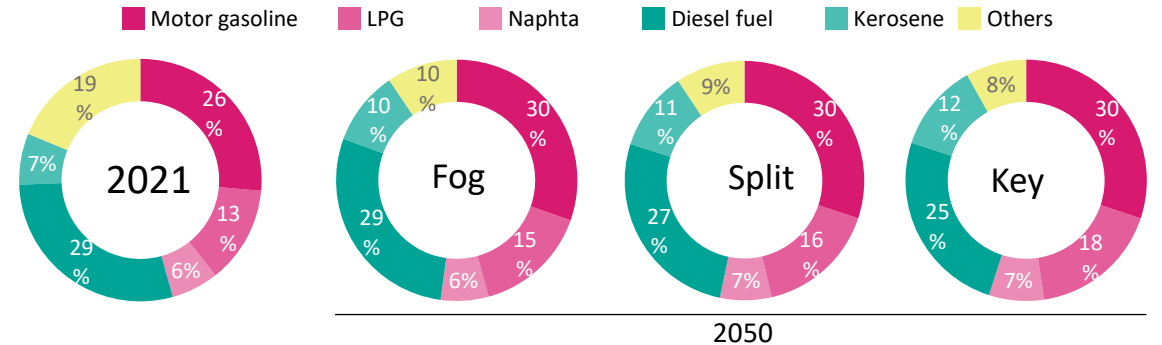


**~75%**  
of global coal production will be provided by one region

- ~ 50% China
- ~ 16% India
- ~ 10% other developing Asia countries

Changes in oil products consumption breakdown by type

mtoe

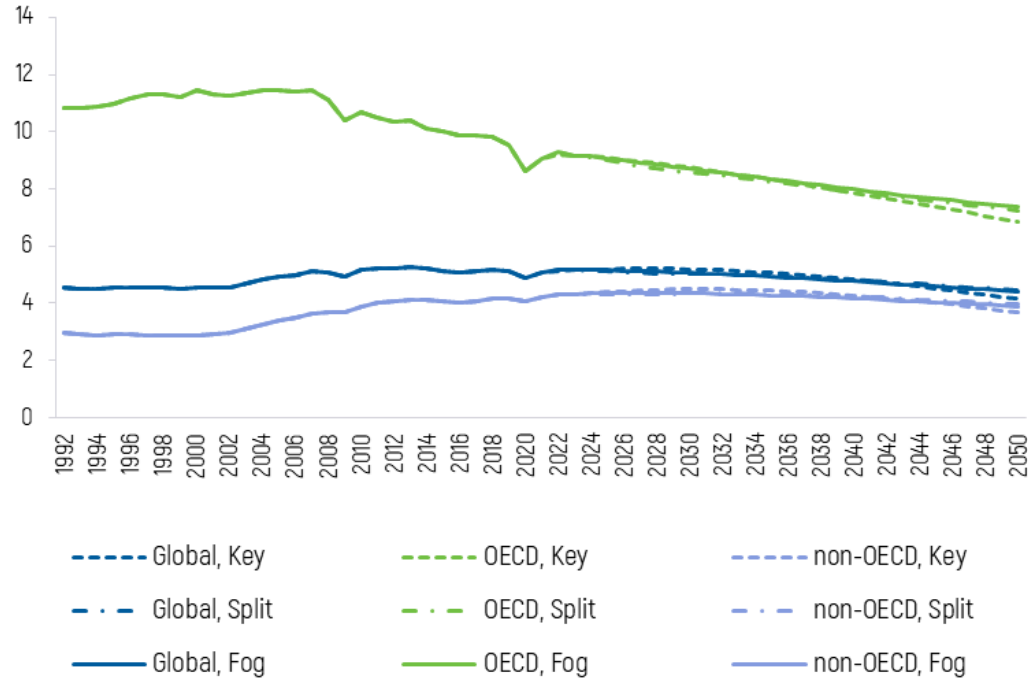


OPEC+ countries will remain key players in the oil market throughout the period under review, accounting for 55-56% of global oil production by 2050.

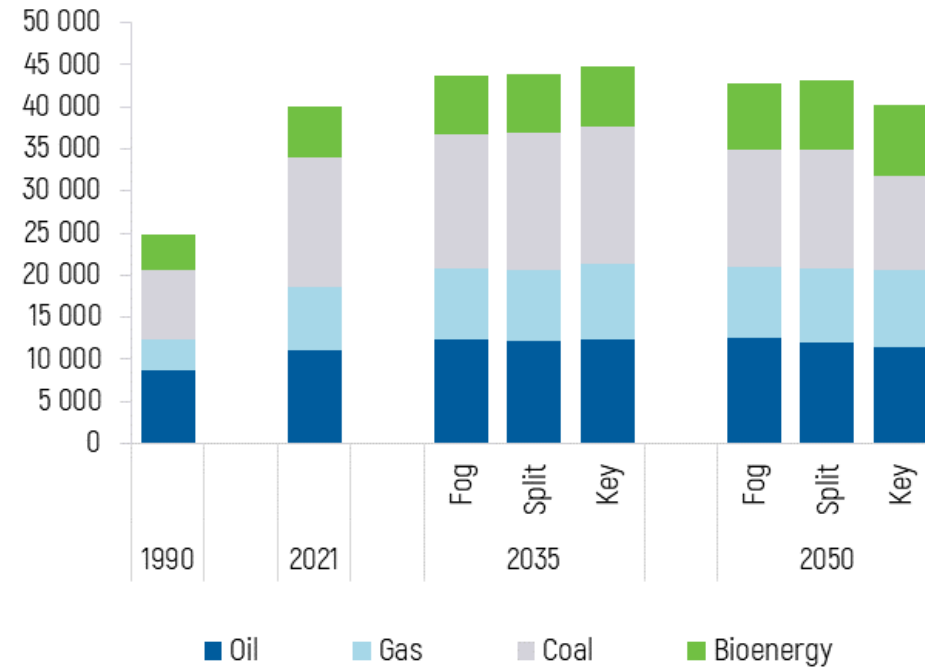


# The world passes peak GHG emissions from combustion in all scenarios

GHG emissions per capita in OECD and non-OECD countries in 1992-2050  
t CO<sub>2</sub>/person



GHG emissions by types of fuel combusted  
mln t CO<sub>2</sub> eq.



Note: Emissions from fuel combustion are shown without taking into account possible capture, disposal and utilization!

A significant contribution to emissions growth is made by suboptimal logistics associated with trade restrictions in the Split scenario. It leads to an increase in emissions of more than 1 billion tons of CO<sub>2</sub> eq, which is more than the annual emissions of Germany and France combined.



# Key findings

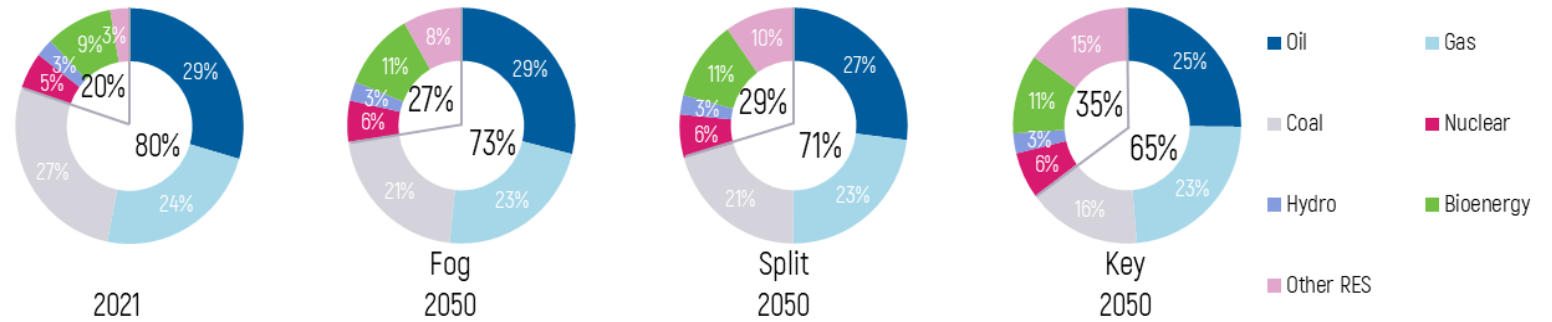
- **Growth in primary energy consumption slows down** significantly by 2050 and passes its historical peak in the Fog scenario
- The world has long waited and feared peaks in oil and gas production due to depleting reserves. There will be a historic moment on the horizon of the next decades - these **peaks will be passed**. But the reason will not be exhaustion of reserves but rather a reduction in demand. At the same time, the resource base capacity will remain at high levels
- In all the above scenarios, the world passes **the peak of CO2 eq. emissions** from energy combustion at the horizon of 2035-2040



**27-35%** The share of RES and nuclear energy in the global fuel and energy mix by 2050 while their production growth will reach 1.6-2.2 times

**50-70%** The share of RES and nuclear in electricity generation by 2050

Global world energy consumption mix by scenario by fuel type



Global world electrical power generation mix by scenario by fuel type

