Carports in Poitiers, France

TotalEnergies

TotalEnergies
Energy Outlook 2024

Description of the three scenarios

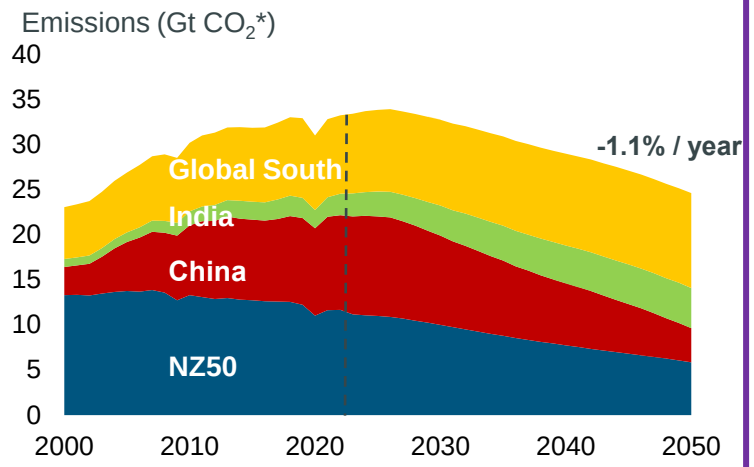
November 4th, 2024

Pioneers for 100 years

Three possible scenarios to 2050

Decarbonization achievable but strong acceleration required

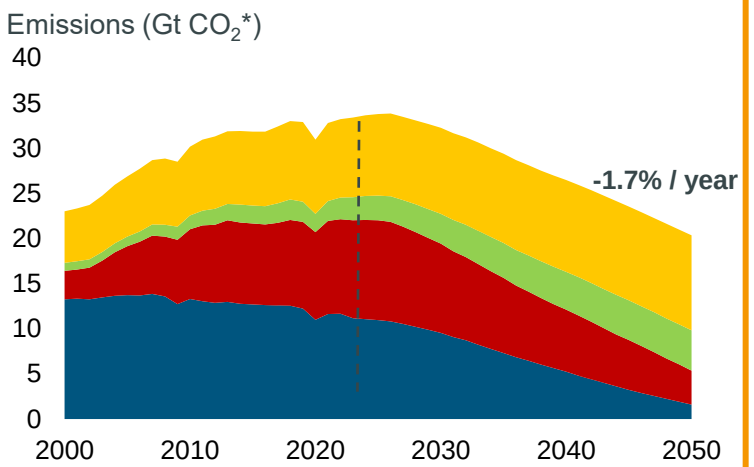
Trends



- Based on current trends, NZ50 countries fail to reach their long-term objectives, while China makes progress to NZ60
- India and Global South are developing without decarbonizing

~ +2.6-2.7°C by 2100**

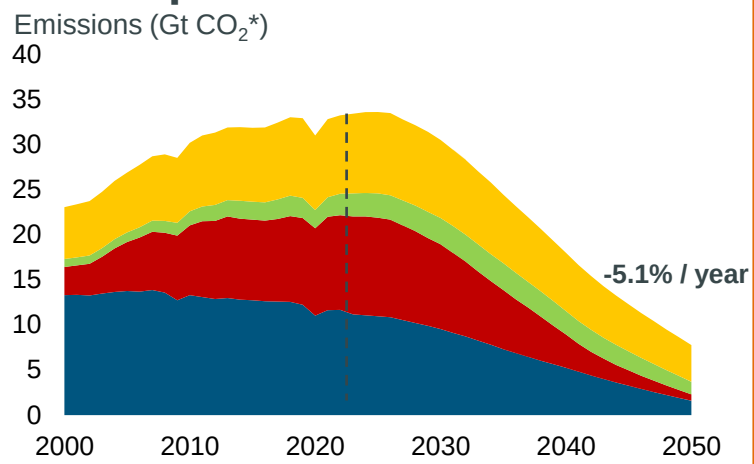
Momentum



- NZ50 countries and China reach their 2050/2060 targets
- In India and Global South, around half of the growth in energy demand is met by low-carbon energies

~ +2.2-2.3°C by 2100**

Rupture



- Global cooperation enables India and Global South to join in the race to Net Zero
- Demand growth is addressed with low-carbon energies and efficiency gains

~ +1.7-1.8°C by 2100**

Our collective challenge: move away from the “Trends" scenario without compromising growth in emerging countries

** CO_2 emissions related to energy combustion*

*** Temperature increases estimated at P66-P83, evaluation conducted by MIT*

From Trends to Momentum and Rupture

All decarbonization levers are pushed further to remain well-below 2°

	Trends 2050	Momentum 2050	Rupture 2050
Strong electrification of end-use	~30% of final demand	~35%	~40%
Deep decarbonization of electricity grid	24 500 TWh* (~50% of power generation)	27 500 TWh* (~53%)	35 000 TWh* (~62%)
Energy efficiency acceleration**	+2.3%/yr 2022-50	+2.4%/yr	+2.7%/yr
Sustainable mobility	~45% Zero Emission Vehicles in light vehicles fleet	~55%	~70%
	Sust. aviation fuels (SAF) @ ~10% of demand	SAF @ ~35%	SAF @ ~65%
Gas going greener	~11% green gases*** in gas supply	~16%	~25%
Increasing plastics' circularity	~25% of gross demand coming from recycled materials	~30%	~45%
CCS to abate remaining emissions	~1.5 Gt (~6% CO_2 emissions)	~2.7 Gt (~12%)	~6.1 Gt (~44%)
Support to Global South	~30% of non-fossil sources in primary energy demand (vs ~47% in NZ50 countries)	~30% (vs ~65% in NZ50 countries)	~52% (vs ~65% in NZ50 countries)

** Solar & Wind - Excluding Renewable electricity generation for green H_2*
*** Energy efficiency is defined here as the decrease in primary energy required to produce 1$ of GDP*
**** Green gases include Biogas and H_2 -- excluding H_2 share for liquid e-fuels production*

TotalEnergies

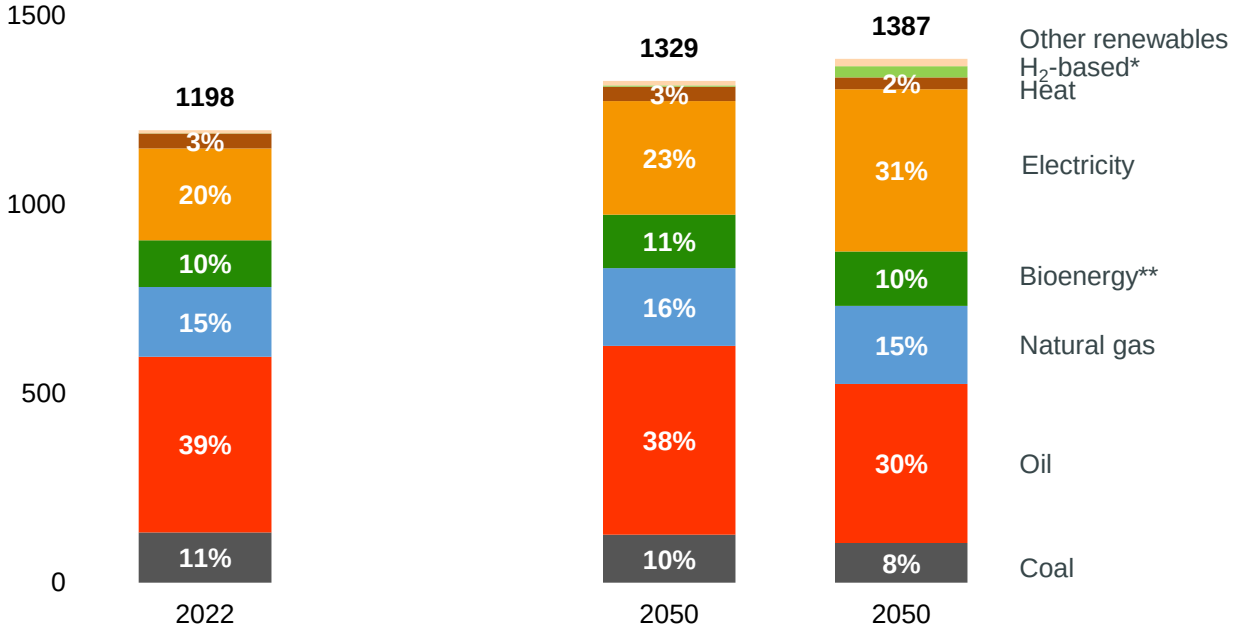
Trends

Pioneers for 100 years

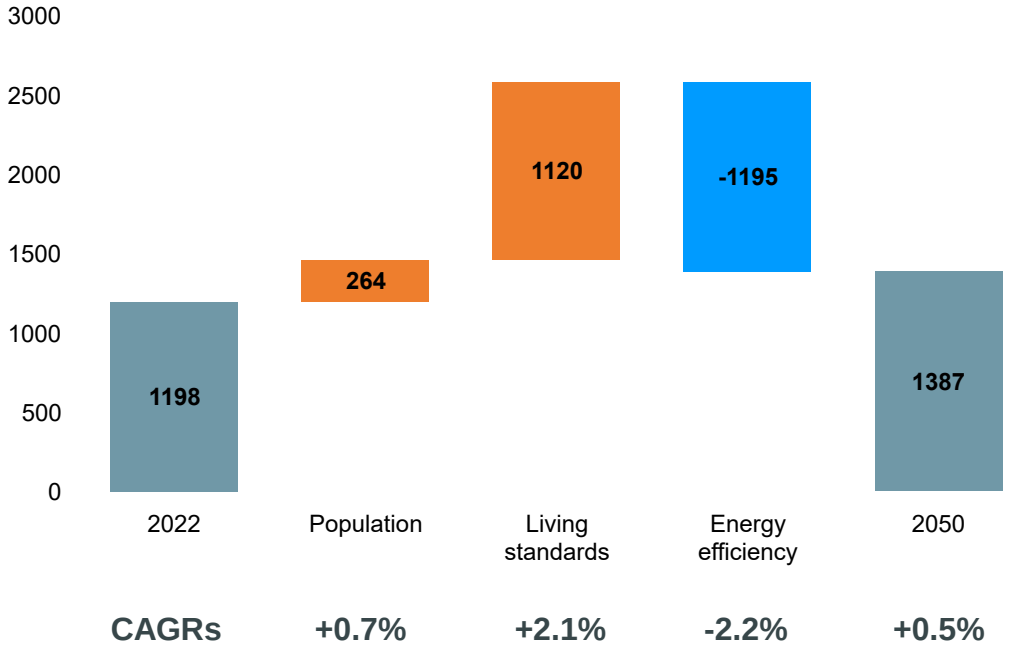
World total final consumption

Insufficient technology substitution and international cooperation limit decarbonization of the final demand

World total final consumption
PJ/d



Changes in annual total final consumption over 2022-2050***
PJ/d



- In Trends, fossil fuels still represent ~53% of final demand in 2050 vs. ~65% in 2022
- Already mature technologies (renewables, EV, …) are deployed but not at scale

Electrification in Trends contributes to higher energy intensity gains than historical average (~ -1.5 %/year over the past 20 years)

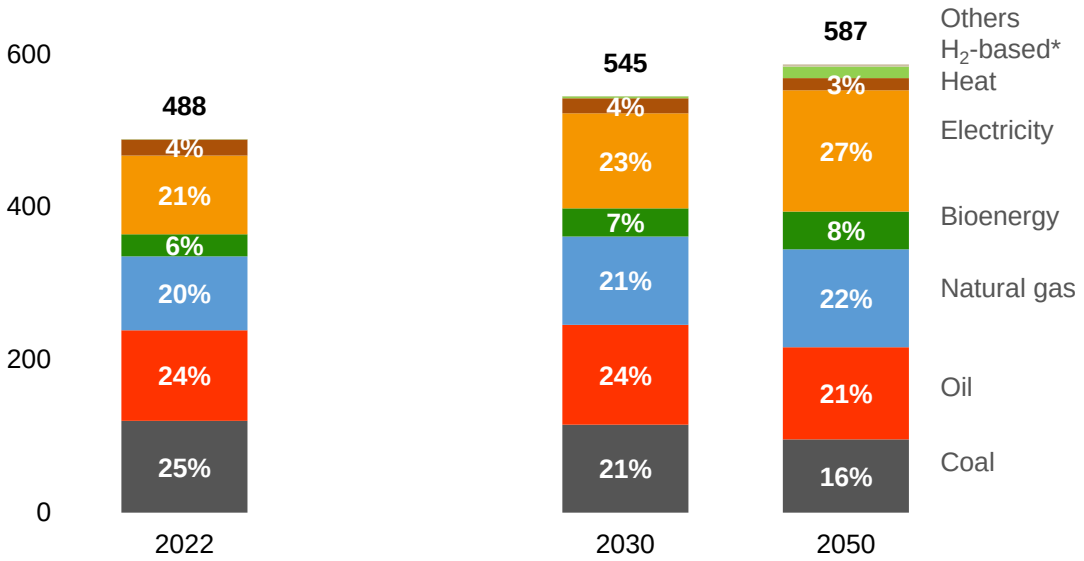
** Includes H2, e-fuels (H2 + CO2), methanol, ammonia…*
*** Includes traditional use of biomass, waste, biofuels, biogas …*
**** Living standards: GDP per capita ($/person); Energy efficiency: decrease in final energy required to produce 1$ of GDP (MJ/$)*

Final consumption in industry and buildings

Slow decarbonization in industry but strong electrification in buildings

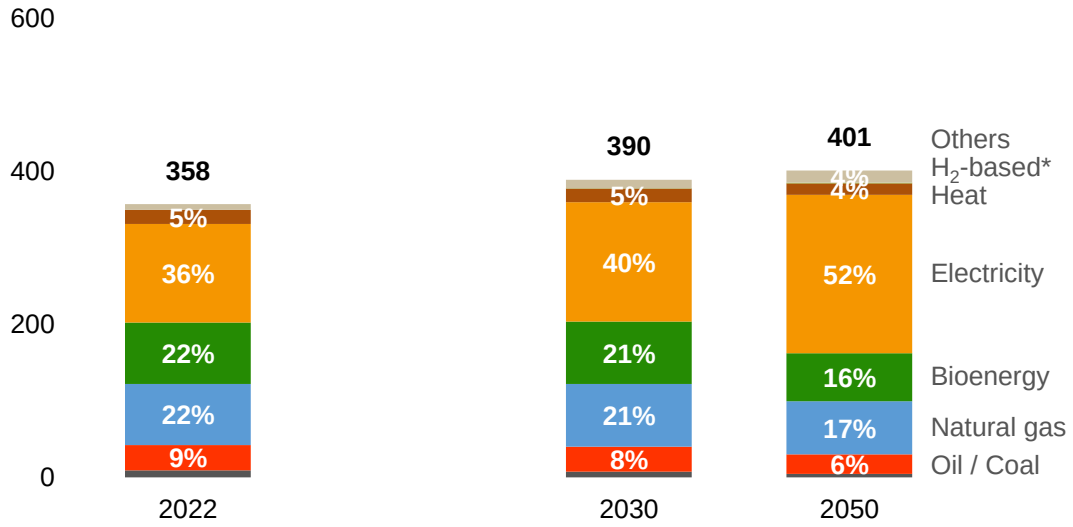
Industry Total Final Consumption

PJ/d



Residential & Commercial Final Consumption

PJ/d



- Electrification increases, hence fossil fuels share decrease
- However, fossil fuels usage increases as industrial demand increases in India and Global South

Buildings electrification is underway

** H_2 and derivatives such as ammonia*

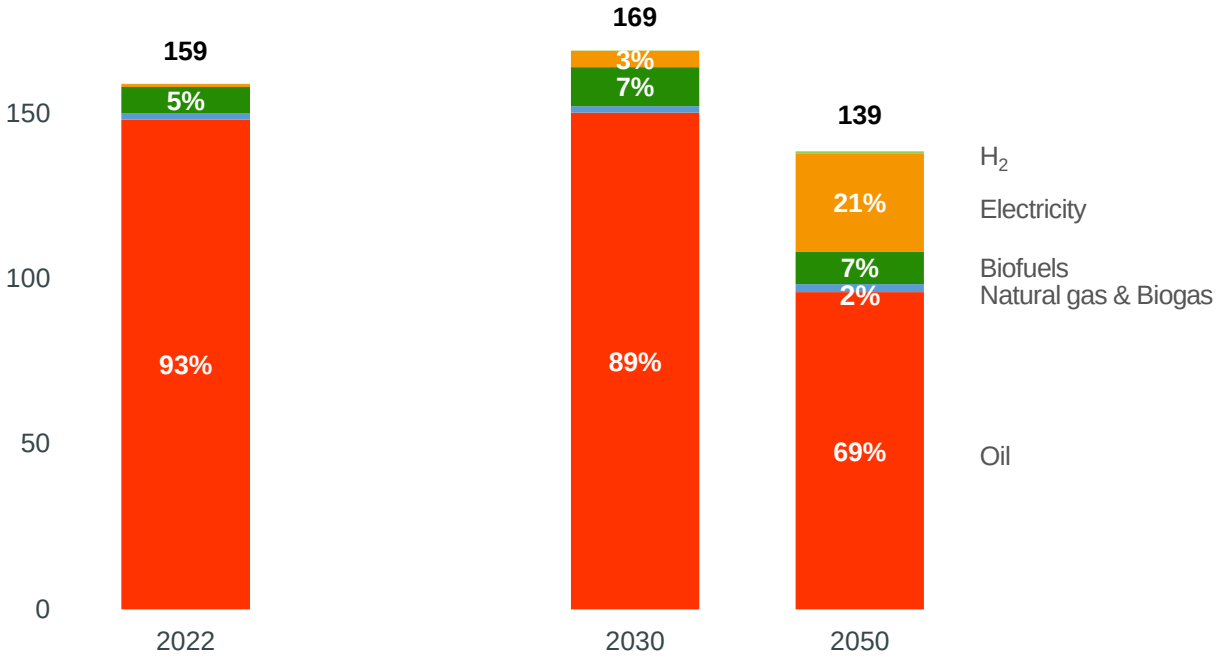
Trends

Electrification of Light Duty Vehicles

Electrification reduces Light Duty Vehicles oil demand by 2050

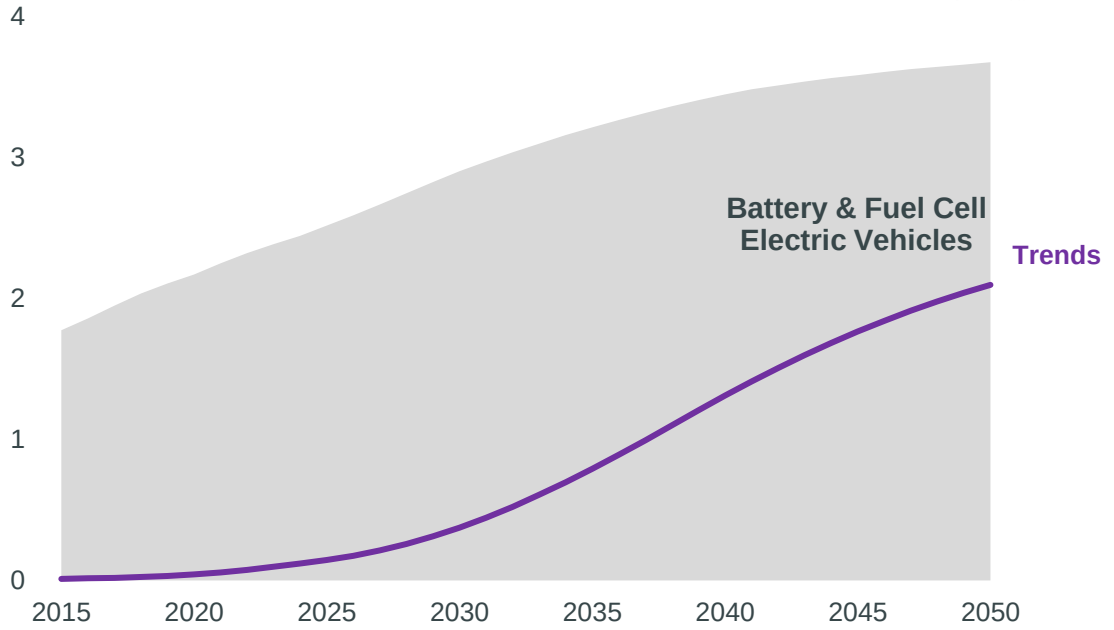
Light Duty Vehicles* Final Consumption

PJ/d



Light Duty Vehicles fleet

Billion



- LDV: ~ 50% of 2022 Transport final energy demand and CO_2 emissions
- Between 2022 and 2050, kilometers traveled globally almost double, 60% of this additional traffic comes from Asia
- Electric engines are about 3 times more efficient than the thermal ones, hence energy required is lower in 2050 than in 2022

By 2050, ~60% of the LDV fleet is converted to electricity in Trends : ~55% in NZ50 countries, ~80% in China, ~50% in India and ~50% in Global South

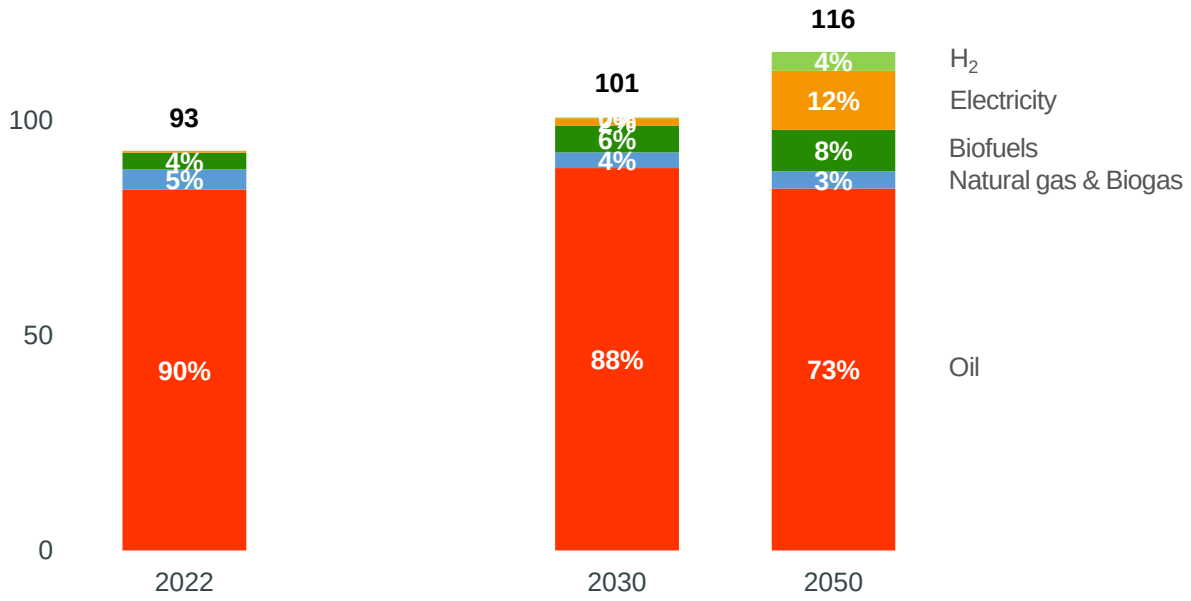
** Passenger cars + Light Commercial Vehicles + 2-3 wheelers*

Trends

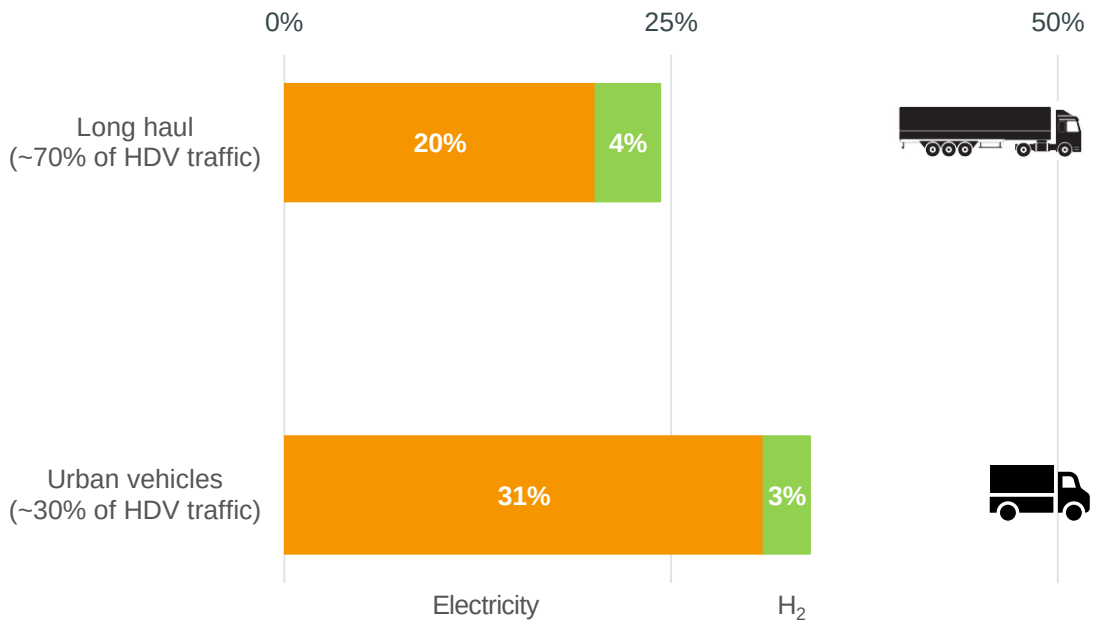
Mix diversification in Heavy Duty Vehicles

Biofuels and electricity penetration stabilizes oil demand

Heavy Duty Vehicles* Final Consumption
PJ/d



Zero Emissions Vehicles share of HDV traffic
2050, % of km travelled



- HDV: 30% of 2022 Transport final energy demand and CO_2 emissions
- Biofuels and electricity are the primary drivers of decarbonization
- In 2050, fossil fuel volume is similar to 2022 as demand growth (primarily in India and Global South) is balanced by low carbon energies penetration

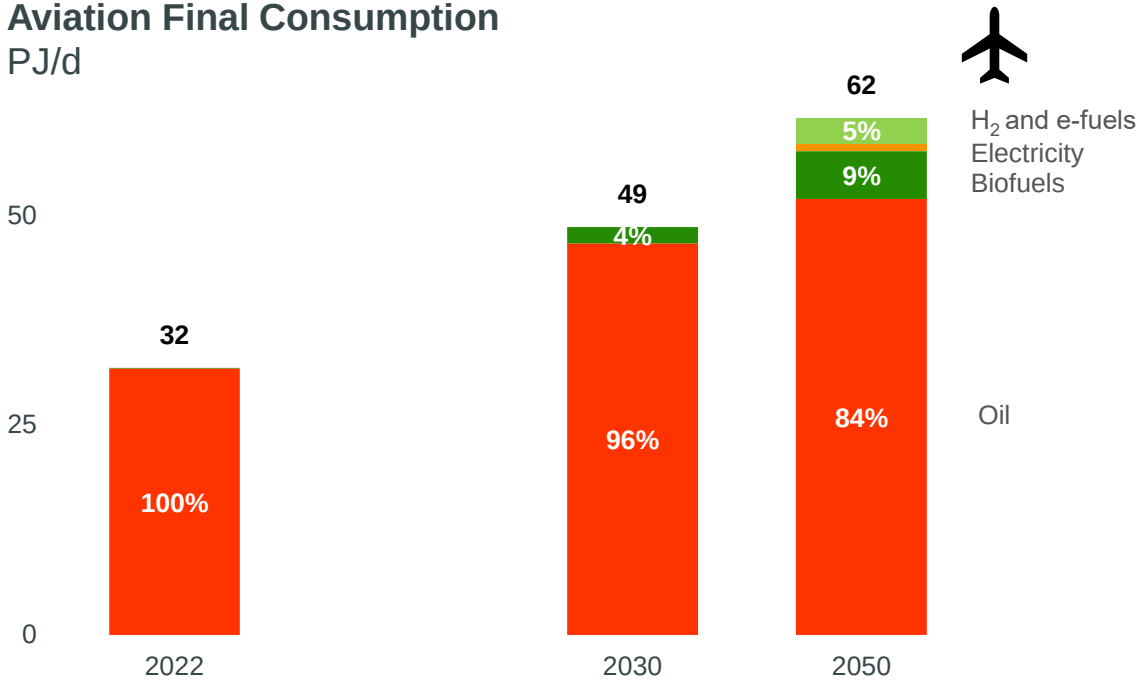
Hydrogen penetration remains low, due to high costs and the need to develop supporting infrastructure

** Trucks + Buses + Coaches*

Multiple decarbonization paths for Aviation & Marine

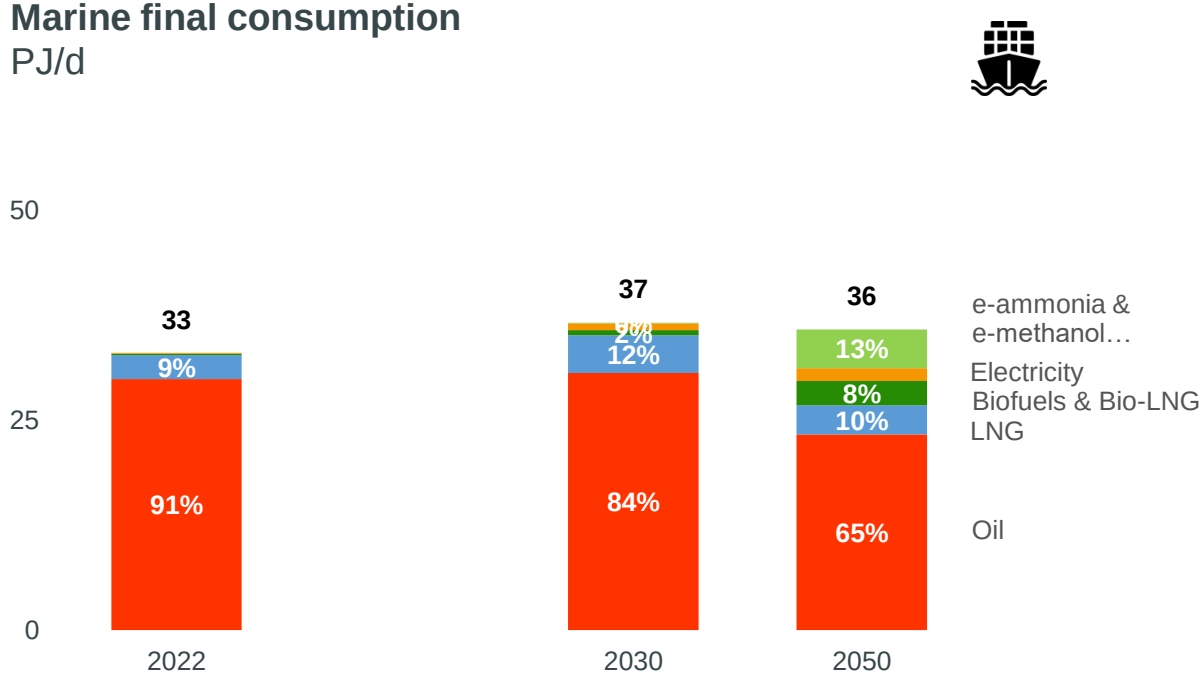
Bio-energies & green electricity for e-fuels are the primary lever of decarbonization

Aviation Final Consumption
PJ/d



- Aviation: 10% of 2022 Transport final energy demand and CO_2 emissions
- Between 2022 and 2050, passenger.km are expected to roughly triple with Asia contributing more than half of the increase, while efficiency gains reduce energy required per passenger.km by ~30%
- Limited availability and high costs of biofuels and green electricity for e-fuels limit their penetration

Marine final consumption
PJ/d



- Marine: ~10% of 2022 Transport final energy demand and CO_2 emissions
- In 2050, energy demand from Shipping is expected to be around the same level as today, as efficiency gains balance traffic increase
- A mix of alternative fuels partially decarbonize marine demand

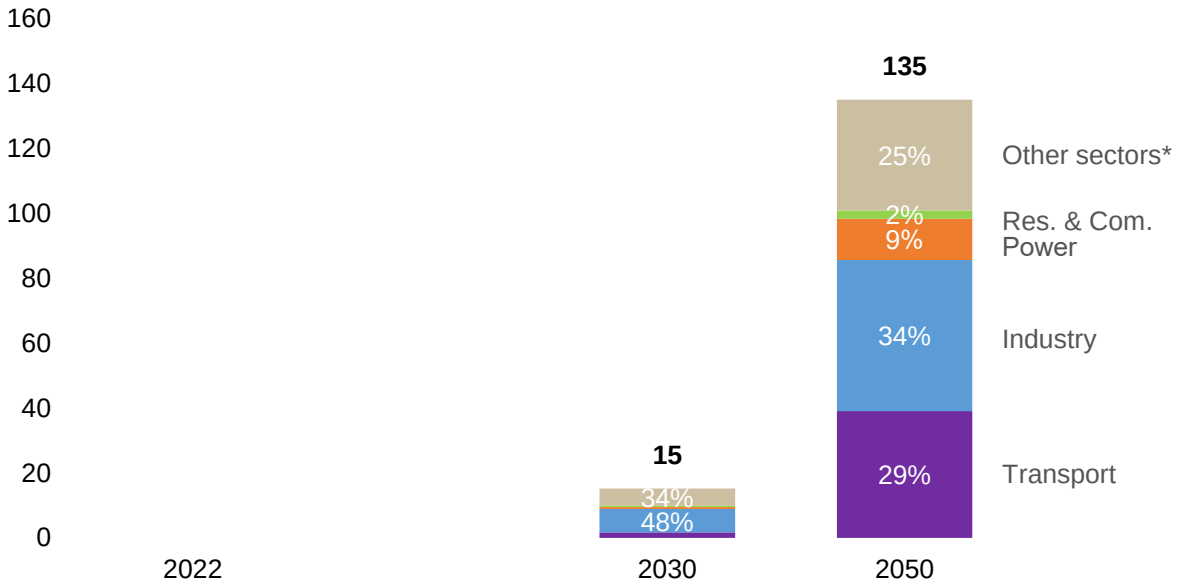
Trends

Limited role for clean hydrogen

Clean hydrogen is not expected to grow significantly before 2030

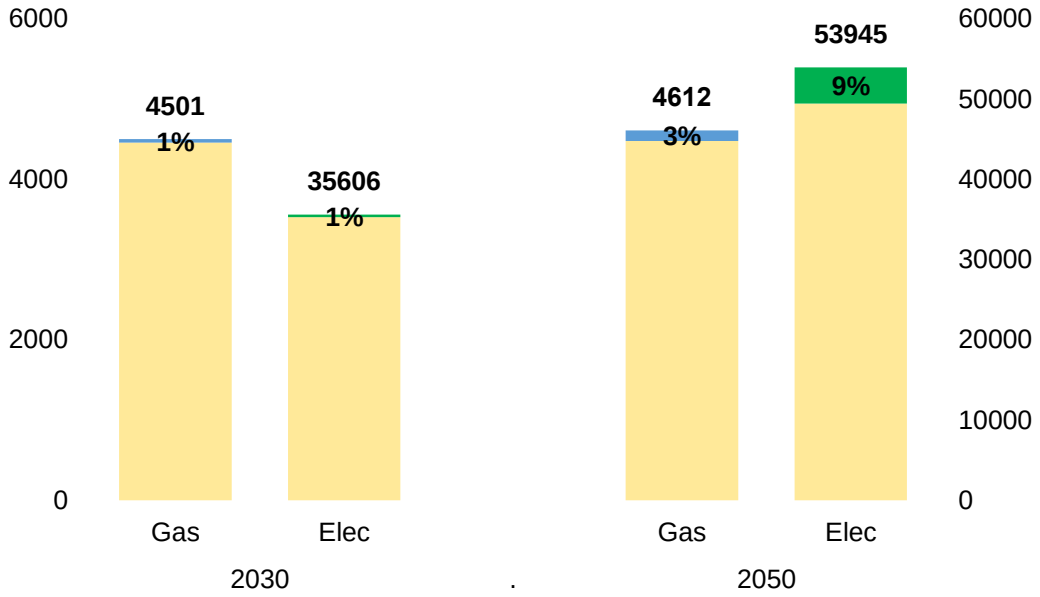
Clean H_2 demand by sector

Mt H_2



Nat Gas and Power for H_2 and e-fuels production

Bcm (left) & TWh (right axis)



- Hydrogen projects currently face headwinds, as a result fewer than expected will be operating by 2030
- By 2050, hydrogen and derivatives represent around 2% of total final consumption, industry is expected to be the main consumer of clean hydrogen

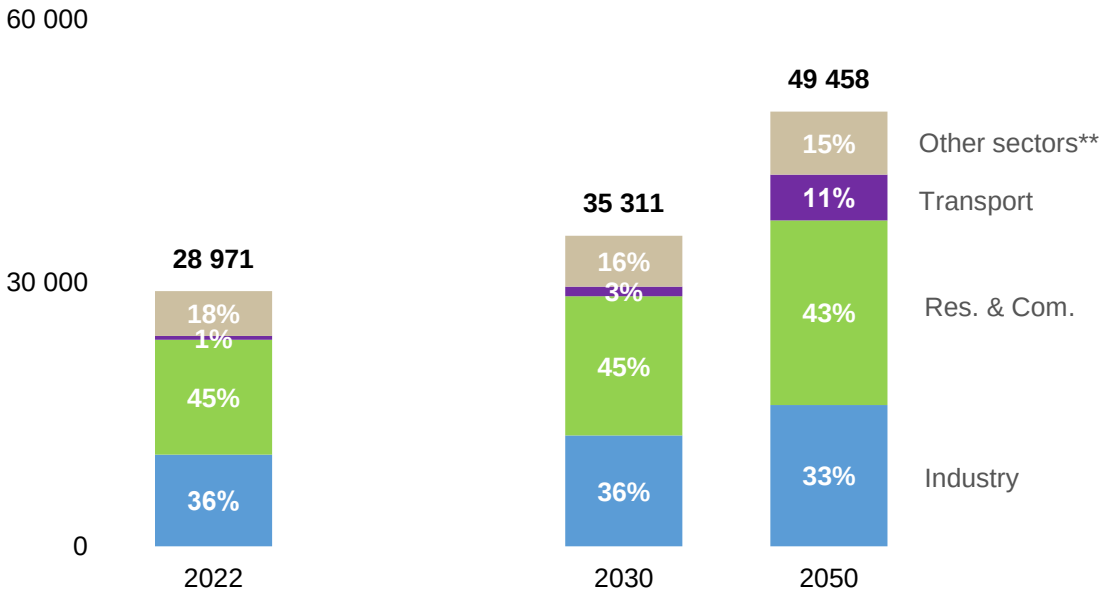
- In 2030, 60% of clean hydrogen is produced from natural gas, while in 2050 ~75% of hydrogen is produced from electrolysis

** Other energy use, non-energy use and agriculture*

World electricity demand and generation

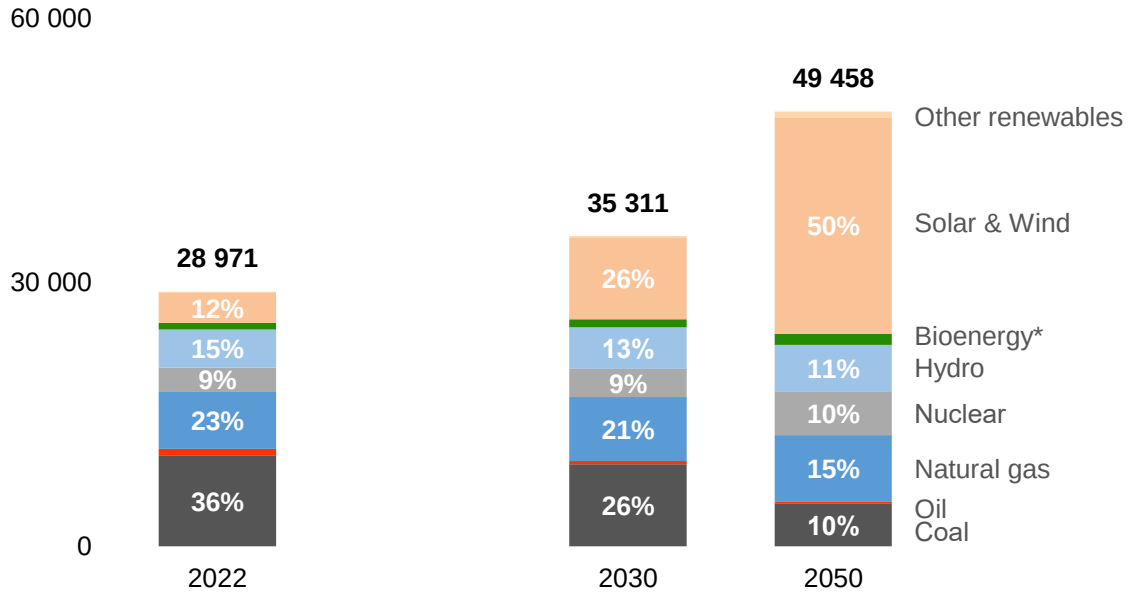
Renewables are the main technology deployed to meet almost doubling demand

Electricity demand, excluding electricity for Green H_2
TWh



- All sectors contribute almost equally to electricity demand increase
- Transport demand grows the most in relative terms (x 12)

Electricity generation, excluding electricity for Green H_2
TWh



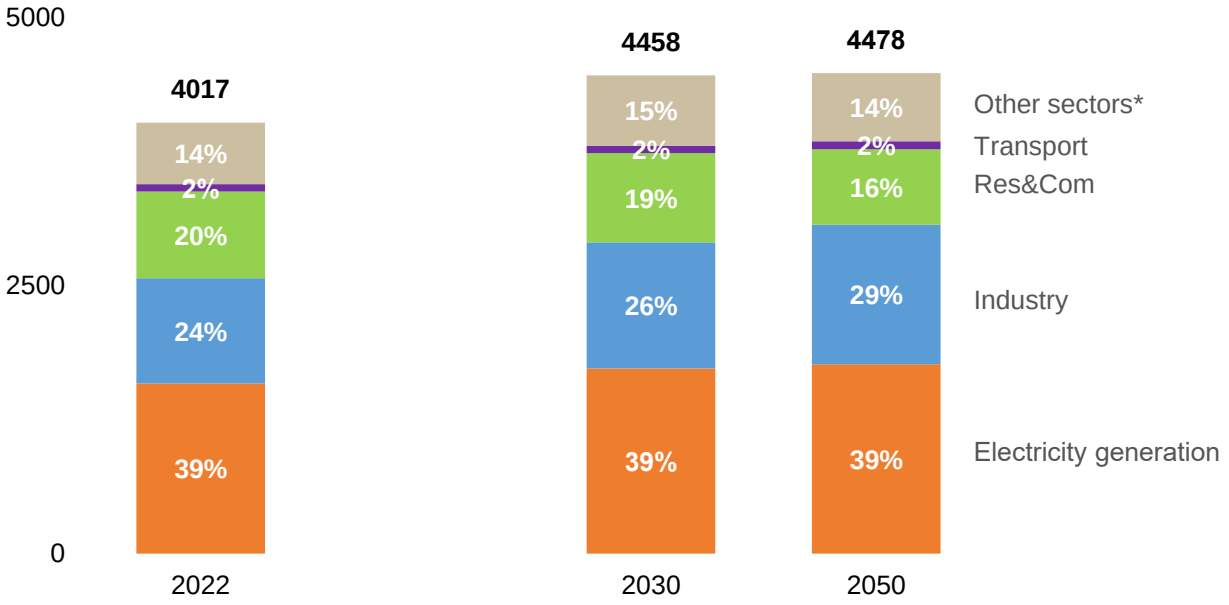
- Renewables represent more than half of electricity generation in 2050 as they are already competitive in many countries
- Natural gas provides flexibility to balance the variability of renewables

** Includes traditional use of biomass, waste, biofuels, biogas…*
*** Other energy use and agriculture*

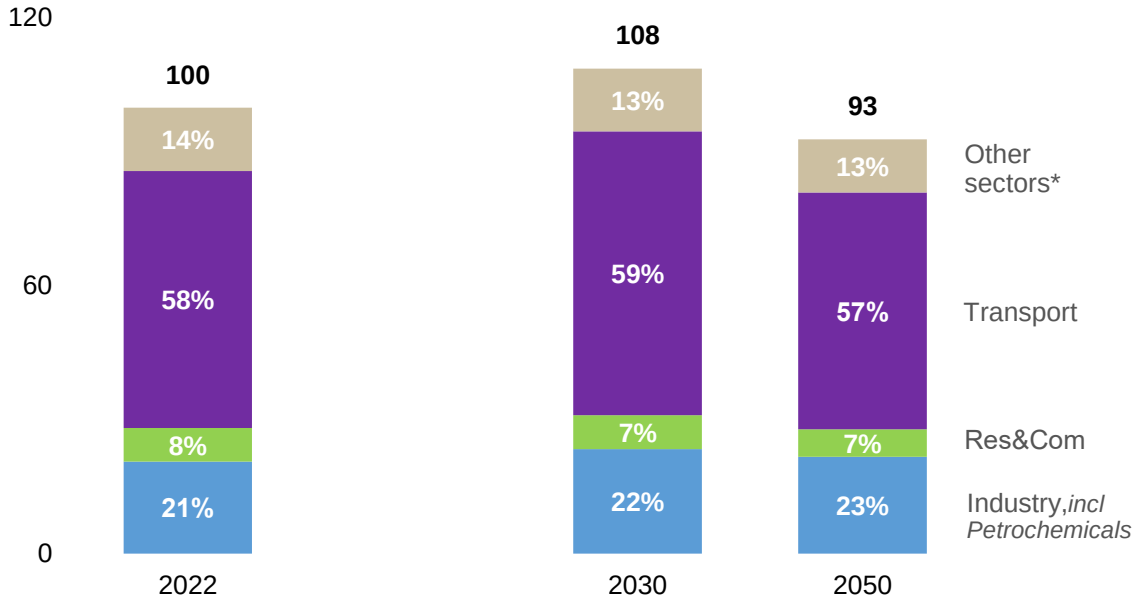
World Liquids & Natural Gas Demand

Natural gas key for energy transition; oil demand will reach a plateau until the end of the 2030s, then slowly decreases

Natural gas demand by sector, excluding gas for Blue H_2
Bcm



Liquids (oil + bio-fuels) demand by sector
Mb/d



- Natural gas demand grows slightly to 2050, driven by electricity generation and industry
- Natural gas is a key transition fuel, reducing emissions with coal to gas switch and providing flexibility to the electricity system

- Liquids demand grows to 108 Mb/d by 2030, then plateaus until the late 2030, and slowly decreases afterwards
- Liquids demands for Heavy Duty Vehicles, Aviation and Petrochemicals are higher in 2050 than today

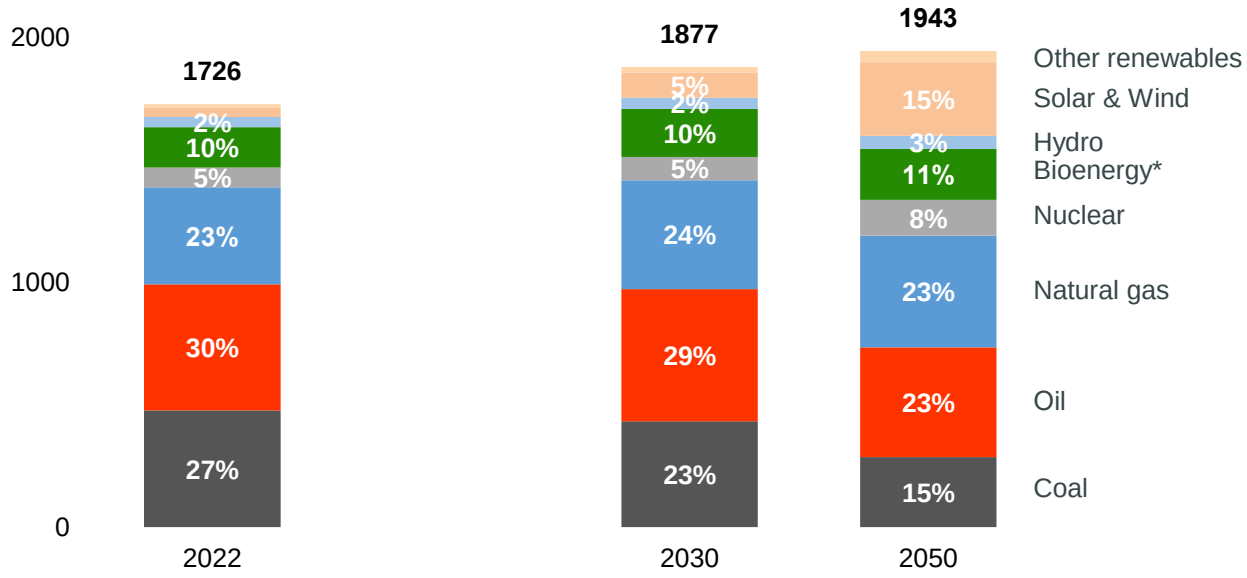
** Other energy and non-energy use, agriculture…*

World primary energy demand and CO_2 emissions

Acceleration required to remain well-below 2°C by 2100

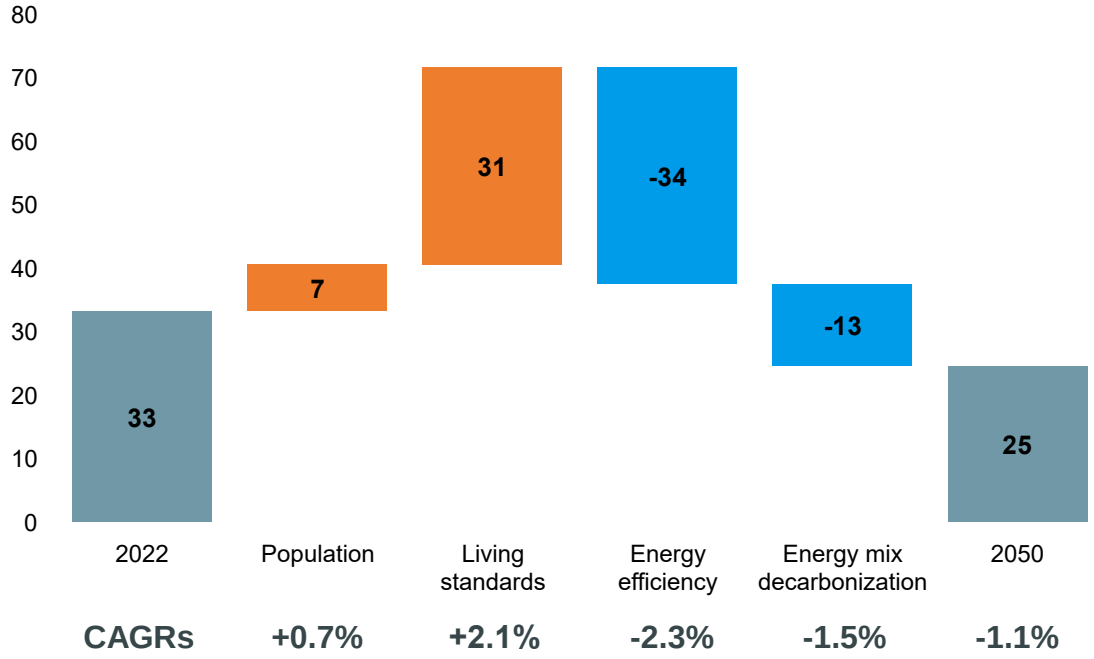
Total primary energy demand

PJ/d



Changes in annual CO_2 emissions over 2022-2050**

Gt CO_2



- Share of fossil fuels remains high in 2050 (61% vs 80% in 2022)
- NZ50 countries do not achieve their 2050 target
- Insufficient financial support limits deployment of low carbon technologies in developing countries

- Emissions are only reduced by ~25% by 2050
- This leads to a temperature increase of +2.6-2.7°C by 2100***

** Includes traditional use of biomass, waste, biofuels, biogas…*

*** Living standards: GDP per capita ($/person), Energy efficiency: decrease in primary energy required to produce 1$ of GDP (MJ/$), energy mix decarbonization: CO_2 emissions per unit of energy (gCO2/MJ)*

**** Temperature increases estimated at P66-P83, evaluation conducted by MIT*

Trends

TotalEnergies

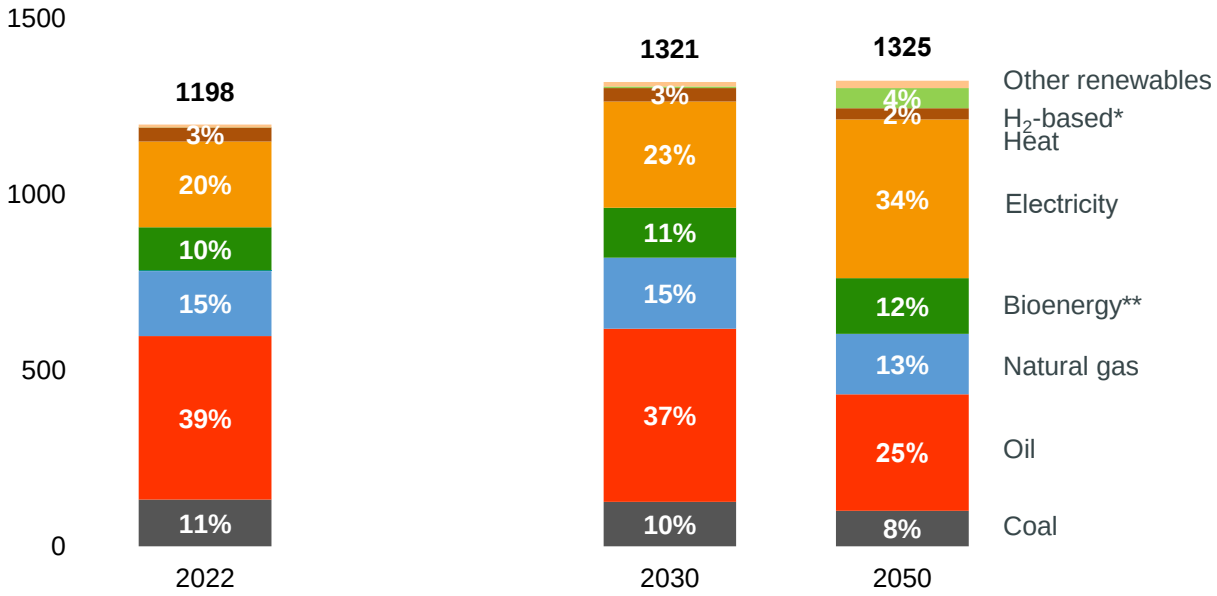
Momentum

Pioneers for 100 years

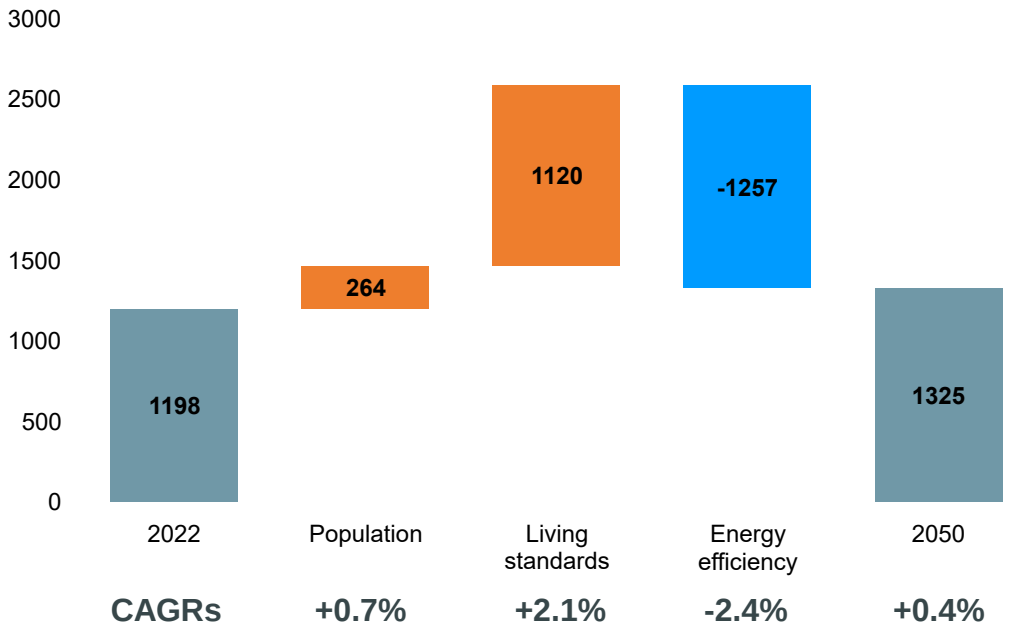
World total final consumption

Final consumption keeps growing, supported by emerging economies development

World total final consumption
PJ/d



Changes in annual total final consumption over 2022-2050***
PJ/d



Electrification is underway and increases after 2030 with EV and heat pumps adoption, which displace fossil fuels

- Growth in total final consumption is driven by increasing living standards, especially in developing economies
- Final sectors energy conversion efficiency**** improved by ~30% by 2050, mainly in developed economies

** Includes H2, e-fuels (H2 + CO2), methanol, ammonia…*
*** Includes traditional use of biomass, waste, biofuels, biogas …*
**** Living standards: GDP per capita ($/person); Energy efficiency: decrease in final energy required to produce 1$ of GDP (MJ/$)*
***** Mesured as the ratio of useful energy (e.g. energy transmitted the wheels of a car) divided by final energy (e.g., energy used by the engine of a car)*

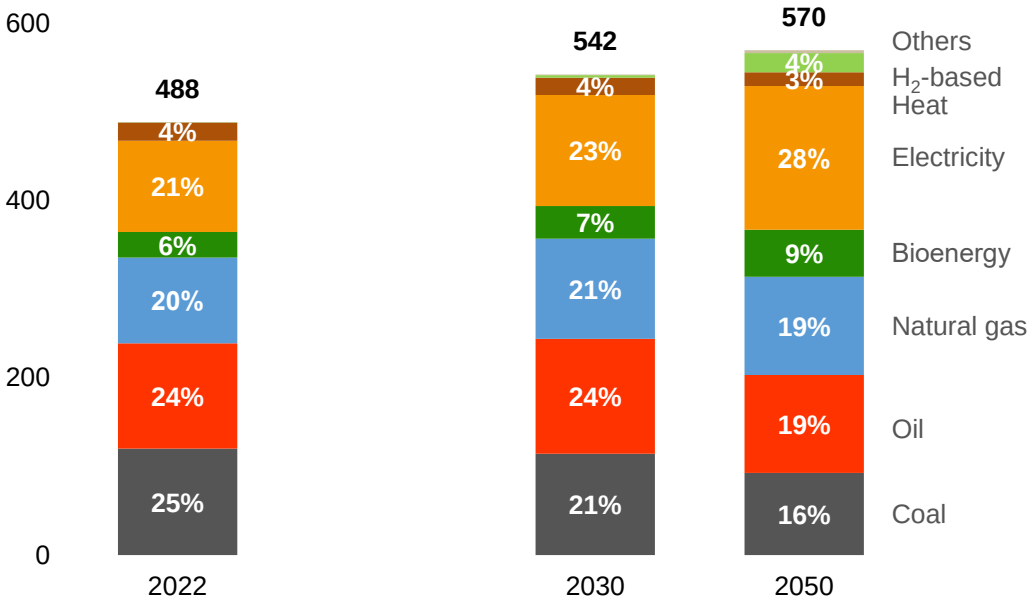
Momentum

Decarbonization underway in industry and buildings

Electricity replaces less efficient fossil fuels

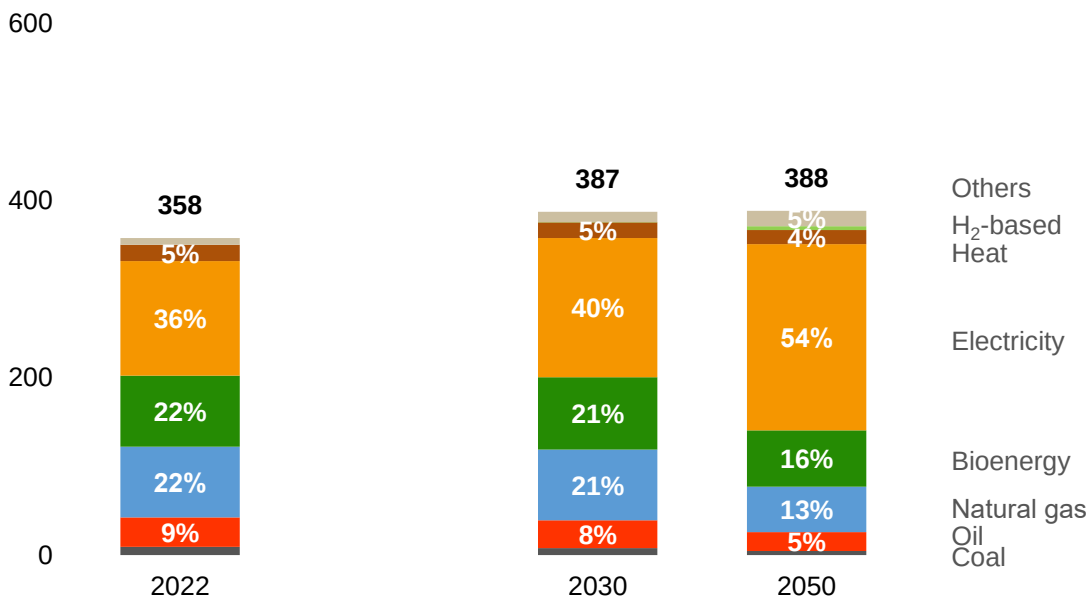
Industry Total Final Consumption (Momentum)

PJ/d



Residential and Commercial Final Consumption (Momentum)

PJ/d



- Post 2030, electrification accelerates; industry replaces coal and oil processes by electric ones, in particular for steel production and medium- and low-temperature heating (less than 400°C)
- Carbon Capture and Storage helps to abate some emissions (0.4 Gt CO_2* in 2050), but sector still emits more than 4 Gt CO_2* in 2050

Despite higher population and living standards, demand barely grows to 2050 due to increased efficiency: heat pumps efficiency can be higher than 300%, versus ~80% for boilers

** Energy related CO_2 emissions from combustion*

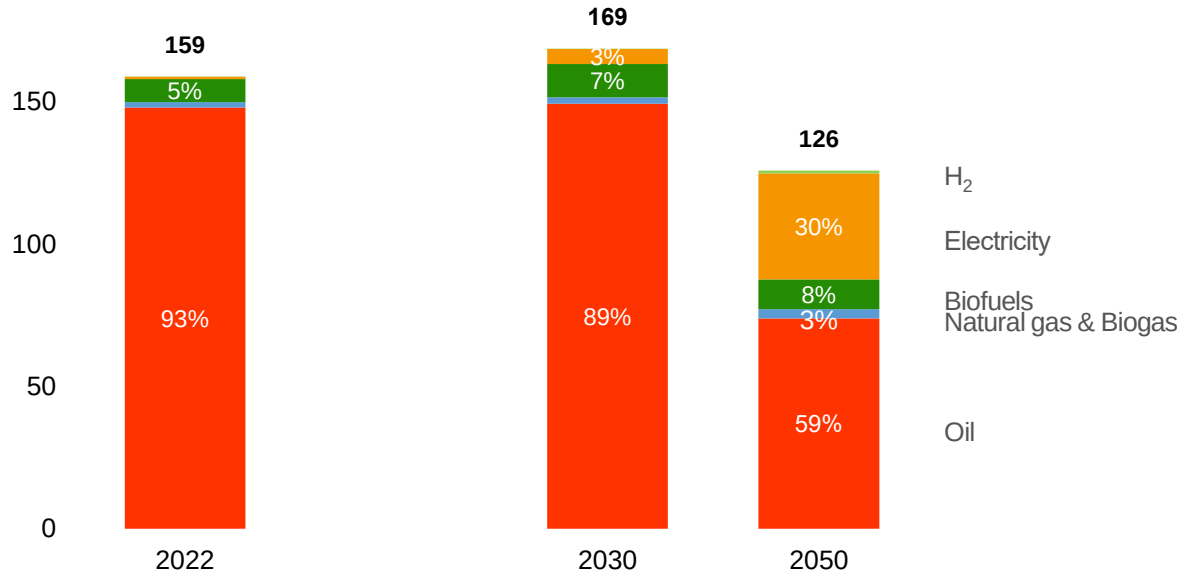
Momentum

Electrification of Light Duty Vehicles

China and NZ 2050 countries lead electrification

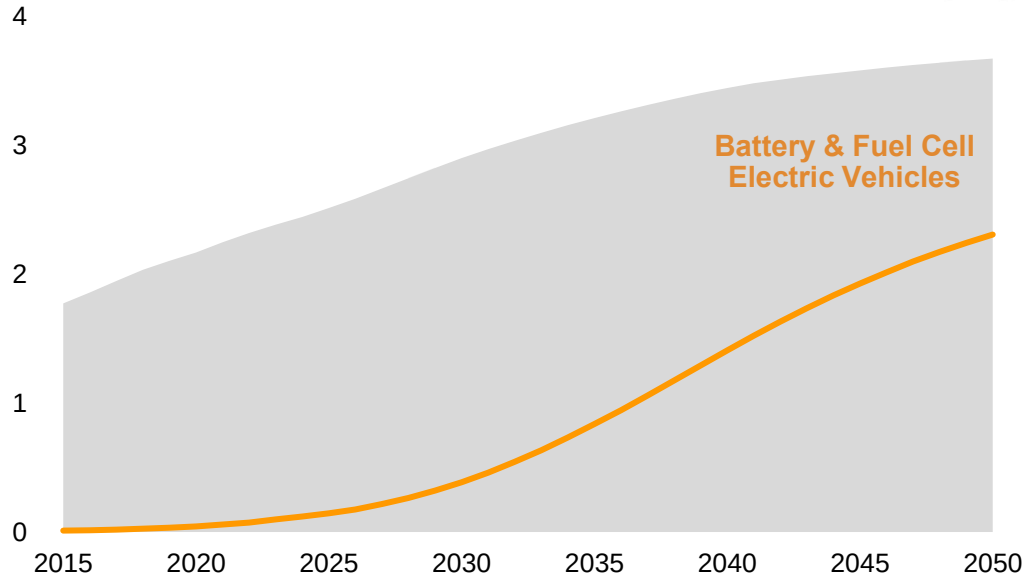
Light Duty Vehicles* Final Consumption (Momentum)

PJ/d



Light Duty Vehicles fleet (Momentum)

Billion



Momentum assumes rapid penetration of EVs in NZ50 countries and China, hence ~6 Mb/d of oil is displaced globally as soon as 2030, of which 20% comes from 2-3 wheelers electrification

- Battery & Fuel Cell EV sales penetration of Passenger Cars accelerates from 12% in 2023 to ~30% in 2030 and ~65% in 2050, largely driven by China
- By mid-century, ~ 80% of the LDV fleet in NZ50 countries and China is converted to electricity, ~ 50% in Global South
- By 2050 in Momentum, LDV electricity demand rises to ~3800 TWh, around 7% of global electricity demand

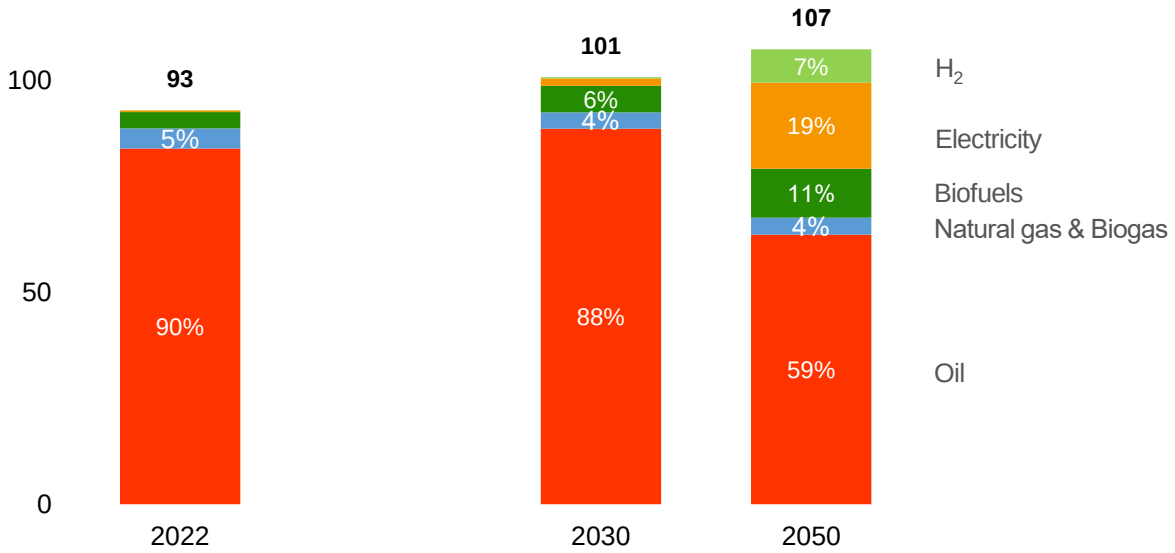
** Passenger cars + Light Commercial Vehicles + 2-3 wheelers*

Momentum

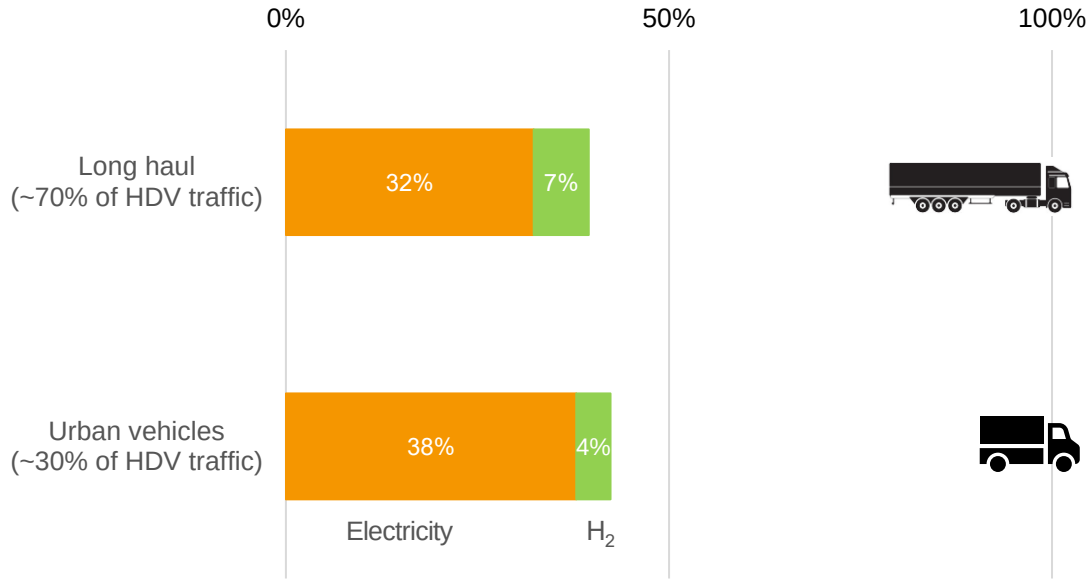
Mix diversification in Heavy Duty Vehicles

Electrification is the primary lever for trucking decarbonization

Heavy Duty Vehicles* Final Consumption (Momentum)
PJ/d



Zero Emissions Vehicles share of HDV traffic (Momentum)
2050, % of km travelled



- By 2030 in Momentum, oil and gas demand slightly increases; biofuels increase fastest, spurred by mandates, in particular in Europe, North America and ASEAN
- In 2050, electricity is three times larger than H_2 in the energy mix

- Low H_2 penetration is due to the rapid increase in batteries' performance, the high number of models of electric buses and trucks offered, and the growing investment in fast charging infrastructure
- Despite Battery Electric Vehicles progress, fuel-cells remain the preferred solution for Long Haul inter-regional transport corridors, served by Hydrogen Refueling Stations

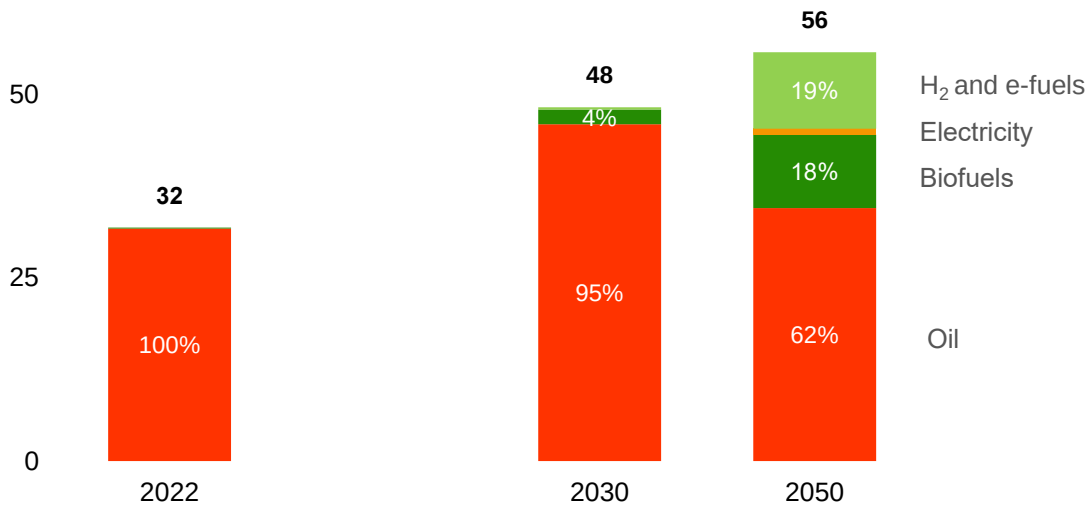
** Trucks + Buses + Coaches*

Momentum

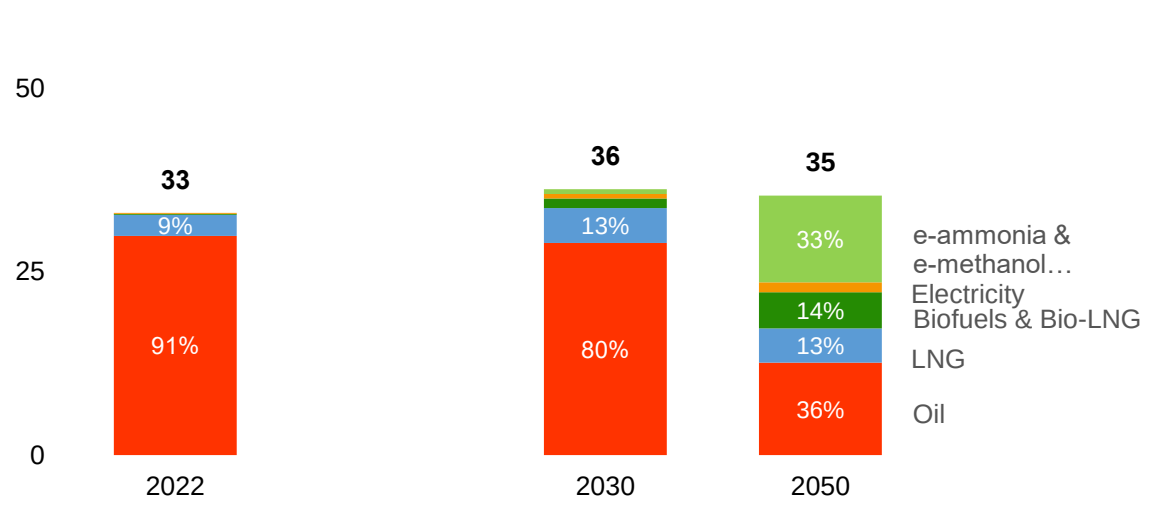
Multiple decarbonization paths for Aviation & Marine

Bio-energies and e-fuels needed to decarbonize these hard-to-abate Transport sectors

Aviation Final Consumption (Momentum)
PJ/d



Marine final consumption (Momentum)
PJ/d



- By 2030, in Momentum, oil demand is ~8 Mb/d with biofuels substituting ~0,5 Mb/d of oil
- By 2050, SAF incorporation level is 12 % globally, reaching 20% in Europe and in the USA

- LNG, moving to bio-LNG, plays a key role in the energy transition in the short-term while e-fuels will be deployed after 2035
- Net Zero 2050 strategy proposed in July 2023 by the International Marine Organization is only partially achieved : 2050 emissions are reduced by only ~45% from 2008

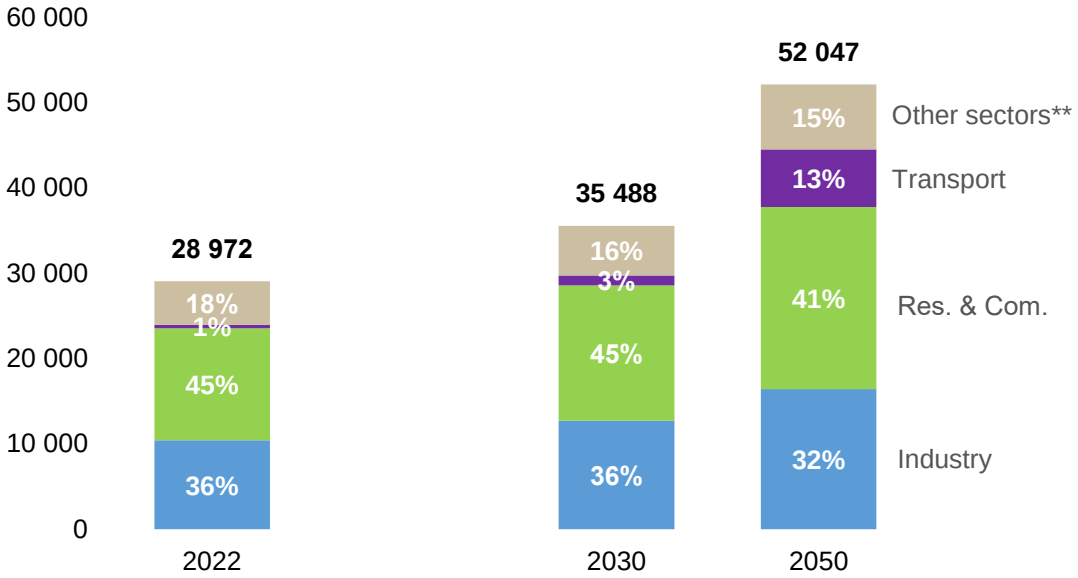
Momentum

World electricity demand and generation

Clean electricity is the energy of the 21th century, which requires significant investment

Electricity demand, excluding electricity for Green H_2

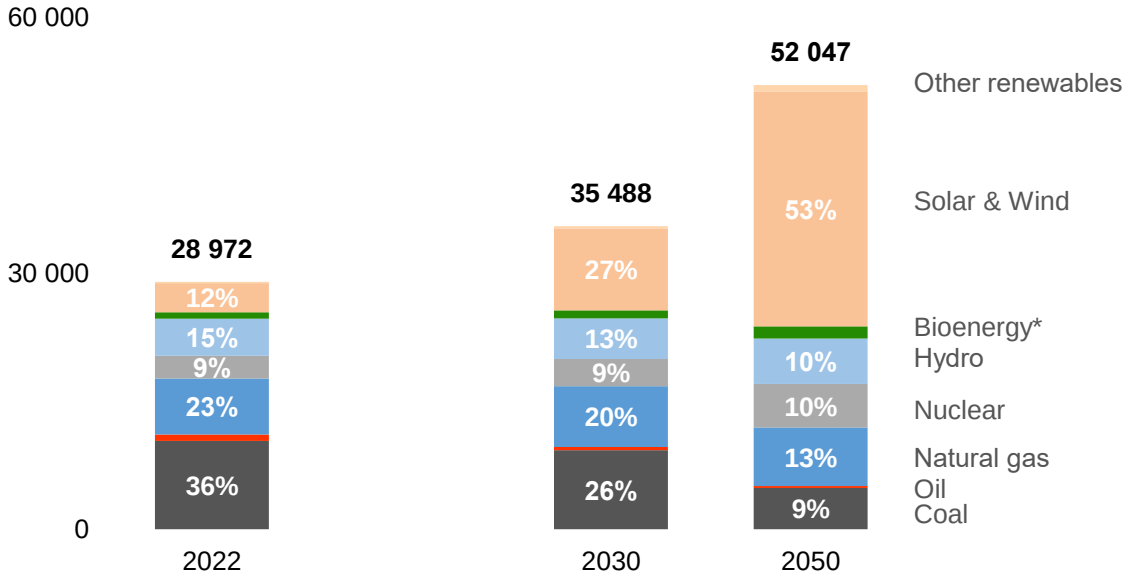
TWh



- Residential and commercial is the largest driver of electricity demand increase (~+8000 TWh) followed by Industry and Transport (~+6000 TWh each)
- Electrification leads to a more efficient use of energy and decarbonization of final consumption

Electricity generation, excluding electricity for Green H_2

TWh



- New solar and wind generation more than meets electricity demand increase
- Gas increases slightly to balance the system, as a complement to intermittent renewables
- Gas and renewables displace coal leading to electricity generation decarbonization (from 443 in 2022 to 133 gCO_2/kWh in 2050)

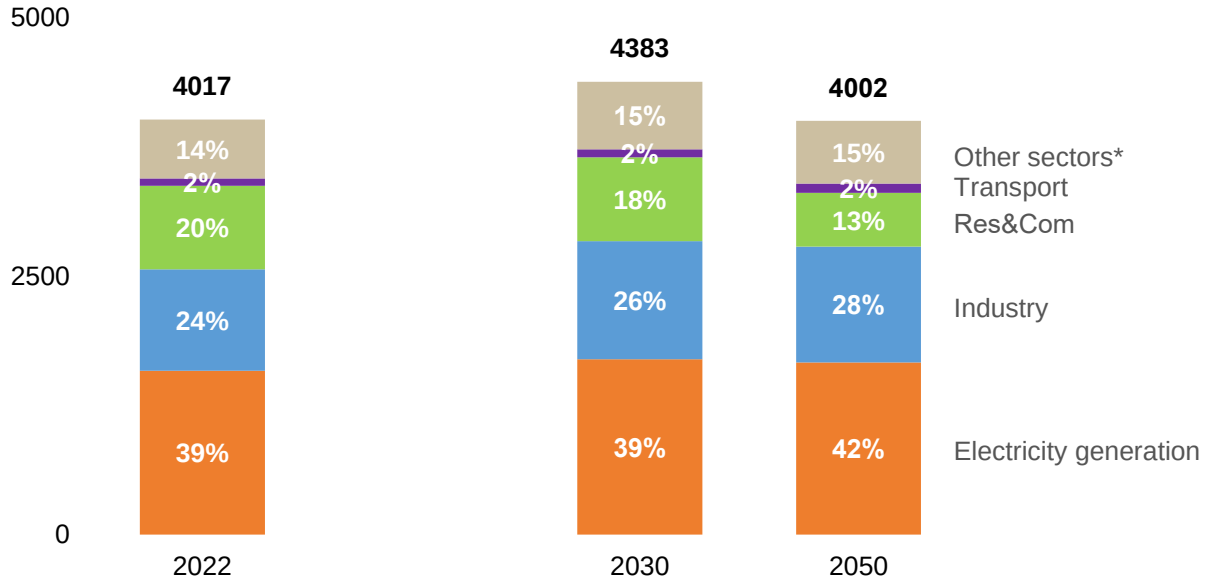
** Includes traditional use of biomass, waste, biofuels, biogas…*
*** Other energy use and agriculture*

World Liquids & Natural Gas Demand

Natural gas key for energy transition; oil demand starts slowly decreasing after 2030

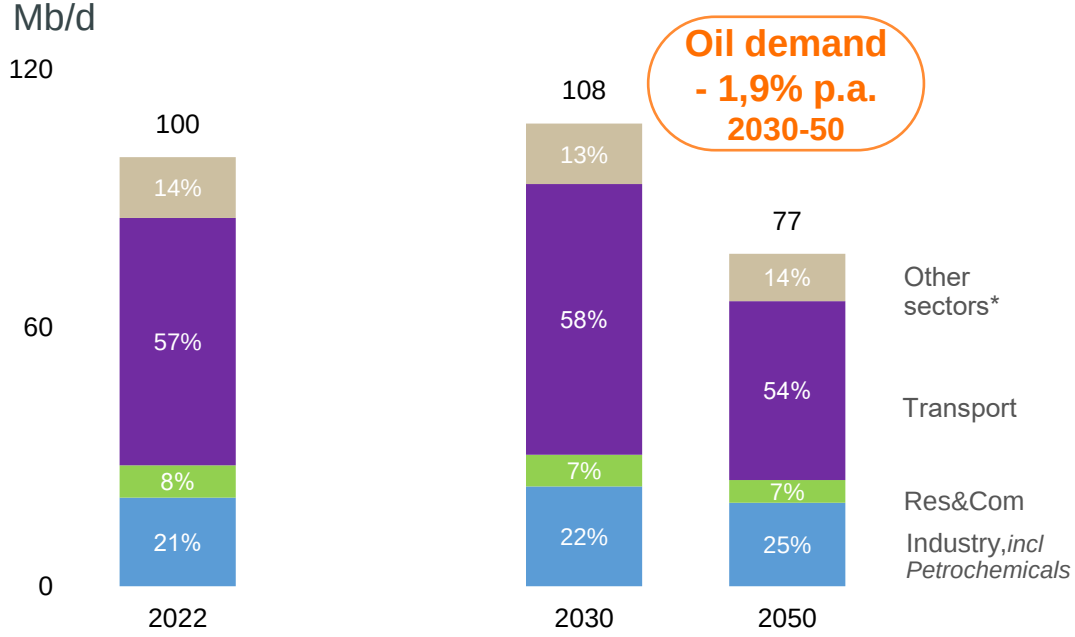
Natural gas demand by sector, excluding gas for Blue H_2

Bcm



Liquids (oil + bio-fuels) demand by sector

Mb/d



- Gas demand increases in the short-term until a plateau between 2030-2035, then decreases slowly to current level by 2050
- Buildings demand decreases (- 36%), as heat pumps replace gas boilers, compensated by industry (+ 14%), as gas replaces coal to reduce emissions, and electricity generation (+ 5%) as gas-fired plants are required to balance a growing electricity system

- By 2030, accelerated electrification of the Transport and Buildings sectors lead to oil demand growing to 102 Mb/d, compared to 97 Mb/d in 2022
- Biofuels could represent up to 6 Mb/d in 2030 and 7 Mb/d of the demand by 2050; more than double the current level
- Oil demand starts decreasing around 2035, but slower than 4-5% p.a. natural decline of existing oil fields. Meeting demand requires therefore developing new fields

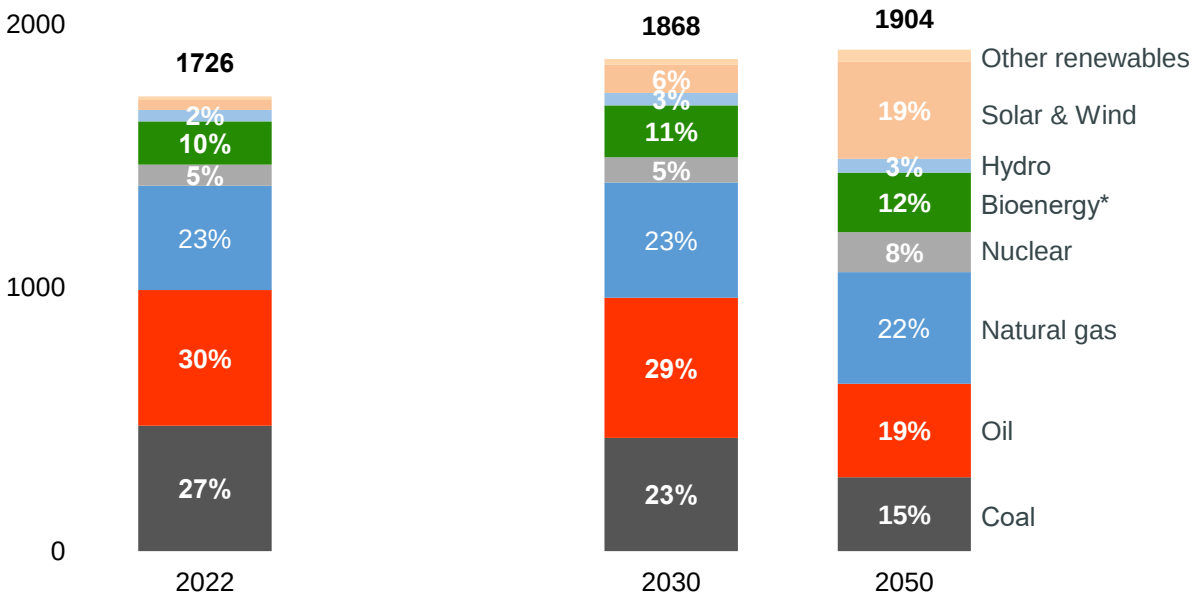
** Other energy and non-energy use, agriculture…*

Momentum

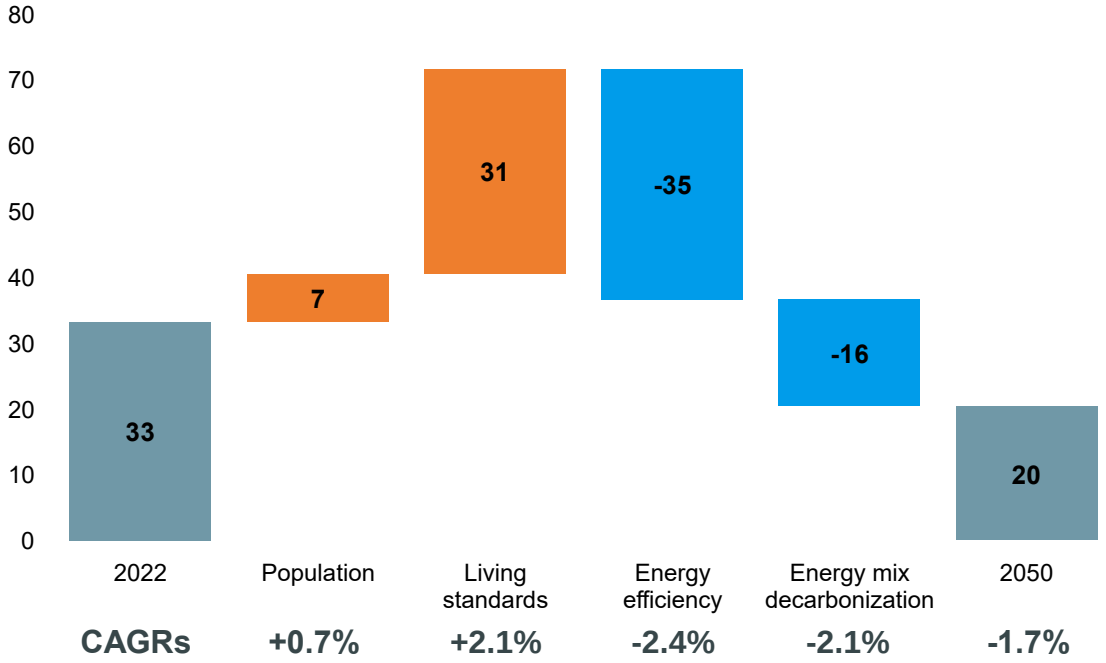
World primary energy demand and CO_2 emissions

Significant progress towards decarbonization achieved, but still falling short

Total primary energy demand
PJ/d



Changes in annual CO_2 emissions over 2022-2050**
GtCO2



- Fossil fuels share in primary energy demand is reduced from 80% in 2022 to 56% in 2050, replaced by green electricity
- Gas is still needed in the long-term to balance power systems and to reduce emissions with coal-to-gas switch

- Emissions are reduced by ~40% by 2050
- More support is needed to emerging economies in order to deploy at scale new technologies, in particular renewables
- This leads to a temperature increase of +2.2-2.3°C by 2100***

** Includes traditional use of biomass, waste, biofuels, biogas…*
*** Living standards: GDP per capita ($/person), Energy efficiency: decrease in primary energy required to produce 1$ of GDP (MJ/$), energy mix decarbonization: CO_2 emissions per unit of energy (gCO2/MJ)*
**** Temperature increases estimated at P66-P83, evaluation conducted by MIT*

TotalEnergies

Rupture

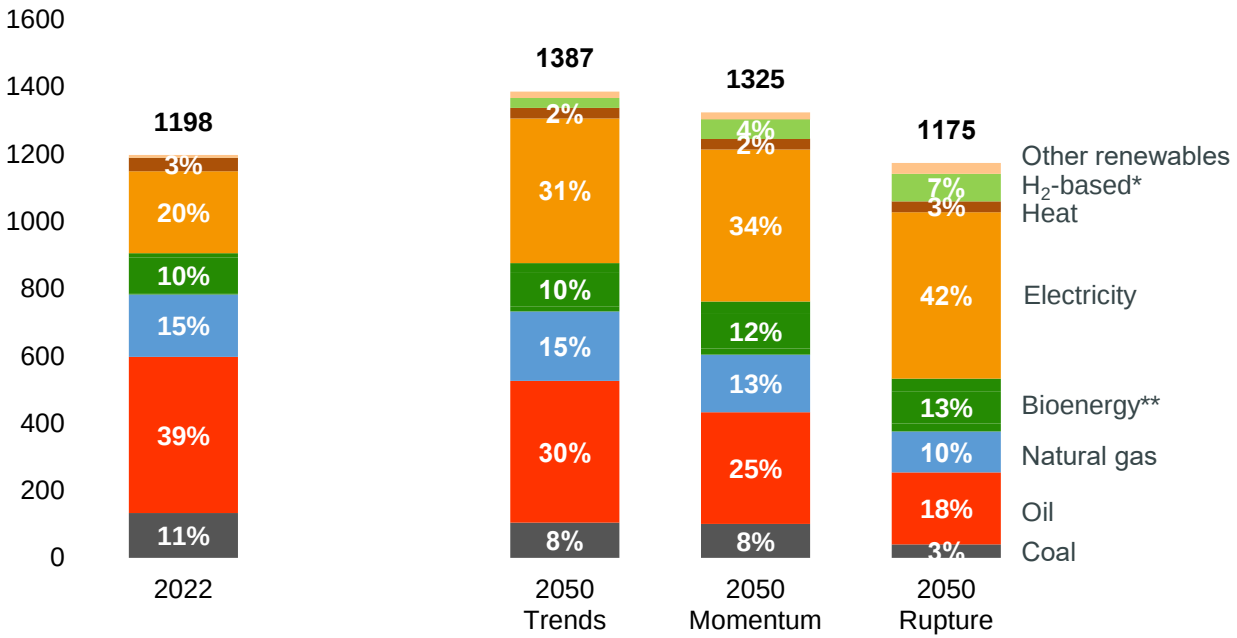
Pioneers for 100 years

World total final consumption

All countries are embarked in reducing emission of end use

World total final consumption

PJ/d



Changes in annual total final consumption over 2022-2050***

PJ/d

- Electrification of all sectors and use of cleaner fuels (H_2-based and bioenergy) reduce fossil fuels use to 31% in 2050
- When support is given to emerging economies, the whole world benefits from clean and advanced technologies

- Electricity and improved efficiency of equipment more than compensate increasing population and living standards
- Final sectors energy conversion efficiency**** improved by 43% by 2050

** Includes H2, e-fuels (H2 + CO2), methanol, ammonia…*
*** Includes traditional use of biomass, waste, biofuels, biogas …*
**** Living standards: GDP per capita ($/person); Energy efficiency: decrease in final energy required to produce 1$ of GDP (MJ/$)*
***** Mesured as the ratio of useful energy (e.g. energy transmitted the wheels of a car) over final energy (e.g., energy used by the engine of a car)*

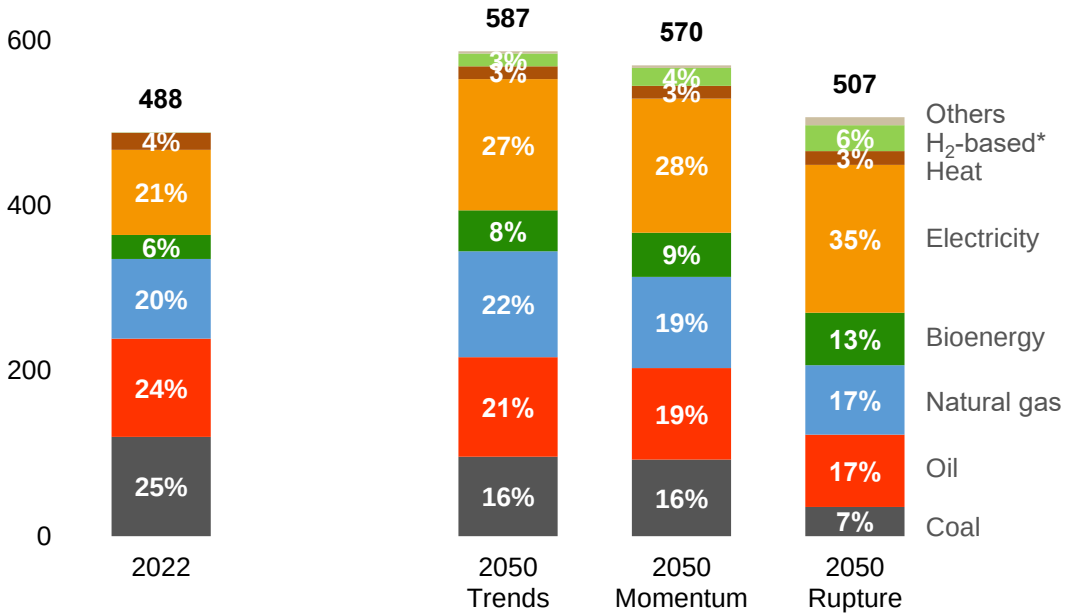
Rupture

Heavy decarbonization in Industry and buildings

Electricity becomes the primary energy vector

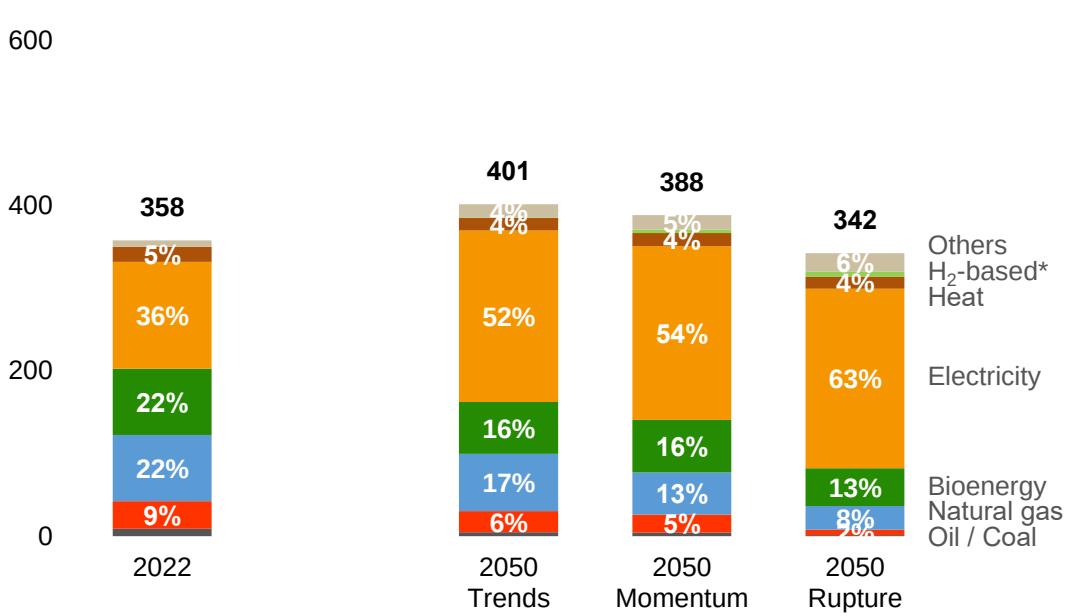
Industry Total Final Consumption

PJ/d



Residential & Commercial Final Consumption

PJ/d



- Post 2030, industry emission reduction accelerates by substitution of coal & fuel oil by electricity and bioenergy
- Carbon Capture Utilization and Storage helps abate the remaining fossil share, especially post 2030

- Electrification in Rupture is higher than in Momentum, no coal and almost no oil left by 2050
- Clean cooking is deployed extensively, replacing use of inefficient traditional biomass, especially in Africa

** H_2 and derivatives such as ammonia*

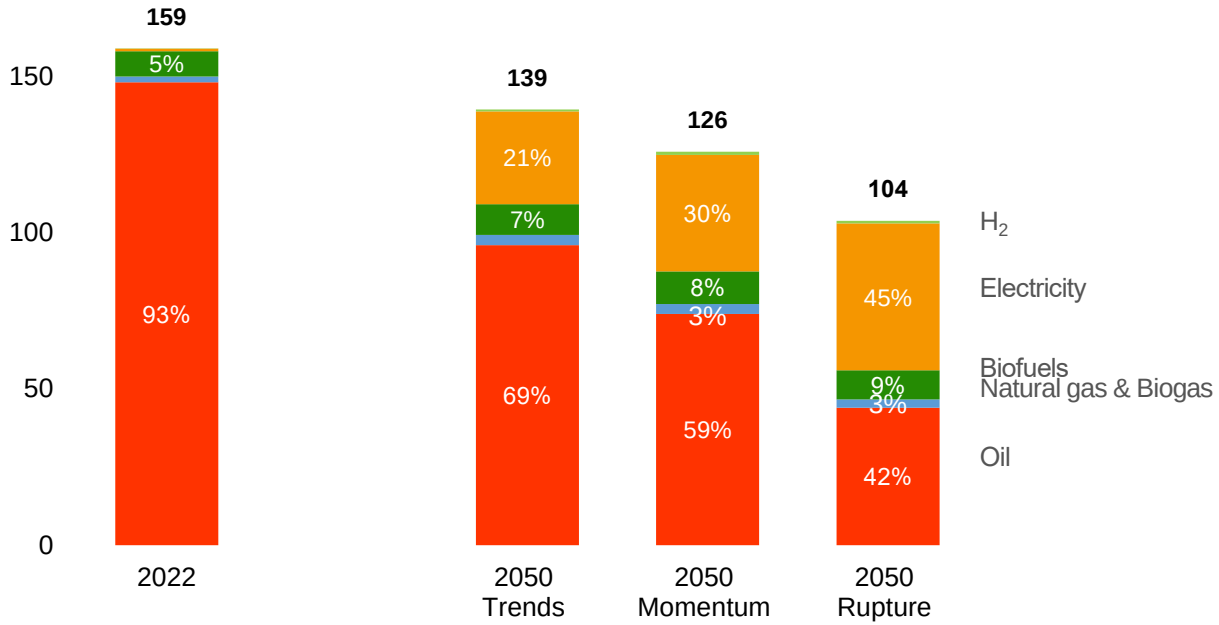
Rupture

Electrification of Light Duty Vehicles

Widespread Light Duty Vehicles electrification reduces their oil demand by 2050

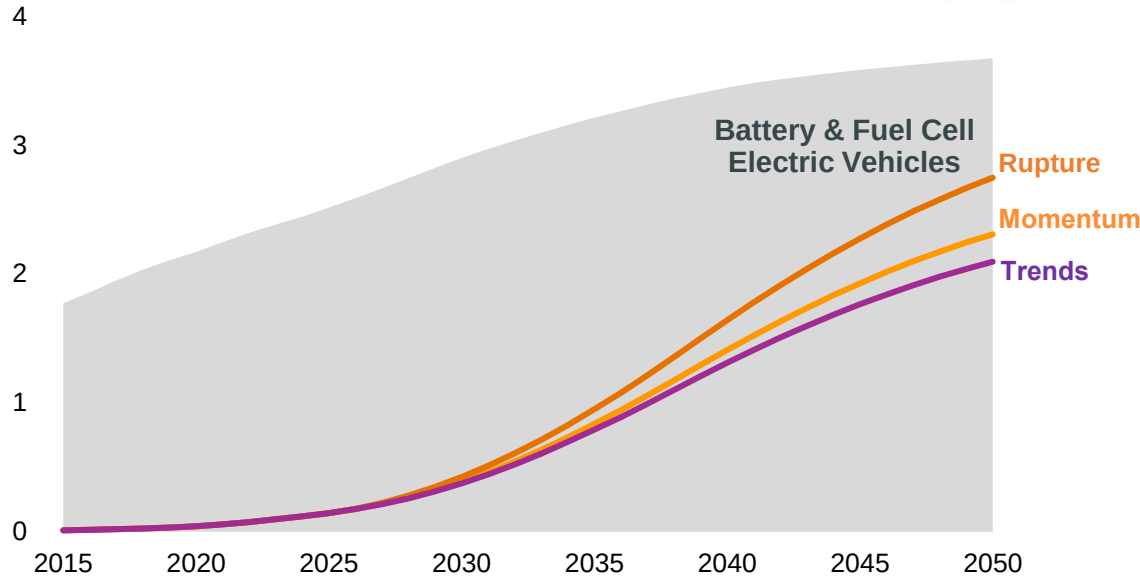
Light Duty Vehicles* Final Consumption

PJ/d



Light Duty Vehicles fleet

Billion



- The share of low-emission fuels by 2050 increases from 30% in Trends to 55% in Rupture, electricity being the main decarbonization solution
- Electric engines are about 3 times more efficient than the thermal ones, hence the energy need is reduced by ~40% in 2050 in Rupture vs Trends

- Battery and Fuel Cell EV sales penetration of passenger cars are close in all scenarios by 2030 and diverge afterwards driven mainly by Global South and India.

** Passenger cars + Light Commercial Vehicles + 2-3 wheelers*

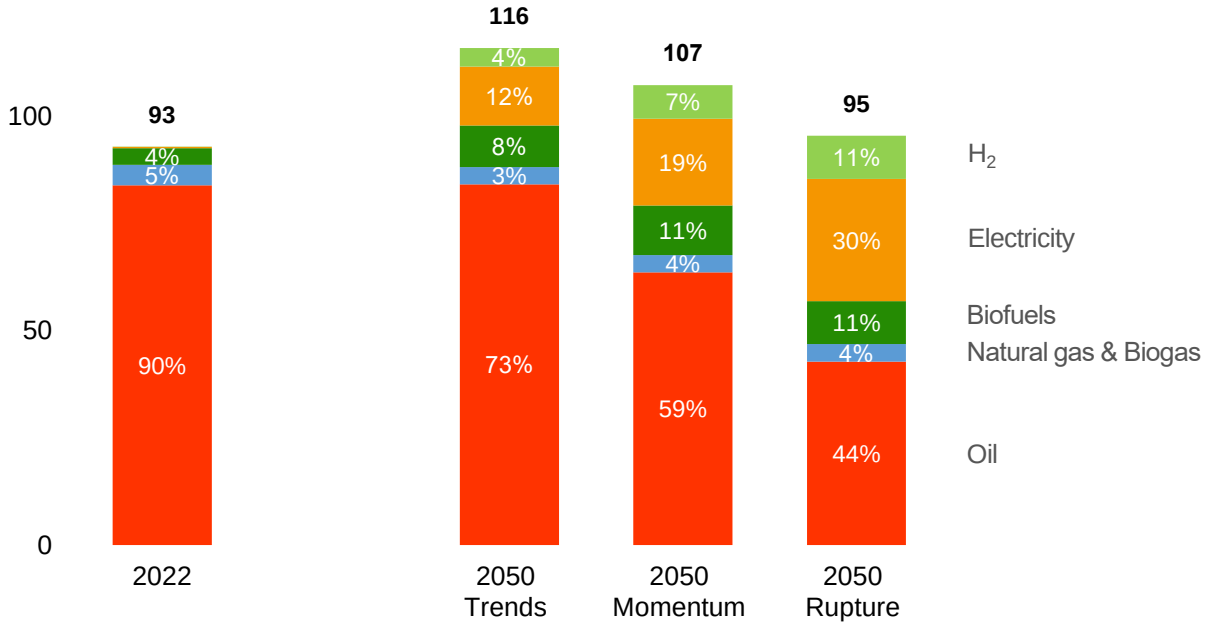
Rupture

Electrification of Heavy Duty Vehicles

Electricity primary driver of decarbonization

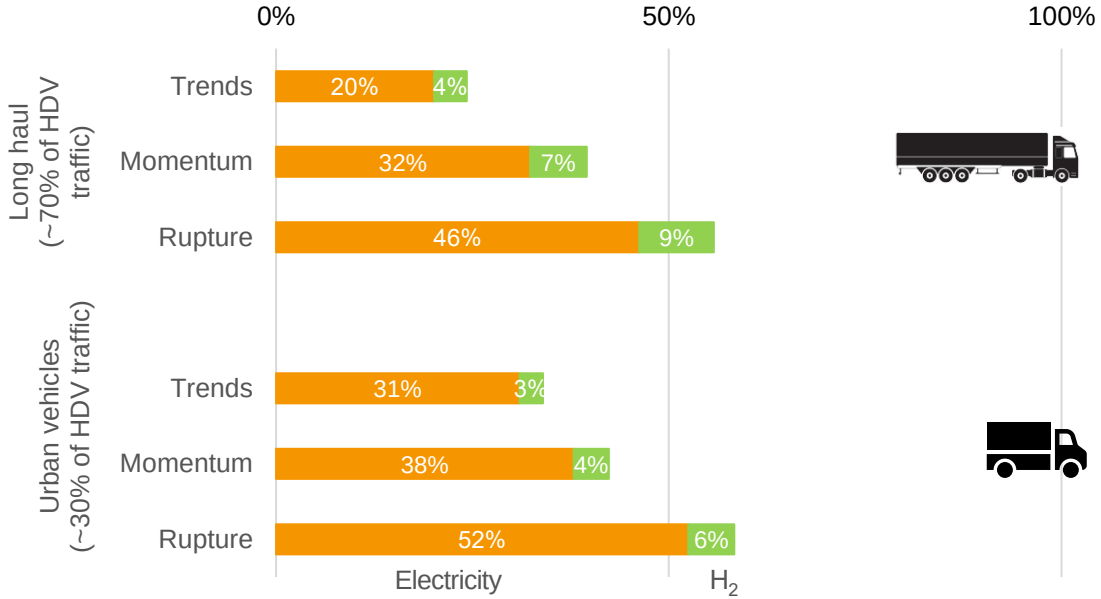
Heavy Duty Vehicles* Final Consumption

PJ/d



Zero Emissions Vehicles share of HDV traffic

2050, % of km travelled



In 2050 in Trends, fossil fuel volume is similar to 2022, whereas it is lower by 25% in Momentum and by 45% in Rupture

Hydrogen penetration increases across scenarios, although it never captures a significant share

** Trucks + Buses + Coaches*

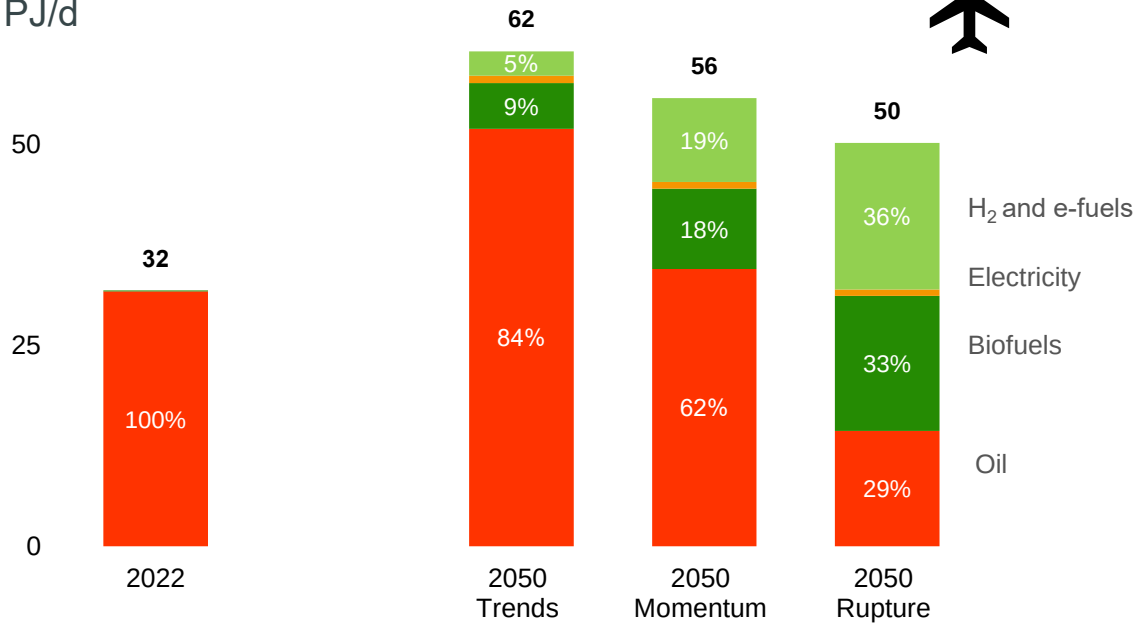
Rupture

Multiple decarbonization paths for Aviation & Marine

Bio-energies & green electricity for e-fuels are the primary lever of decarbonization

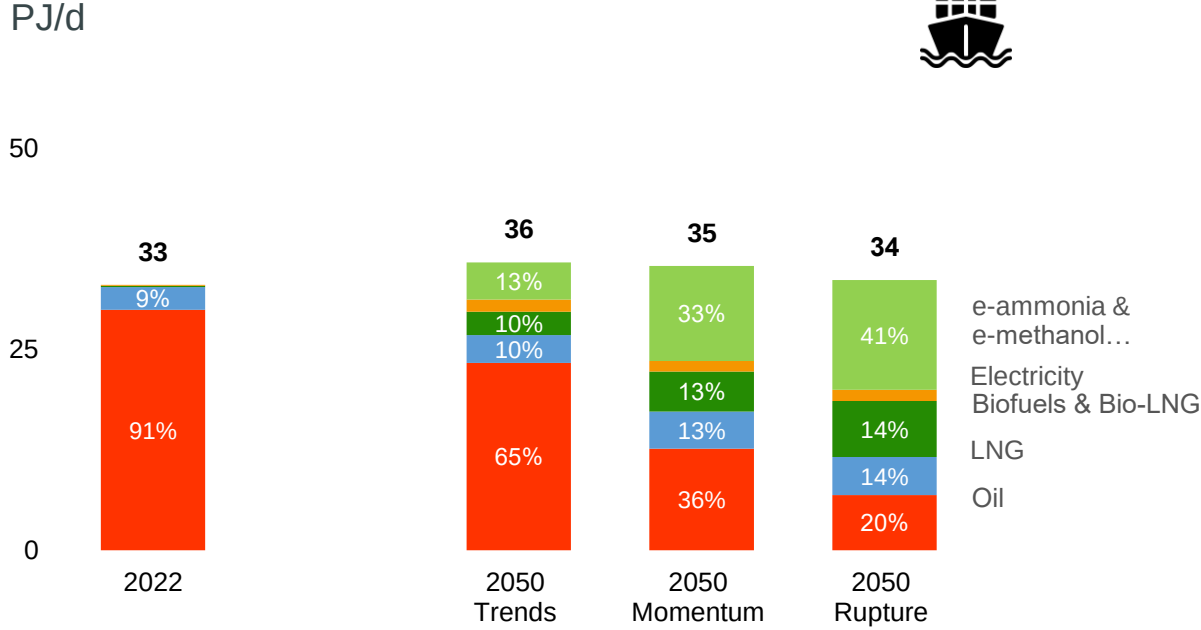
Aviation Final Consumption

PJ/d



Marine final consumption

PJ/d



In 2024, 123 countries (representing ~70% of emissions) have committed to limit their CO_2 emissions by 2035 at 85% of their 2019 level. This ambitious target is only met in Rupture

To move from Trends to Rupture, oil is mostly displaced by e-fuels (either e-methanol or e-ammonia)

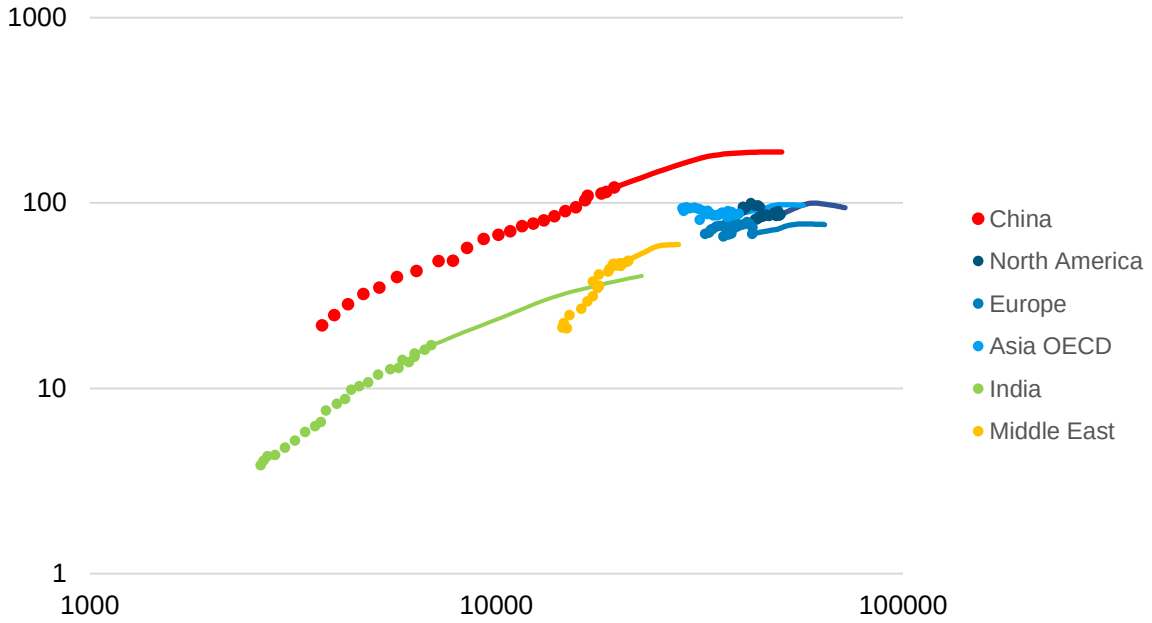
Rupture

Polymers feedstock demand

Recycling is essential to reduce fossil feedstock demand

Polymer gross demand

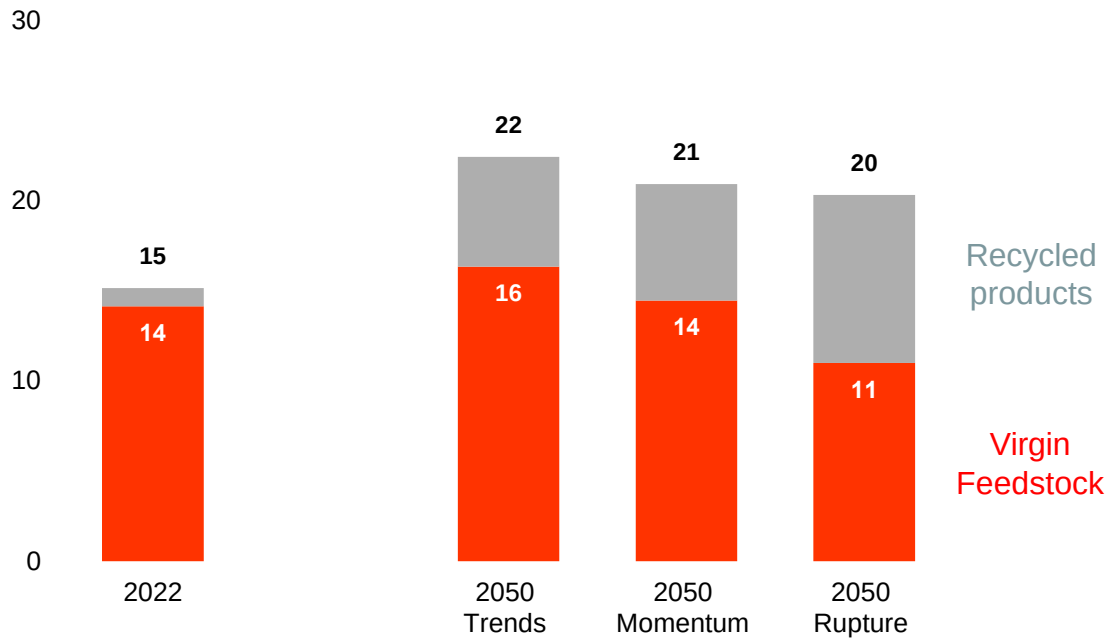
(kg/cap) vs. GDP ($$_{mod}$/cap)*



- In OCDE countries Polymer Gross demand per capita increases with GDP per capita until it stabilizes around ~75-100 kg/cap. This stabilization is expected to occur in all regions over time
- Polymer demand in China higher than in other countries for same GDP level, due to massive exports

Feedstock gross demand

Virgin feedstock (Mb/d) and recycled product (Mb/d_{equ})



- By 2050, virgin feedstock demand increases by +15% in Trends, much lower than ~60% increase in polymer demand, as recycling develops
- Recycling has a large impact in Rupture: virgin demand is reduced by 20% vs current level while polymer increase by 50%

** Dots represent historical data since 2000, solid lines represent projections to 2050*

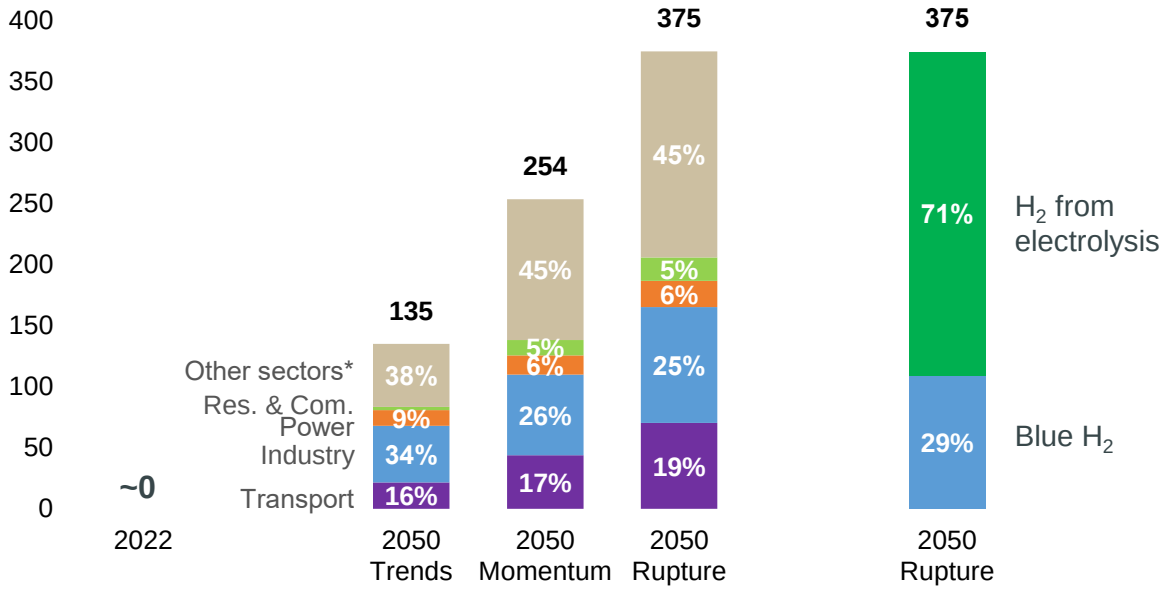
Rupture

Clean Hydrogen

Ambitions more focused to hard-to-abate sectors where clean hydrogen is required

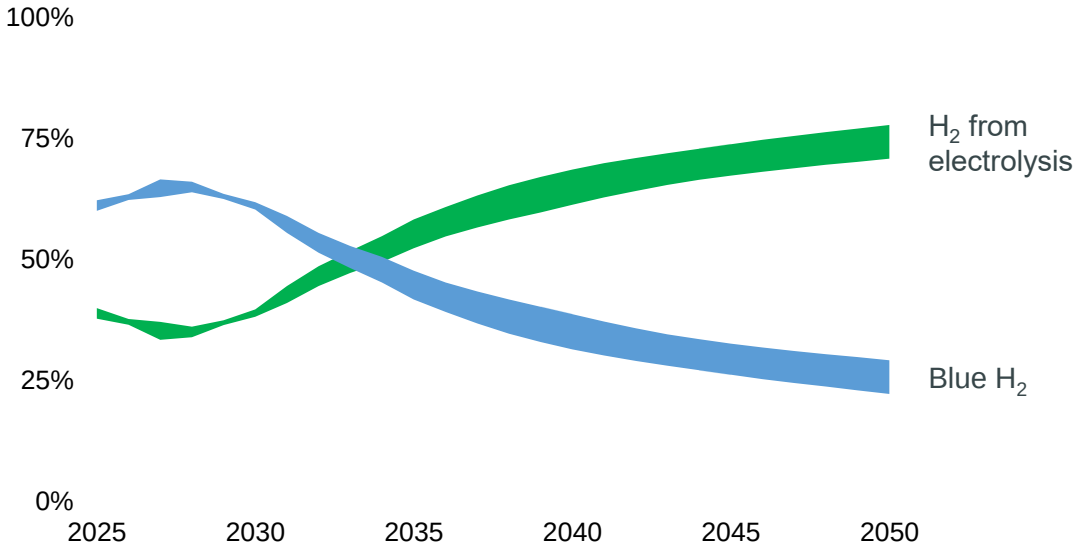
Clean H_2 balance

MtH_2



Pathways to clean hydrogen

% of production by way, range for 3 scenarios



2050 hydrogen demand close to three times higher in Rupture than in Trends, as Hard-to-abate sectors require clean hydrogen and its derivatives to decarbonize

- In all scenarios blue hydrogen is dominant in the short-term as countries with abundant and cheap gas develop this almost mature technology
- By 2040, hydrogen from electrolysis becomes dominant, as an outlet for renewable electricity during periods of excess supply

** Other energy use, non-energy use and agriculture*

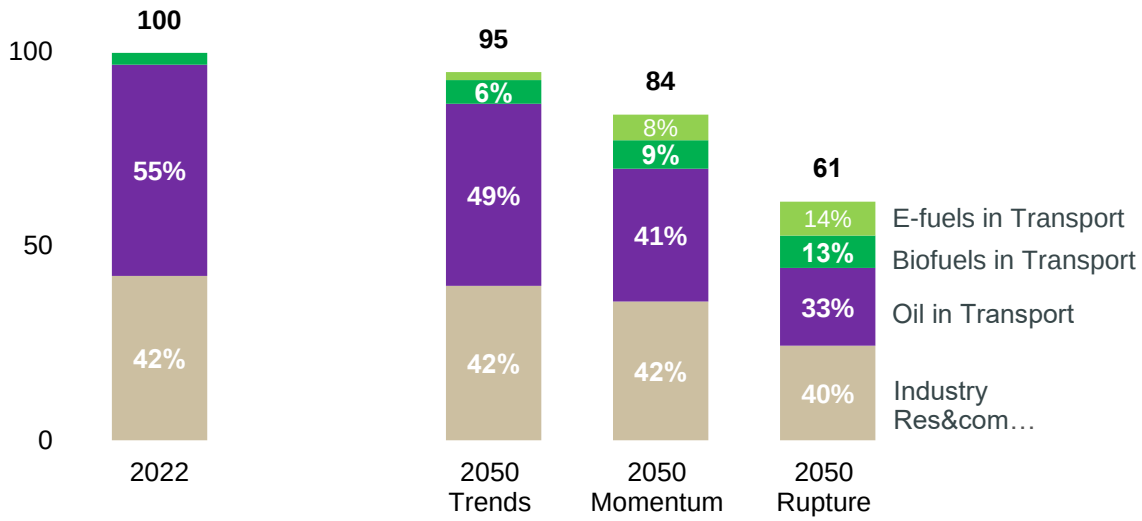
Rupture

World Liquid Fuels demand

Low Carbon fuels represent almost 30% of the liquids demand in 2050

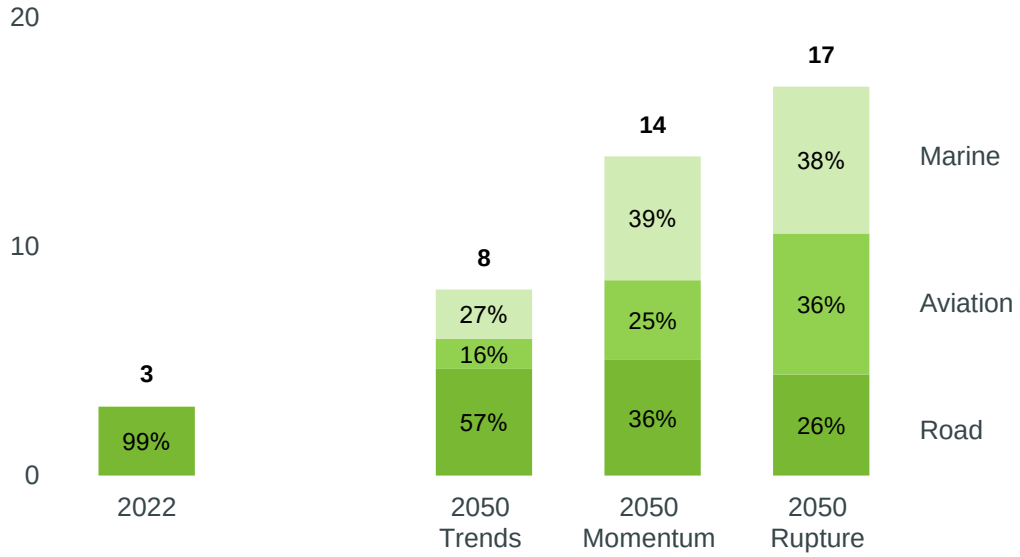
Liquid Fuels (oil + biofuels + e-fuels) demand by sector

Mb/d



Biofuels + e-fuels demand in transport

Mb/d



- Oil demand plateaus until 2030, before reaching ~70 Mb/d in Momentum and ~44 Mb/d in Rupture in 2050, of which 25% (11 Mb/d) comes from Petrochemical sector
- Oil demand decreases faster in Rupture (-3,9% p.a over 2030-2050). Decrease rate still slower than natural decline of existing oil fields
- Sustainable Liquid Fuels represent almost 50% of Transport liquids demand in Rupture (equally split between e-fuels and biofuels)

- In Rupture, Aviation and Marine require 4 times more Sustainable Liquid Fuels by 2050 than today, with biofuels representing 8 Mb/d, compared to available bio-feedstocks estimated between 13-26 Mb/d*
- High EVs penetration rate in Rupture reduces biofuels needs for road transportation by 2050, hence free them up for aviation and marine

** Source : IRENA, IPCC, FAO, Academics publication*

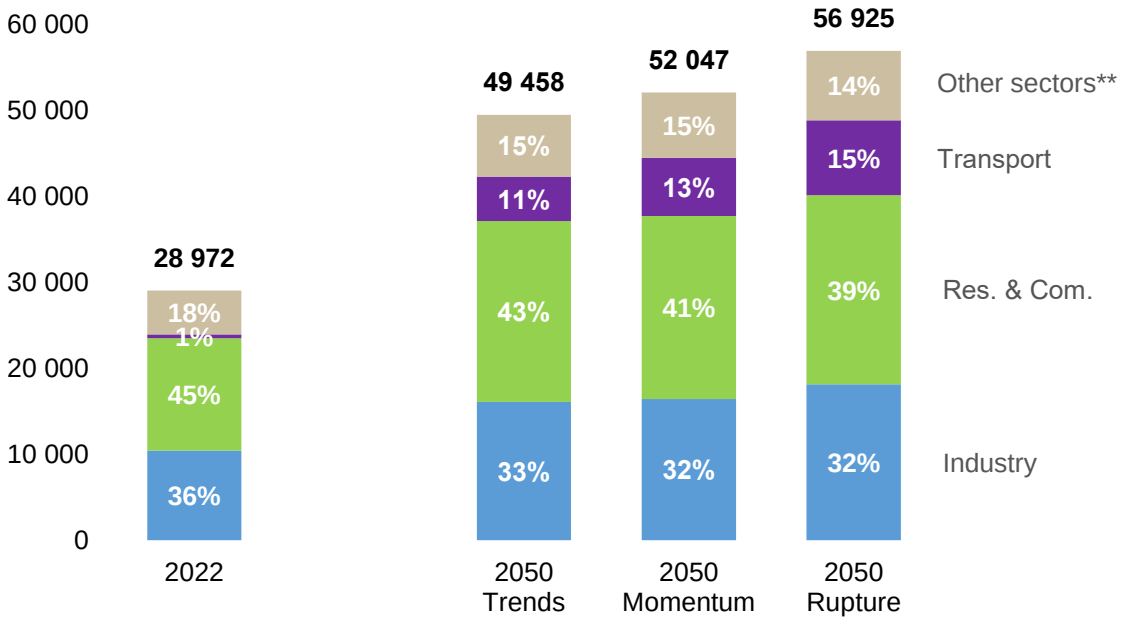
Rupture

World electricity demand and generation

A world well-below 2°C requires a new electricity system

Electricity demand, excluding electricity for Green H_2

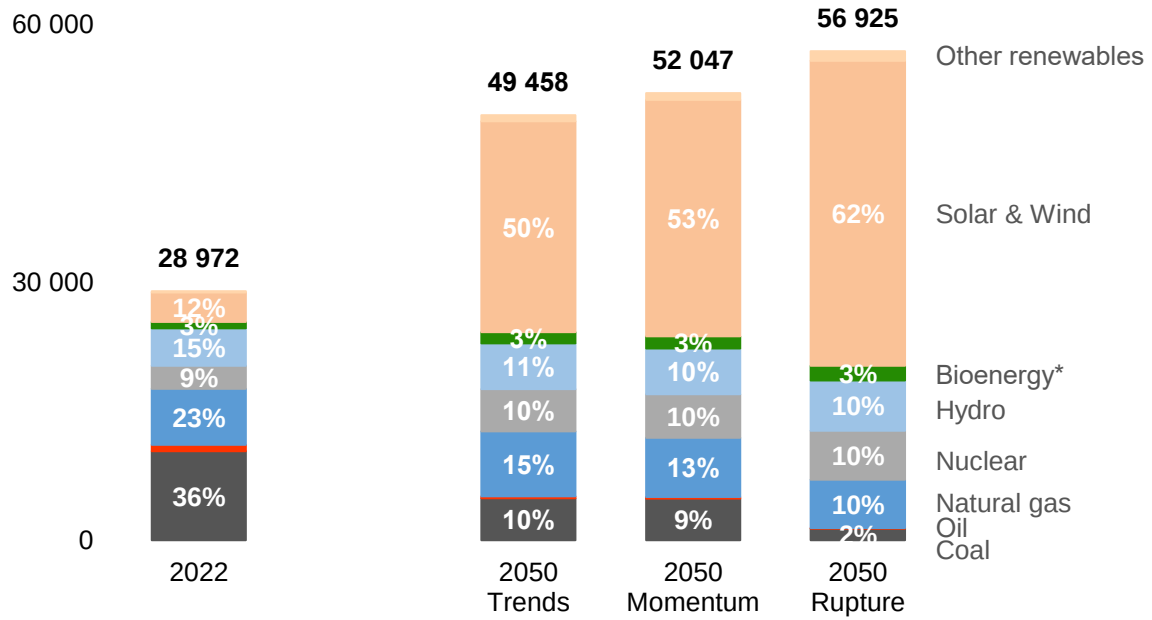
TWh



- Electricity demand accelerates at 2.4% p.a. to 2050 (vs. 2.1% p.a in Momentum and 2.0% p.a. in Trends), doubling to 2050
- Res. & Com. and Industry demand are multiplied by 1.7 between 2022 and 2050, while demand for transportation is multiplied by 20

Electricity generation, excluding electricity for Green H_2

TWh



- Solar & Wind additional generation represents 115% of electricity demand increases, thus also replacing coal and oil
- Renewables deployment requires more flexibility in the system: grid enhancements, storage systems, flexible generation and demand response
- Coal almost disappears in Rupture, natural gas still required to manage variability of renewable energies

** Includes traditional use of biomass, waste, biofuels, biogas…*
*** Other energy use and agriculture*

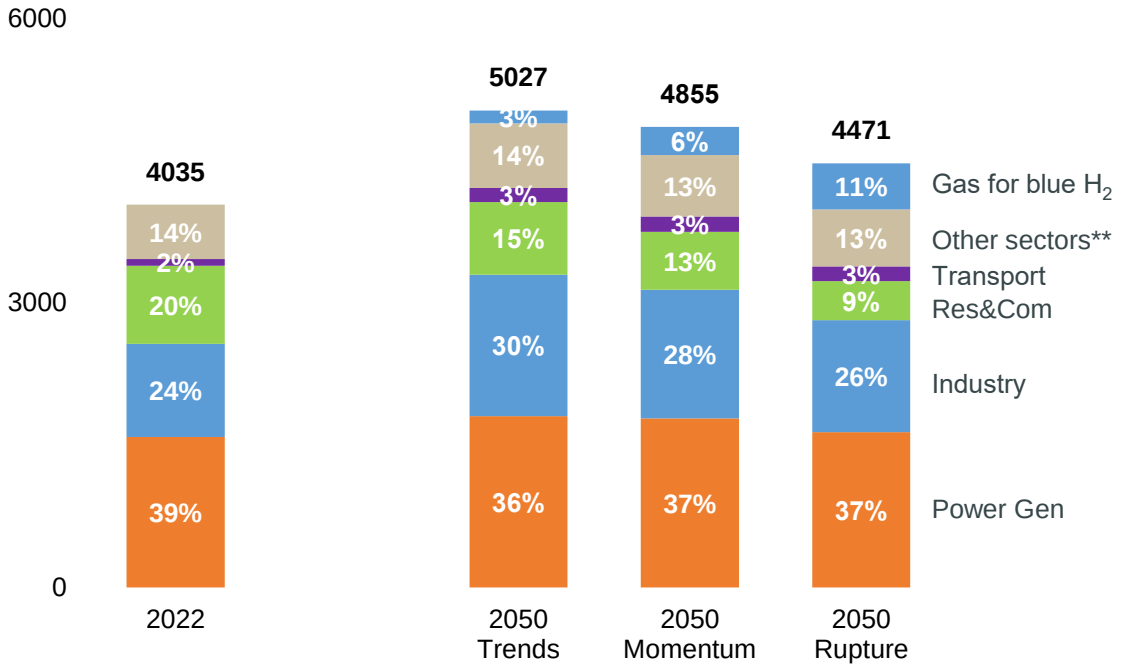
Rupture

World Gases demand

Towards low-carbon gases predominance in a well-below 2°C World

Gases demand by sector

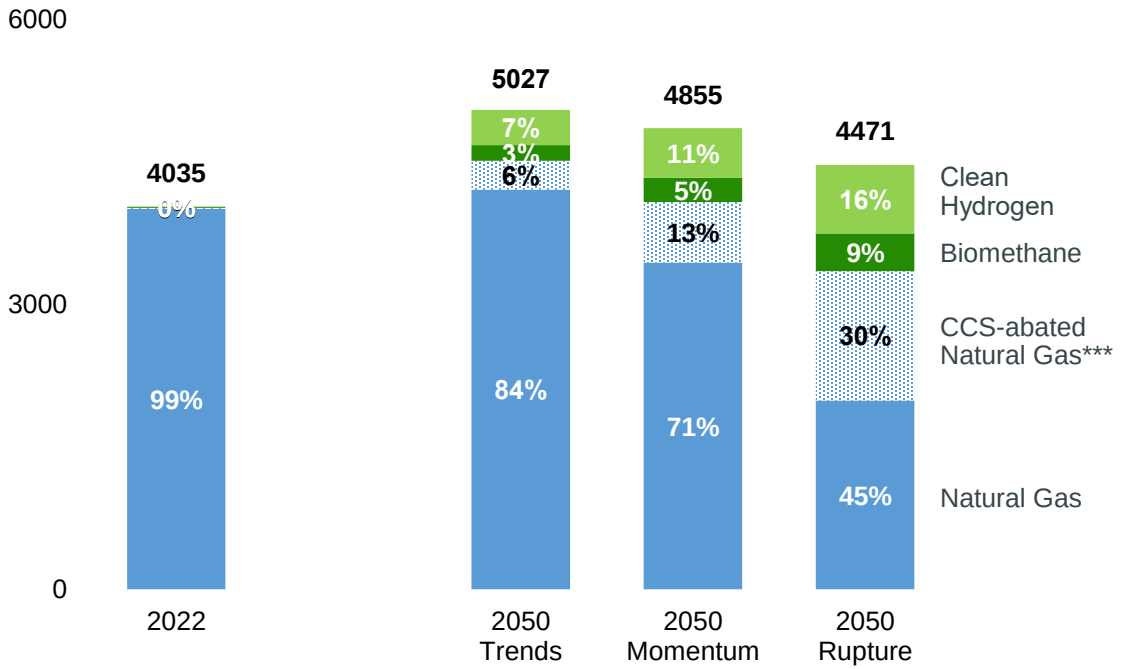
Bcm*



- Gases demand increases in all scenarios in every sector except in Residential & Commercial due to heat pumps deployment
- Natural gas remains very important in power generation to balance the system, in industry to replace coal and to produce low-carbon hydrogen when abated

Gases demand by type

Bcm*



- Green gases and CCS-abated natural gas represent ~60% of World demand in 2050 in Rupture vs ~30% in Momentum

** For hydrogen: volumetric equivalence of natural gas in energy terms; H_2 supply for liquid e-fuels production is excluded*
*** Other energy use, non-energy use and agriculture*
**** CCS-abated natural gas demand excl. the portion used to produce hydrogen through SMR+CCS*

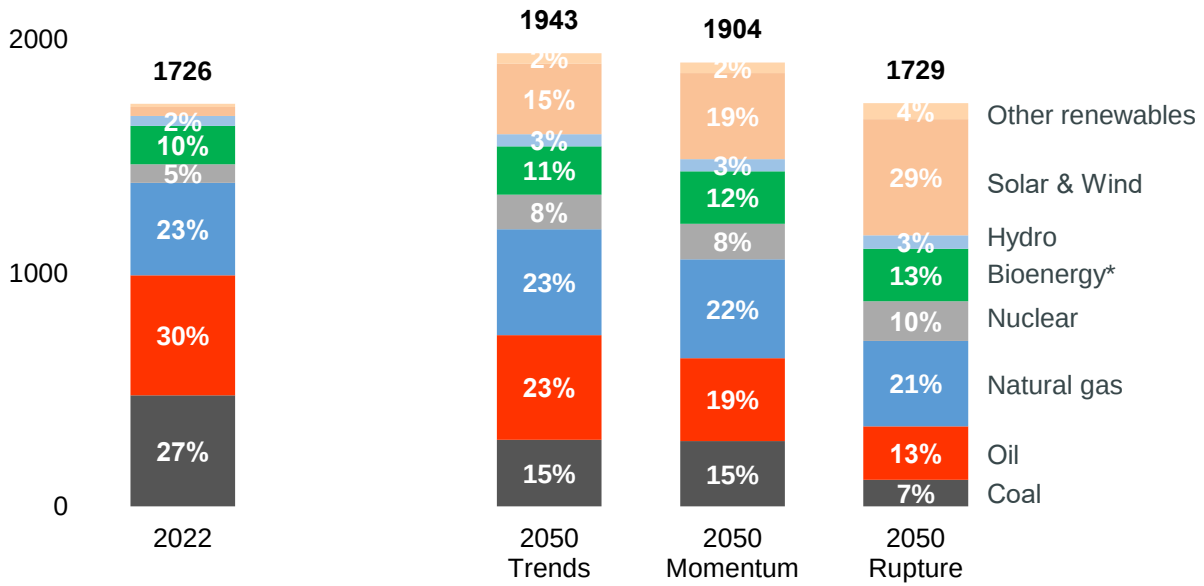
Rupture

World primary energy demand and CO_2 emissions

Global green electrification necessary to remain well-below 2°

Total primary energy demand

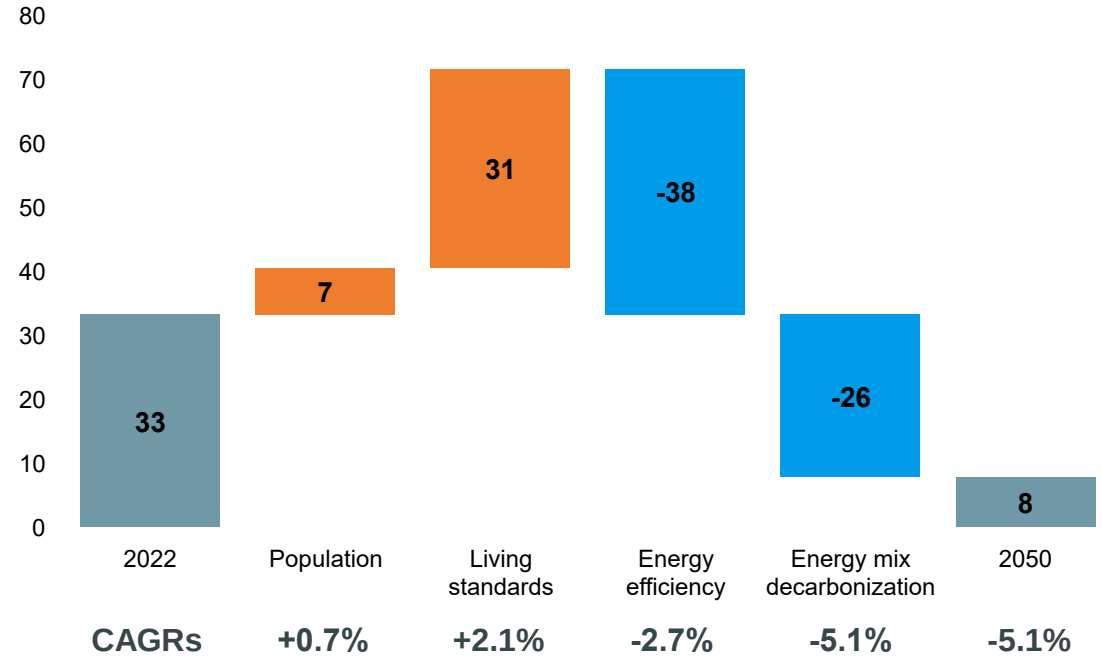
PJ/d



- Stronger deployment of renewables pushes out fossil fuels in Rupture
- Nuclear more than doubles by 2050, as a baseload electricity provider

Changes in annual CO_2 emissions over 2022-2050**

Gt CO_2



- Emissions per $ of GDP decrease by more than 80%, thus combining increased prosperity – especially for emerging economies – with emission reduction
- This leads to a temperature increase of +1.7-1.8°C by 2100***

** Includes traditional use of biomass, waste, biofuels, biogas…*

*** Living standards: GDP per capita ($/person), Energy efficiency: decrease in primary energy required to produce 1$ of GDP (MJ/$), energy mix decarbonization: CO_2 emissions per unit of energy (gCO2/MJ)*

**** Temperature increases estimated at P66-P83, evaluation conducted by MIT*

Rupture

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The TotalEnergies Energy Outlook (TEO) sets out potential scenarios of energy mix evolution at world and regional levels until 2050, and the associated likely increase in global average temperature by the end of the century. It is based on in-house work conducted by the strategy and climate teams of TotalEnergies, and on data and input from third-party forecasters, data providers and consultants. The projections contained in the Trends outlook and the Momentum and Rupture scenarios rely on a set of assumptions that may or may not materialize in the future. The TEO is meant to contribute to the debate and discussions around the energy transition and, while it is taken into consideration by TotalEnergies to inform its strategic decisions, the TEO is not a presentation of TotalEnergies' strategy, which is presented in other publications (Sustainability and Climate Report, Investors' presentations).

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