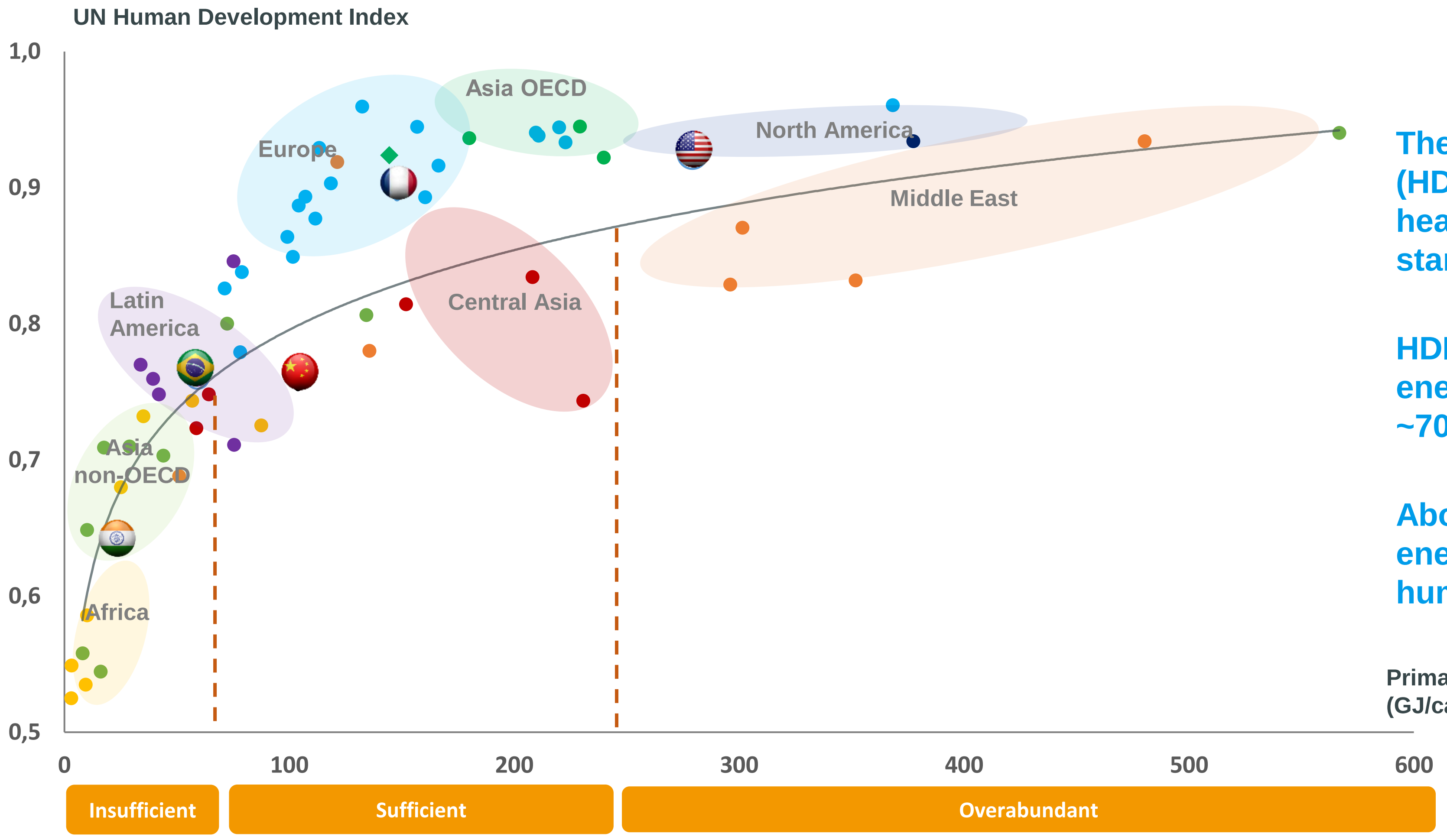

# TotalEnergies
# Energy Outlook 2024

November 4th, 2024

Pioneers for 100 years

# Energy access is essential to human development




**The UN Human Development Index (HDI) measures well-being in terms of health, education and living standards (GDP)**

**HDI increases dramatically with energy access for low levels (below ~70 GJ/cap)**

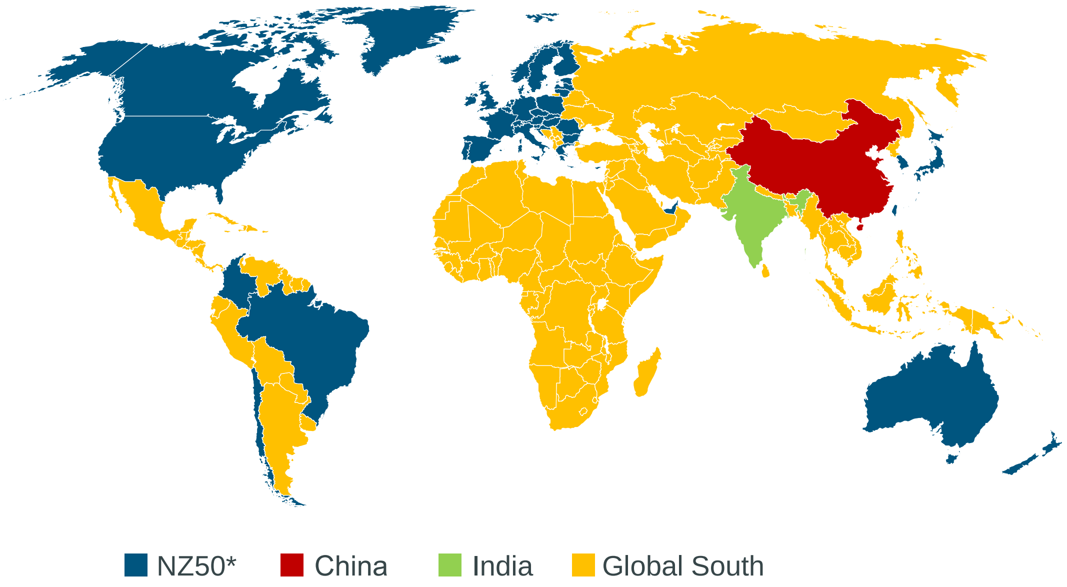
**Above ~240 GJ/cap incremental energy does not significantly improve human development**

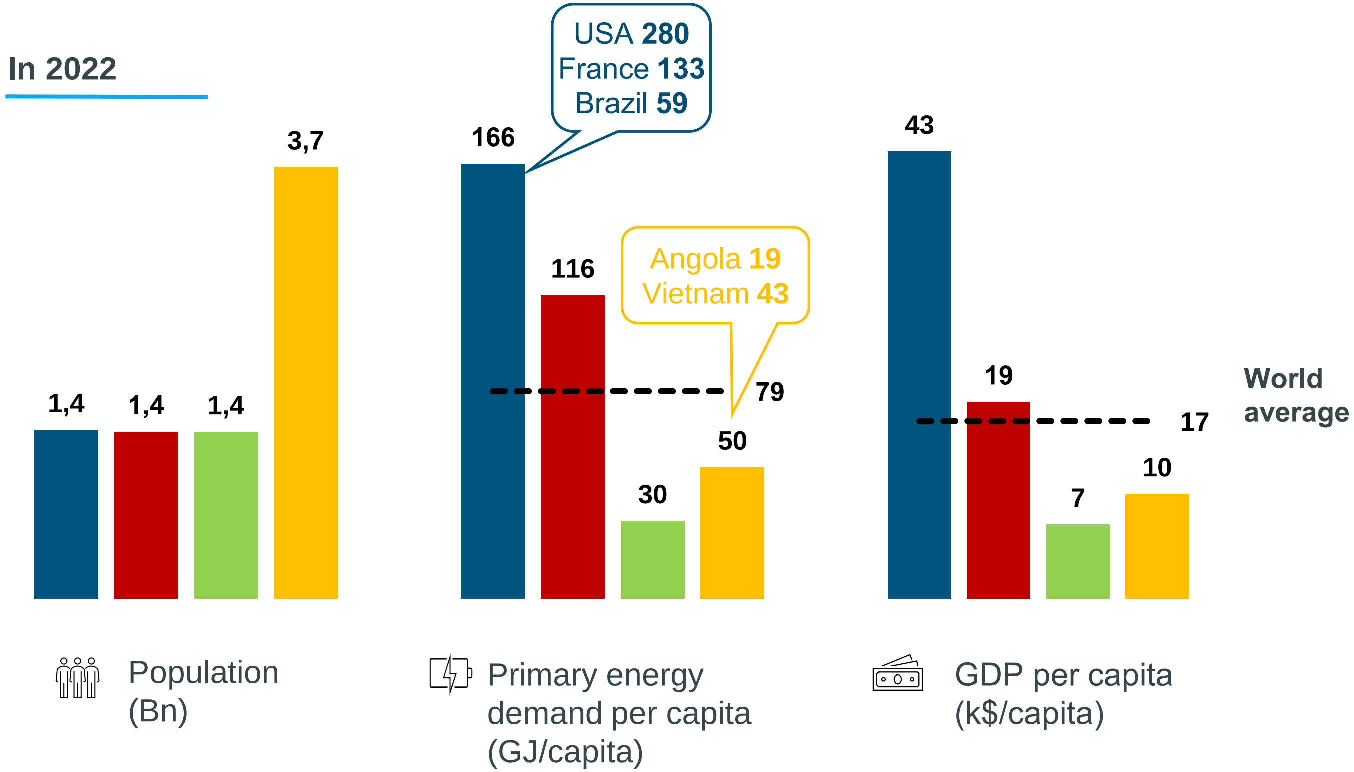
**Today ~4.5 bn people have insufficient access to energy (below ~70 GJ/capita)**



*Sources. HDI: UN data, TPED: Energy Institute & Enerdata, Population: Oxford Economics, graph adapted from Smil (2017)*

# Each country will follow a different energy transition path




**Even countries that have committed to be Net Zero by 2050 (NZ50)* are likely to follow different decarbonization paths**

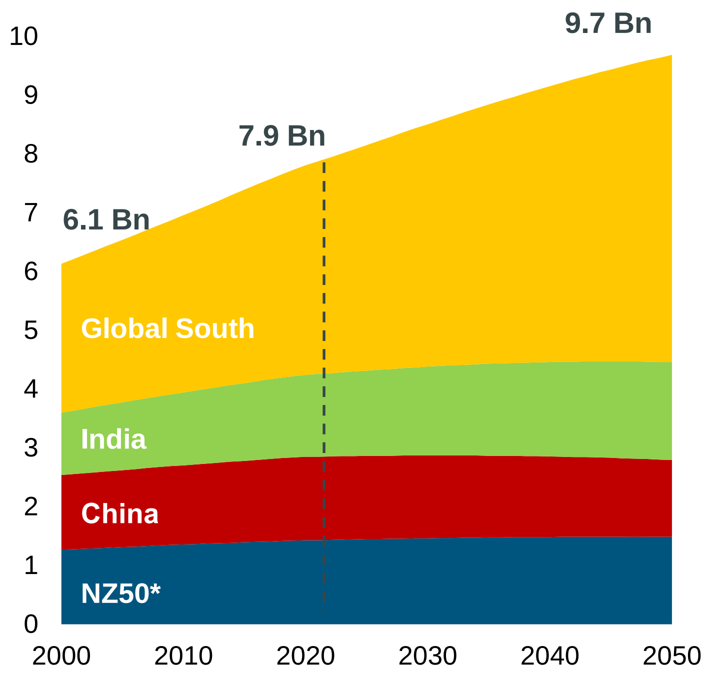


** The 44 countries, mainly OECD countries, that have committed to net carbon neutrality by 2050 – now including Brazil & Colombia*

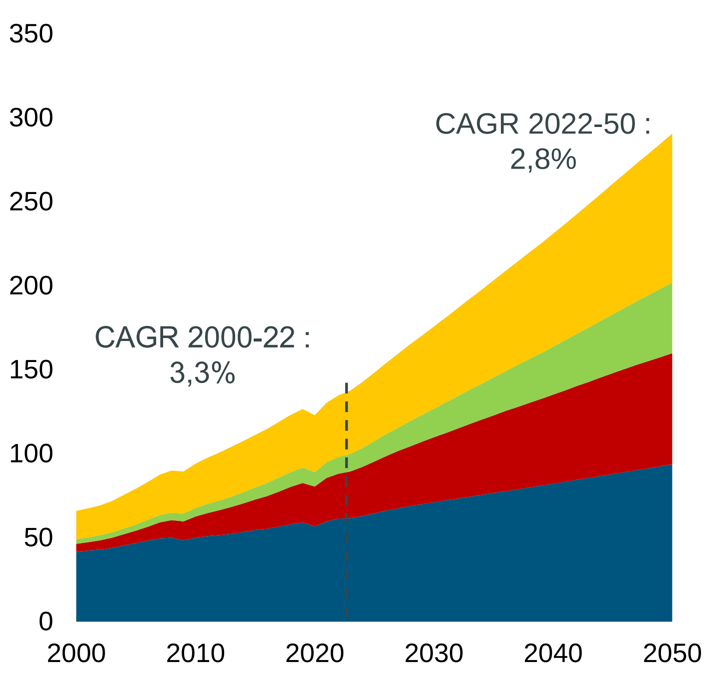
# What to expect in the next 30 years?

## A growing population aspiring to higher living standards in the Global South requires more energy

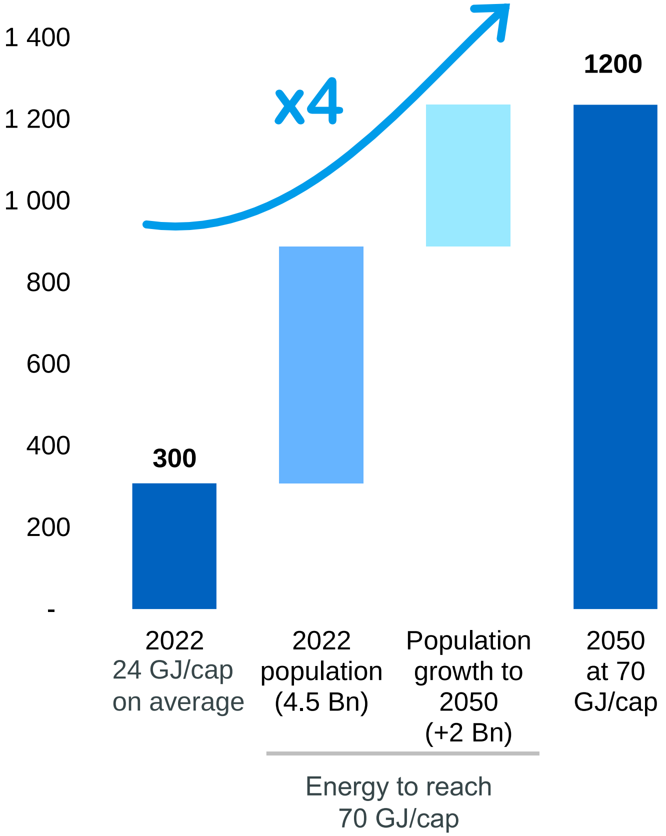
**Population**
Bn of people




**GDP**
Trillion $$_{2015}$




**Primary energy demand in countries with less than 70 GJ/cap today,** PJ/d






*Source: Oxford Economics, Enerdata, TotalEnergies analysis*

# Evolution of global energy indicators since 2000

## Primary Energy demand grows slower than GDP; $CO_2$ emissions start to decouple

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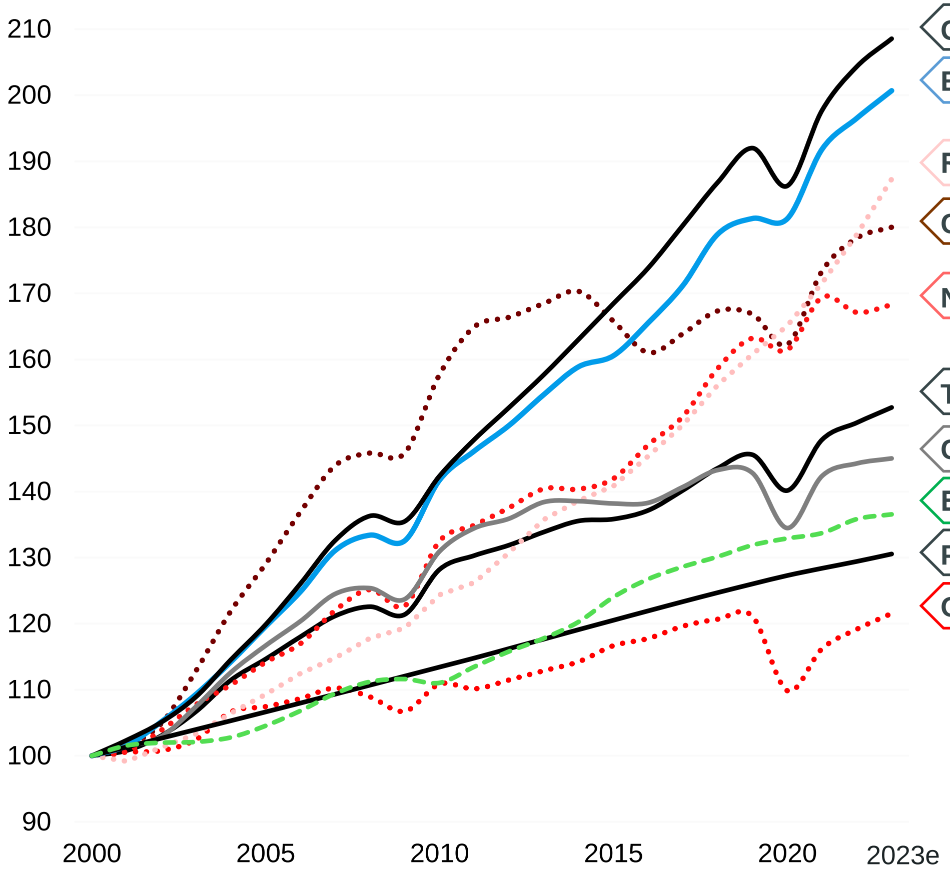
### Evolution of a selection of indicators

2000=100




**Compound Annual Growth Rate (CAGR) 2000-2023**

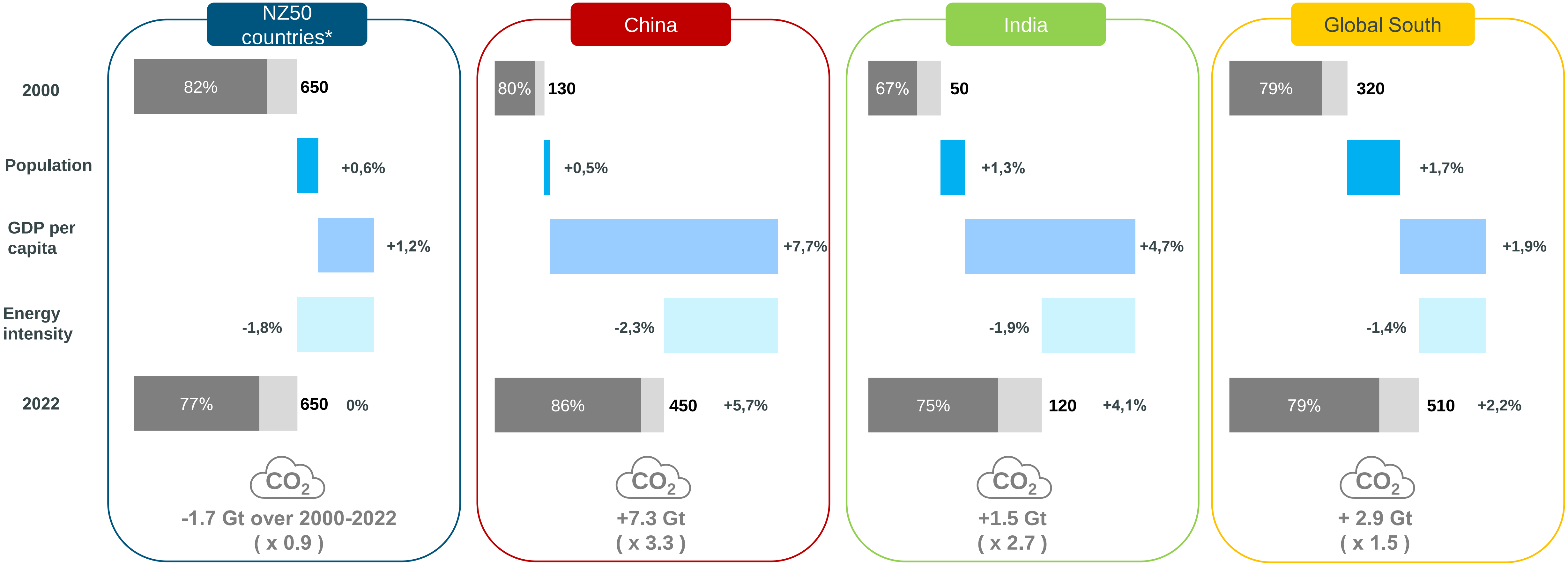
| | |
|---|---|
| GDP | 3,2% |
| Electricity demand | 3,1% |
| Renewable energy supply | 2,8% |
| Coal demand | 2,6% |
| Natural gas demand | 2,3% |
| Total primary energy | 1,9% |
| $CO_2$ emissions | 1,6% |
| Energy efficiency | 1,4% |
| Population | 1,2% |
| Oil demand | 0,9% |

- Electricity demand grows as fast as GDP
- Renewable energy growth has accelerated since 2015
- Coal grows almost as fast as Renewables, benefiting from a cost advantage
- Energy efficiency increase robust, but much lower than the COP28's ambition (3 to 4%/year until 2030)
- Oil demand keeps growing roughly as population

# Energy demand growth primarily driven by improved living standards

**Total Primary Energy Demand (TPED) and emissions growth by region**
PJ/d

+ xx.x % : CAGR over 2000-2022
Unabated fossil
Non-fossil






* *The 44 countries, mainly OECD countries, that have committed to net carbon neutrality by 2050*

# The USA Shale Revolution has transformed the energy landscape in the US and worldwide

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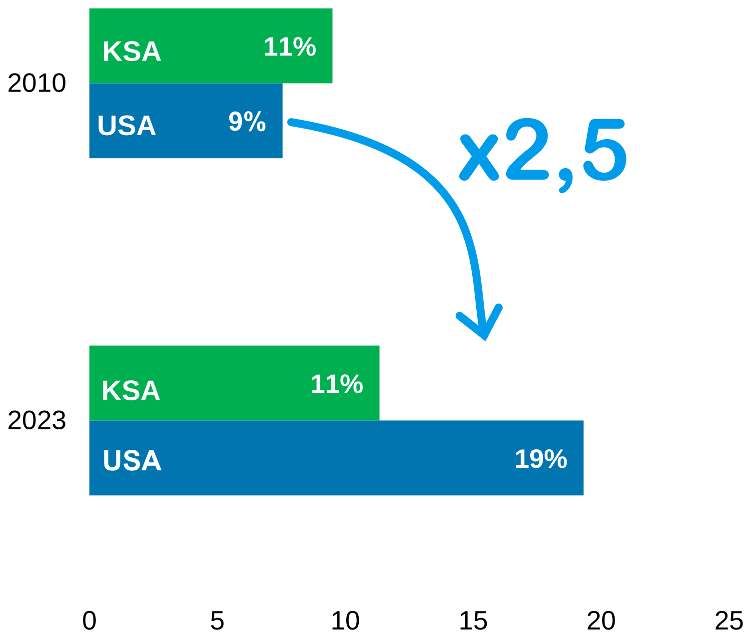
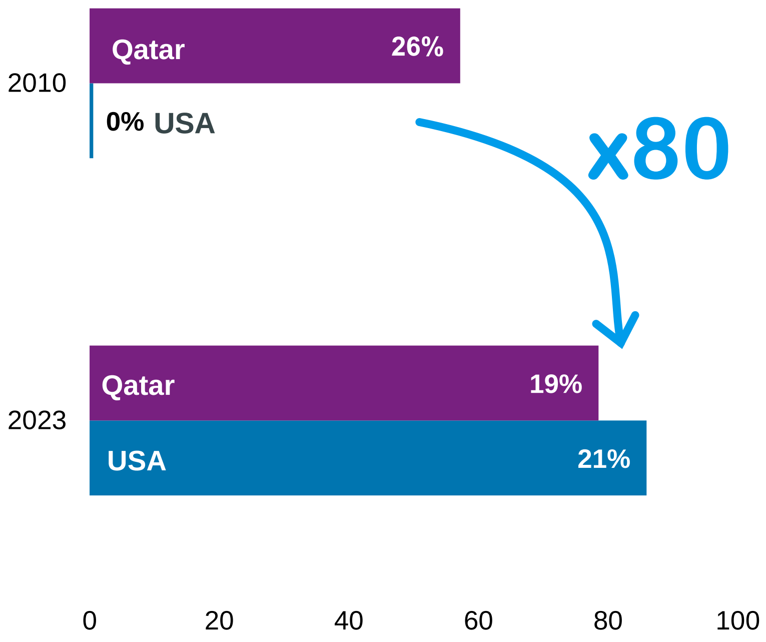
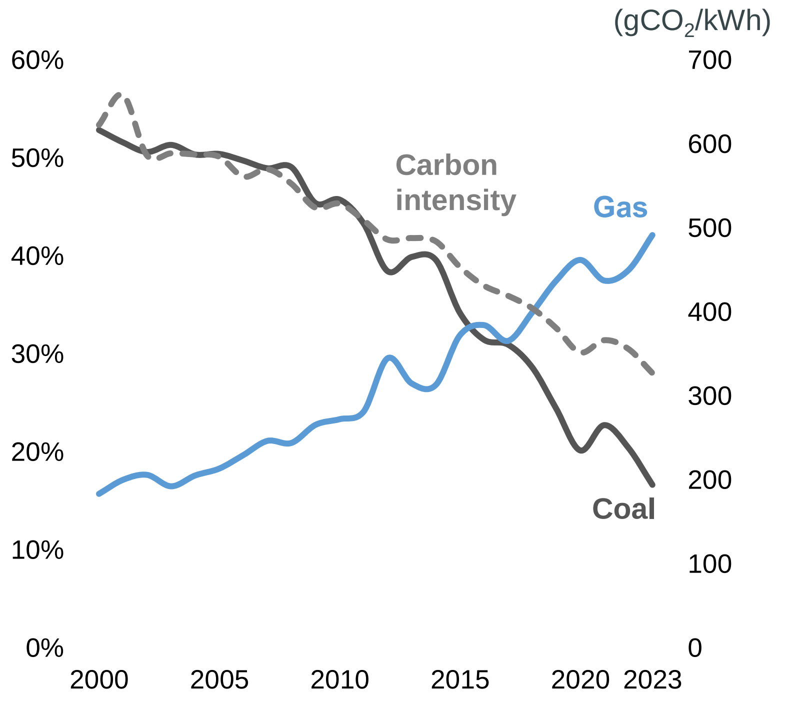
**Liquids* supply by region – 2010 vs 2023**
Mb/d, % of total supply




**LNG exports by region – 2010 vs 2023**
Mtpa, % of total supply




**Fuels shares and emissions of the US electricity mix,** % of fuel (left) and carbon intensity (right)



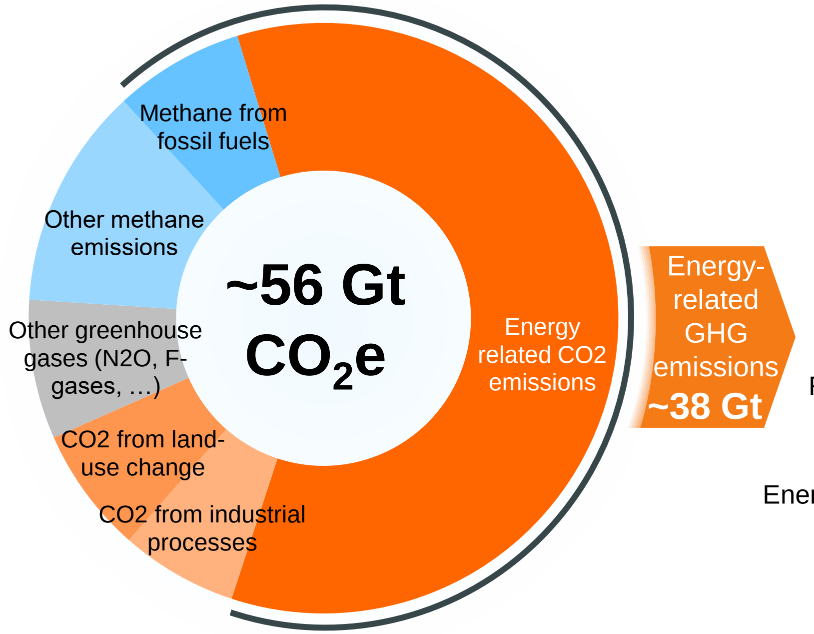

**The USA will set the pace of the world's energy transition**

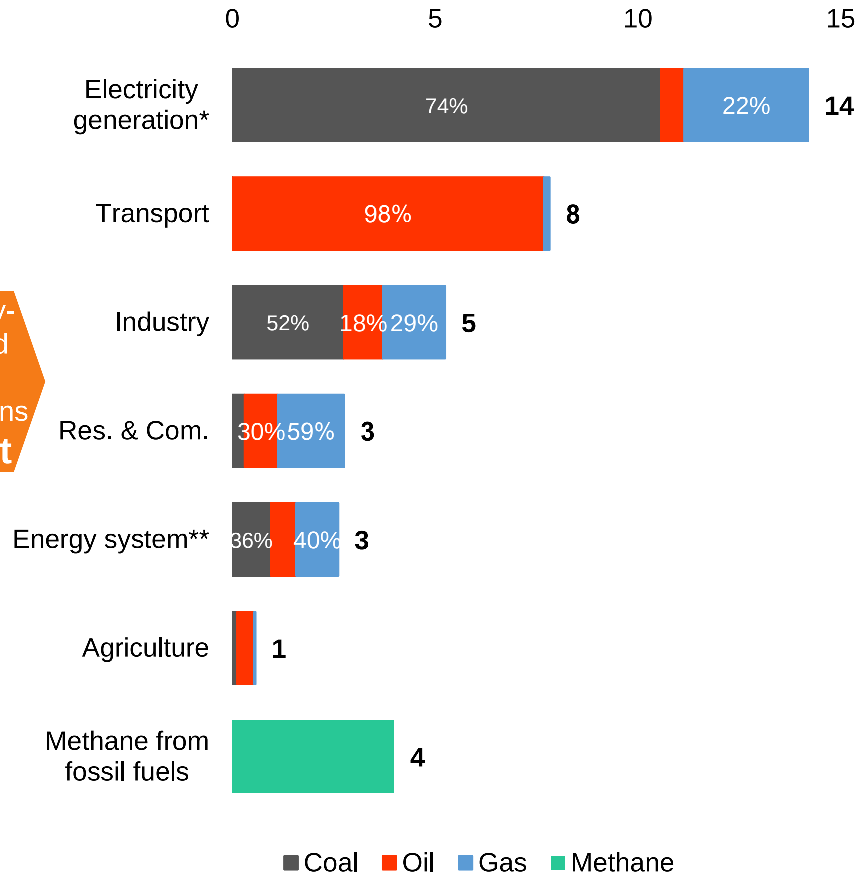
** Liquids supply includes crude oil + condensate + NGL and Biofuels*

# Existing technologies, if deployed fully, could halve energy-related GHG emissions

## Global anthropogenic GHG emissions 2022

$GtCO_2e$




## Available technologies to reduce GHG emissions and their potential impact

**Renewables combined with Flexible Gas** to displace coal from the electricity system (up to ~8 $GtCO_2$)

**Electrification** to decarbonize road transport (up to ~6 $GtCO_2$)

**Heat pumps** to replace fossil boilers (up to ~2 $GtCO_2$)

**Elimination of venting & flaring and leak detection & repair** to cut emissions from fossil fuels production (up to ~4 $GtCO_2e$)

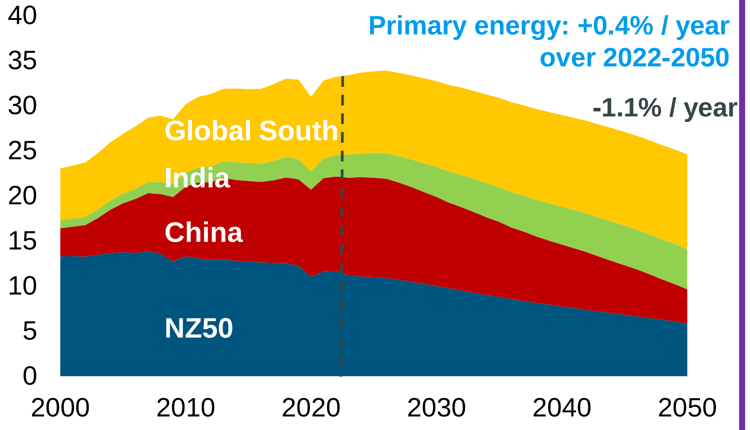
** Including heat combined with power*

*** Includes energy sector own use, transport losses and energy transformation*

*Sources: IEA, Enerdata, TTE analysis. « Methane from fossil fuels » includes methane emissions from the production and transport of fossil fuels*

# Three possible scenarios to 2050

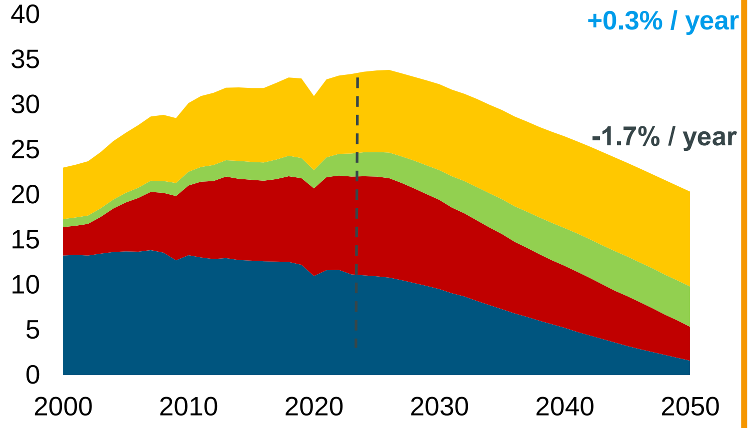
## Trends




- 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**

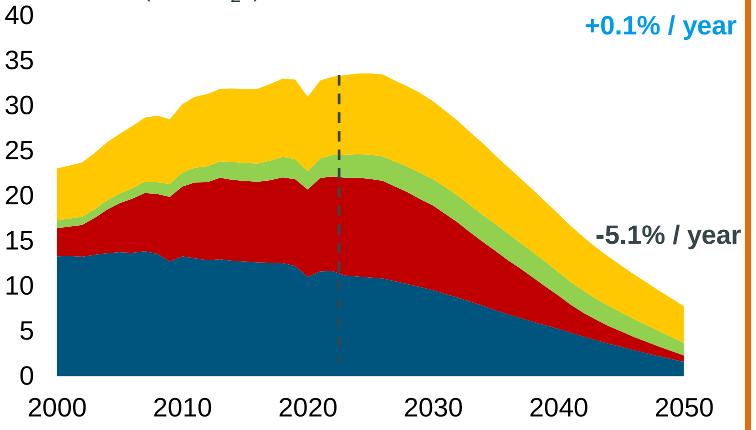
## Momentum




- 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**

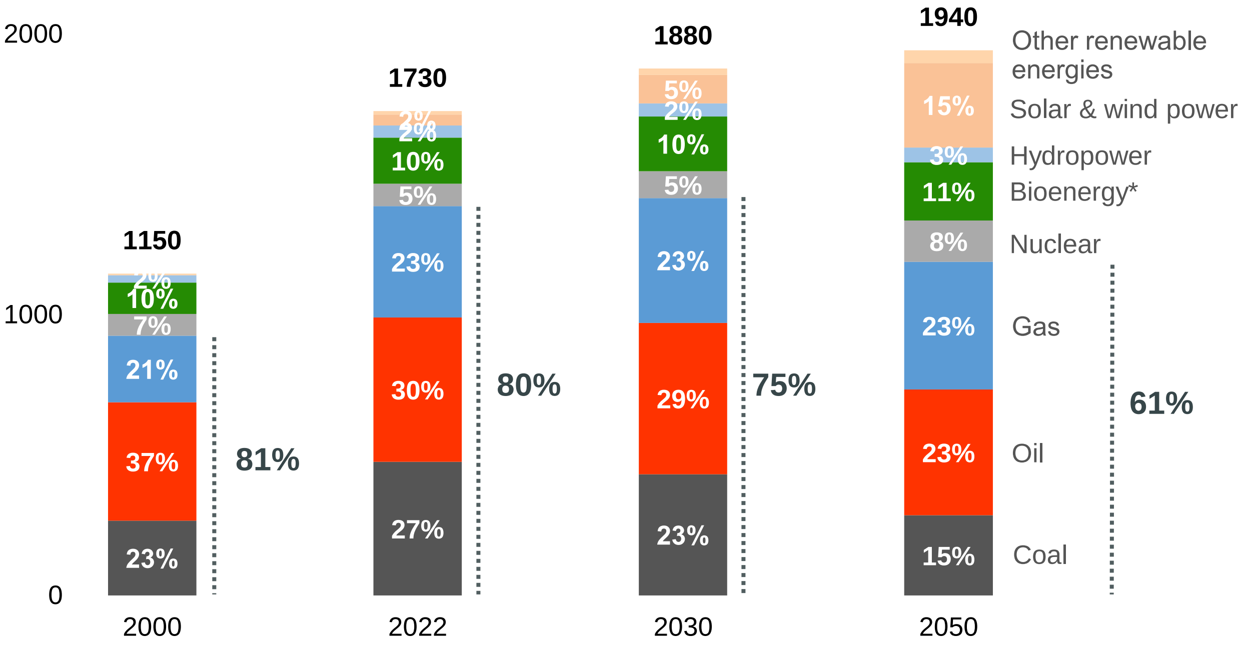


** $CO_2$ emissions related to energy combustion*
*** Temperature increases estimated at P66-P83, evaluation conducted by MIT*

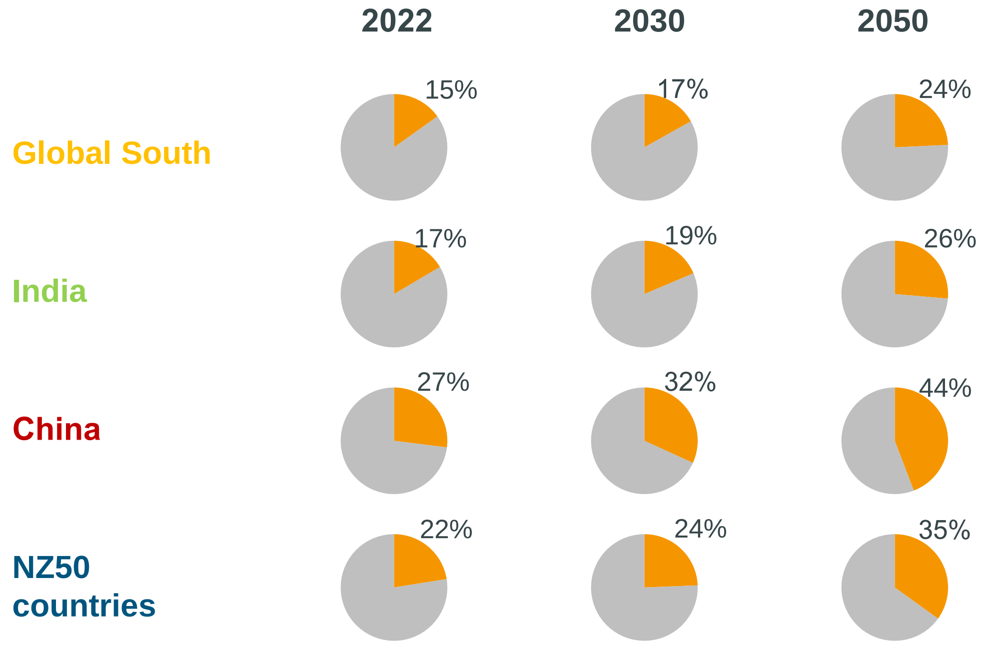
# Trends

## If the world remains on current energy trajectory, it will fall short of Paris objectives

### World Primary Energy Demand (TPED, projection)
PJ/d




### Share of electricity in final consumption
%



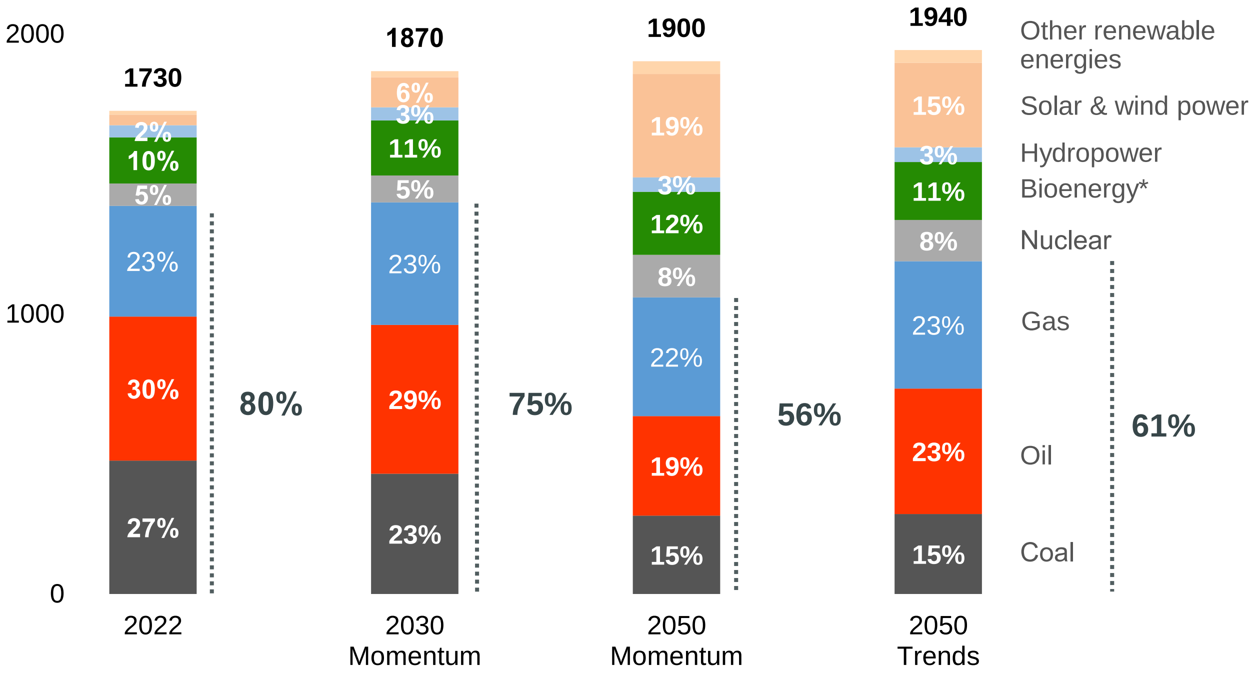

**Temperature increase by 2100 is ~ +2.6-2.7°C****

** Biomass, waste, biofuels, biogas…*
*** Temperature increases estimated at P66-P83, evaluation conducted by MIT*

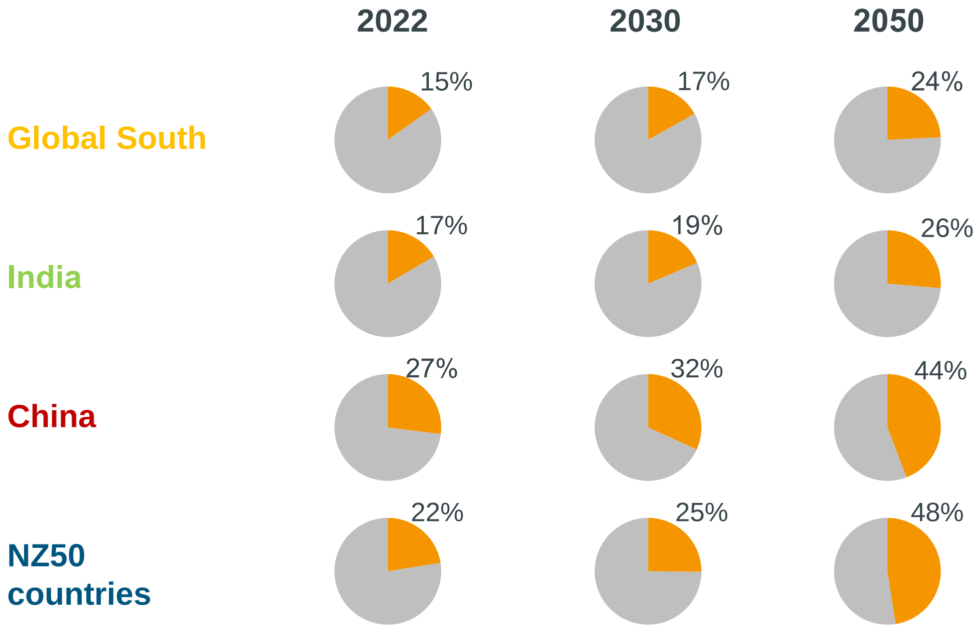
# Momentum

## NZ50 countries step up their efforts to achieve their objectives, but offer limited support to the Global South

### World Primary Energy Demand (TPED, projection)
PJ/d




### Share of electricity in final consumption
%




**Decarbonizing NZ50 countries and China without supporting India and the Global South leads to a 2100 temperature increase ~ +2.2-2.3°C****



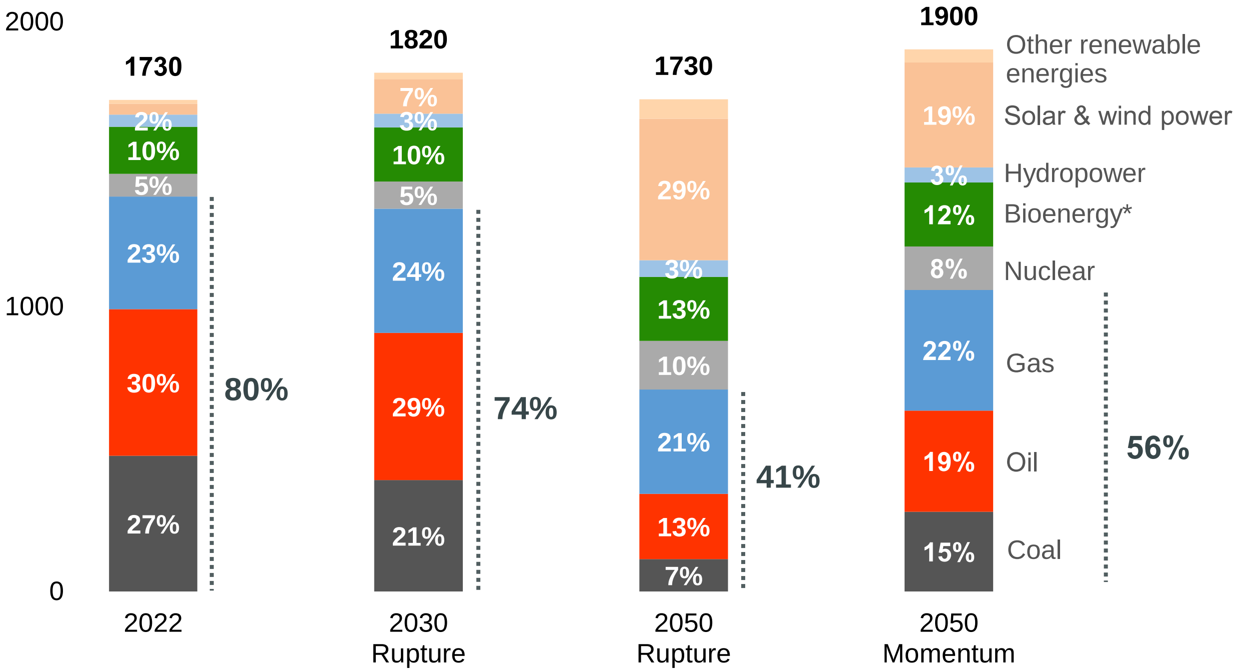
** Biomass, waste, biofuels, biogas…*
*** Temperature increases estimated at P66-P83, evaluation conducted by MIT*

# Rupture

## Global South is supported and included in the race to Net Zero

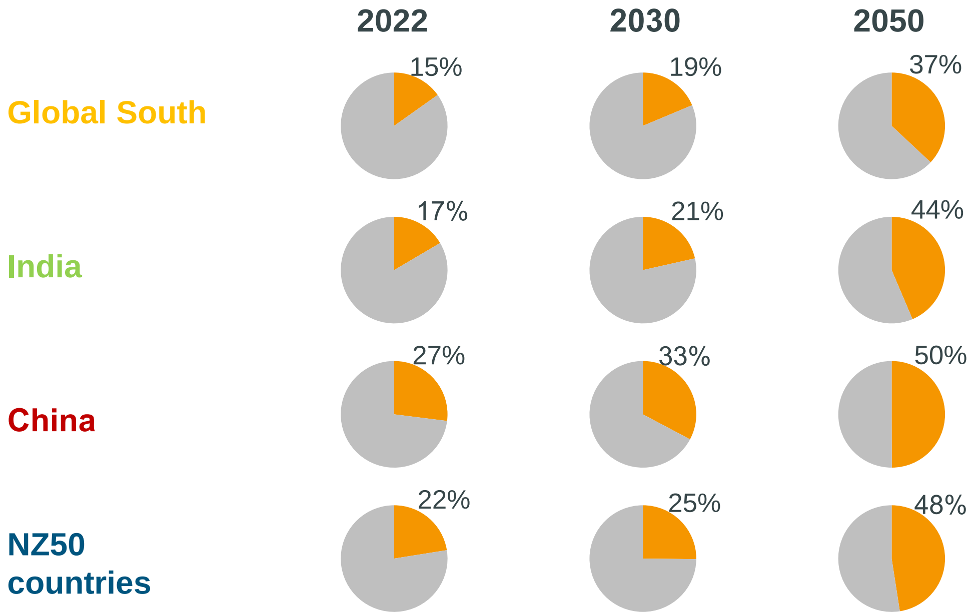
### World Primary Energy Demand (TPED, projection)

PJ/d




### Share of electricity in final consumption

%




**For the world to remain well-below +2°C, highest-priority decarbonation technologies must be deployed globally, including in India and the Global South**



* *Biomass, waste, biofuels, biogas...*

# From Trends to Momentum and Rupture

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

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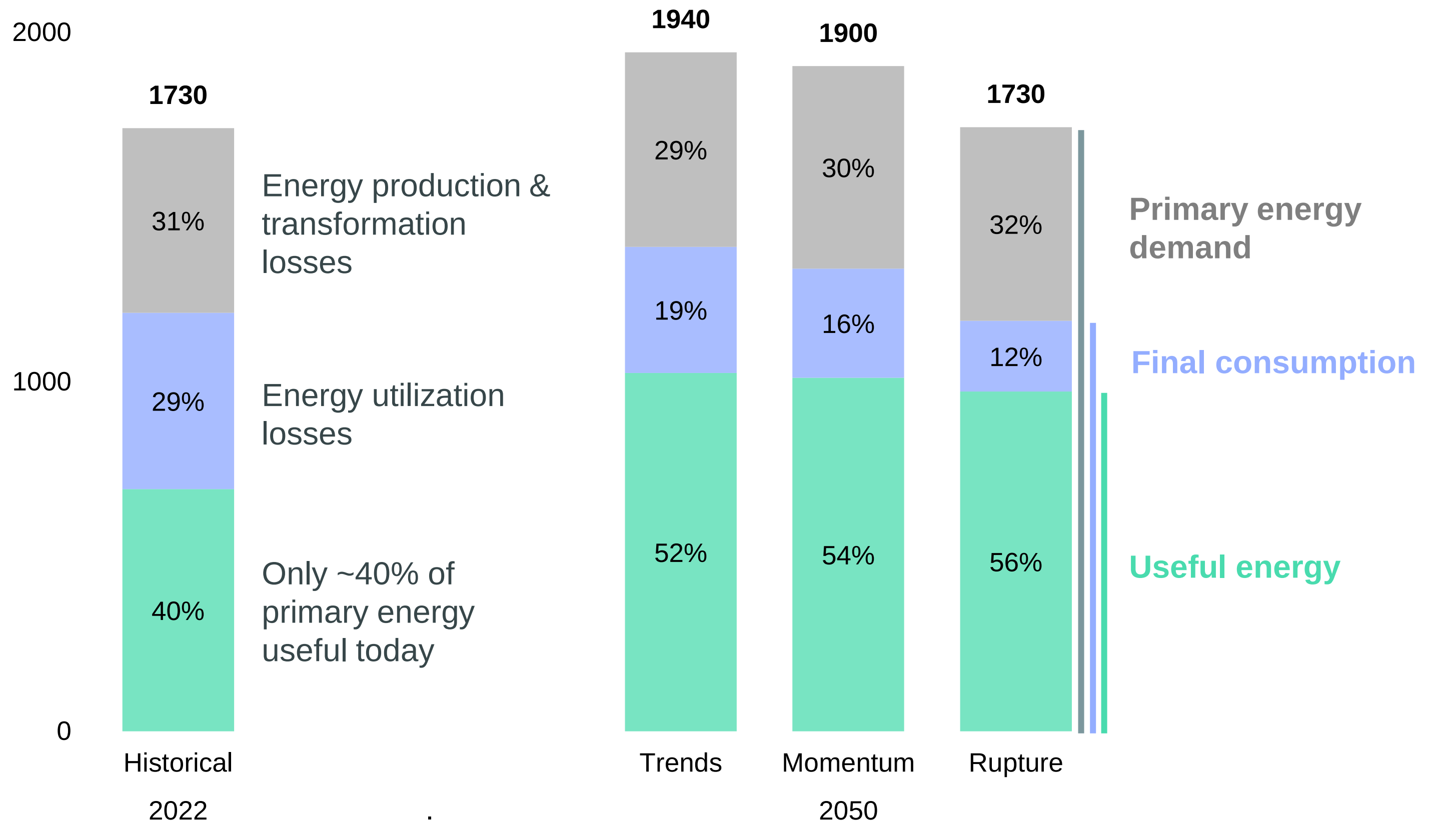
| | Trends 2050 | Momentum 2050 | Rupture 2050 |
|---|---|---|---|
| **Strong electrification of end-use** | ~30% of final demand | ~35% | ~40% |
| **Deep decarbonization of electricity grid** | 24 500 TWh*<br>(~50% of power generation) | 27 500 TWh*<br>(~53%) | 35 000 TWh*<br>(~62%) |
| **Energy efficiency 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<br>(vs ~47% in NZ50 countries) | ~30%<br>(vs ~65% in NZ50 countries) | ~52%<br>(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*

# Green electrification is the core of the energy transition

## It reduces emissions and also losses in the energy system

**Primary energy breakdown across scenarios**
PJ/d




**Substituting renewables and gas for coal improves efficiency of electricity generation**

**Substituting electrical engines for thermal ones and heat pumps for boilers improves efficiency of final energy consumption**

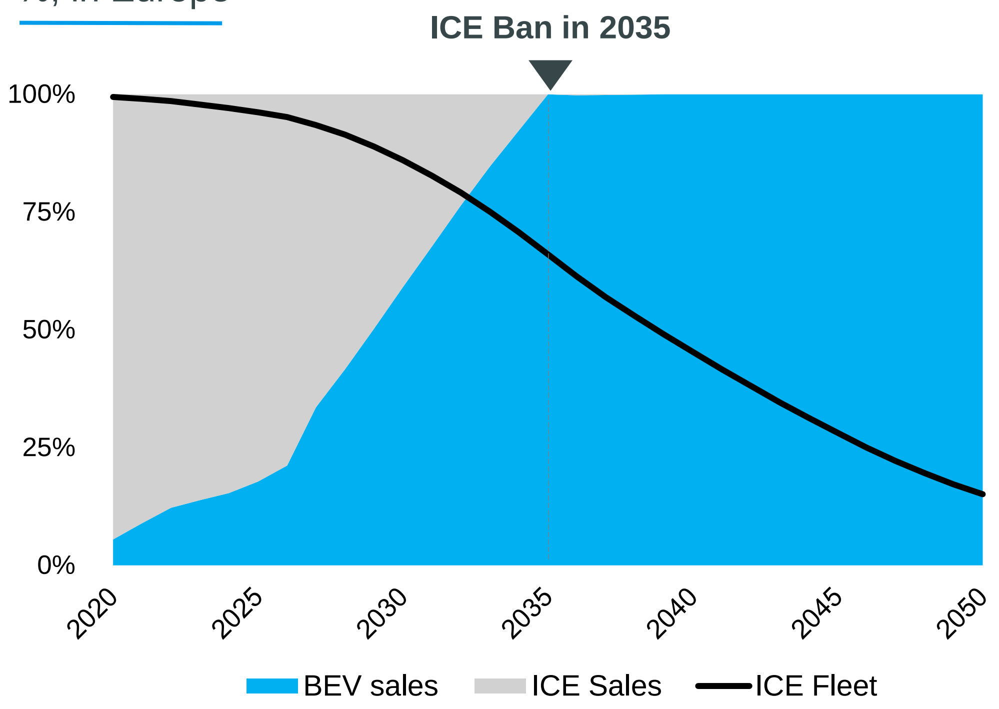
**In all scenarios, useful energy increases by ~1.2-1.4% per year, as living conditions improve**

# Energy systems inertia

## Transforming energy systems takes decades as assets are long-lived

### Light Vehicles Fleet & Sales share evolution per technology

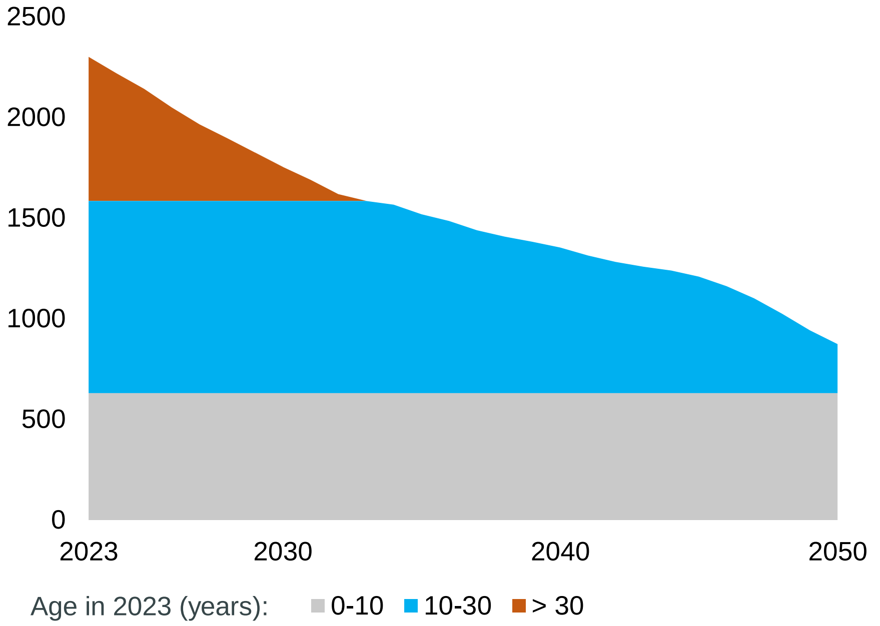
%, in Europe




~20 years required to convert a fleet after full BEV sales transition

### Capacity evolution of existing coal power plants*

GW

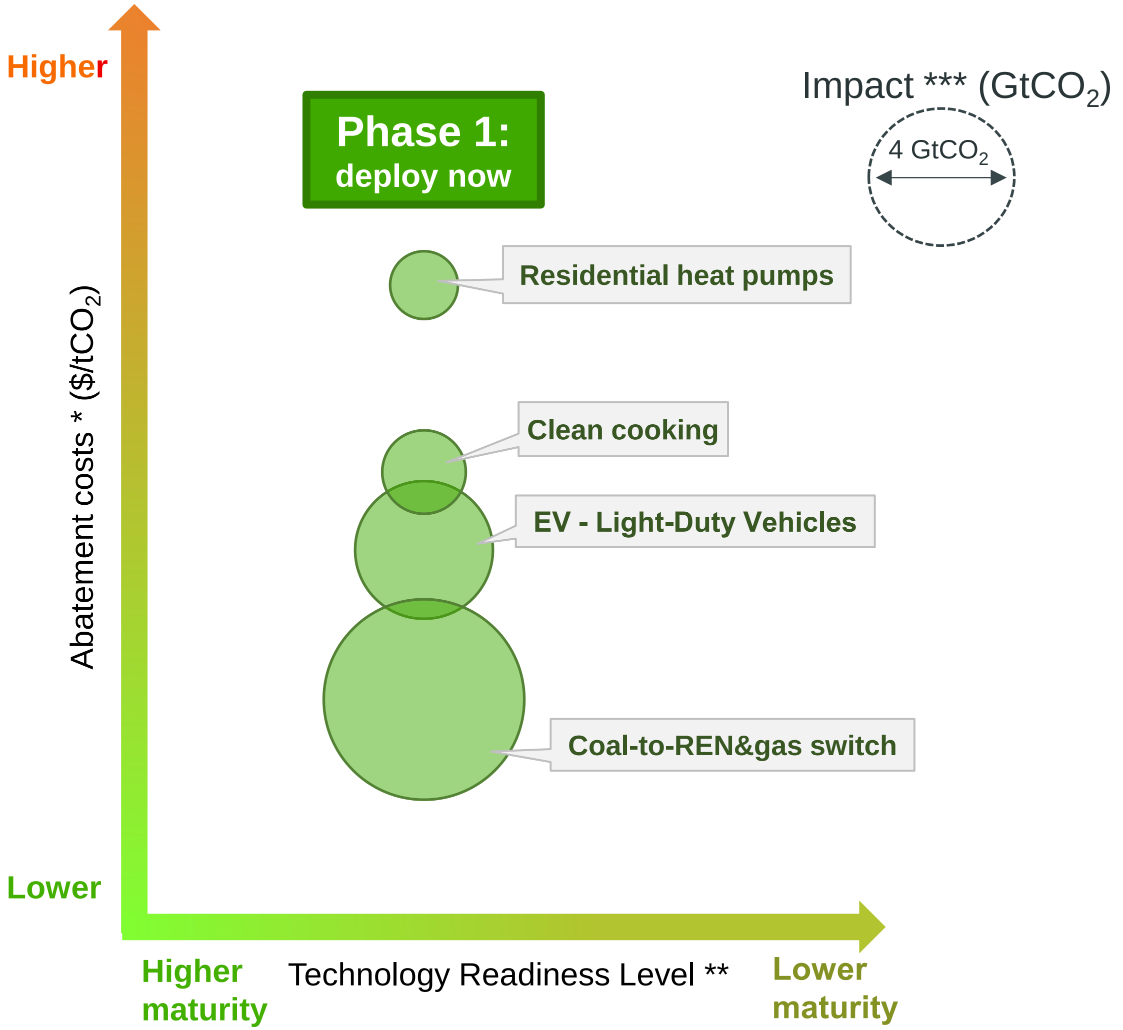



As coal-fired plants operate for 40 years on average, even if construction new coal generation was banned from 2024 onwards, more than a third of existing plants will still be operational by 2050

** Source: Global Data, Energy Intelligence*

# From Trends to Momentum and Rupture

## Top priority is to deploy globally “low-hanging fruit” technologies

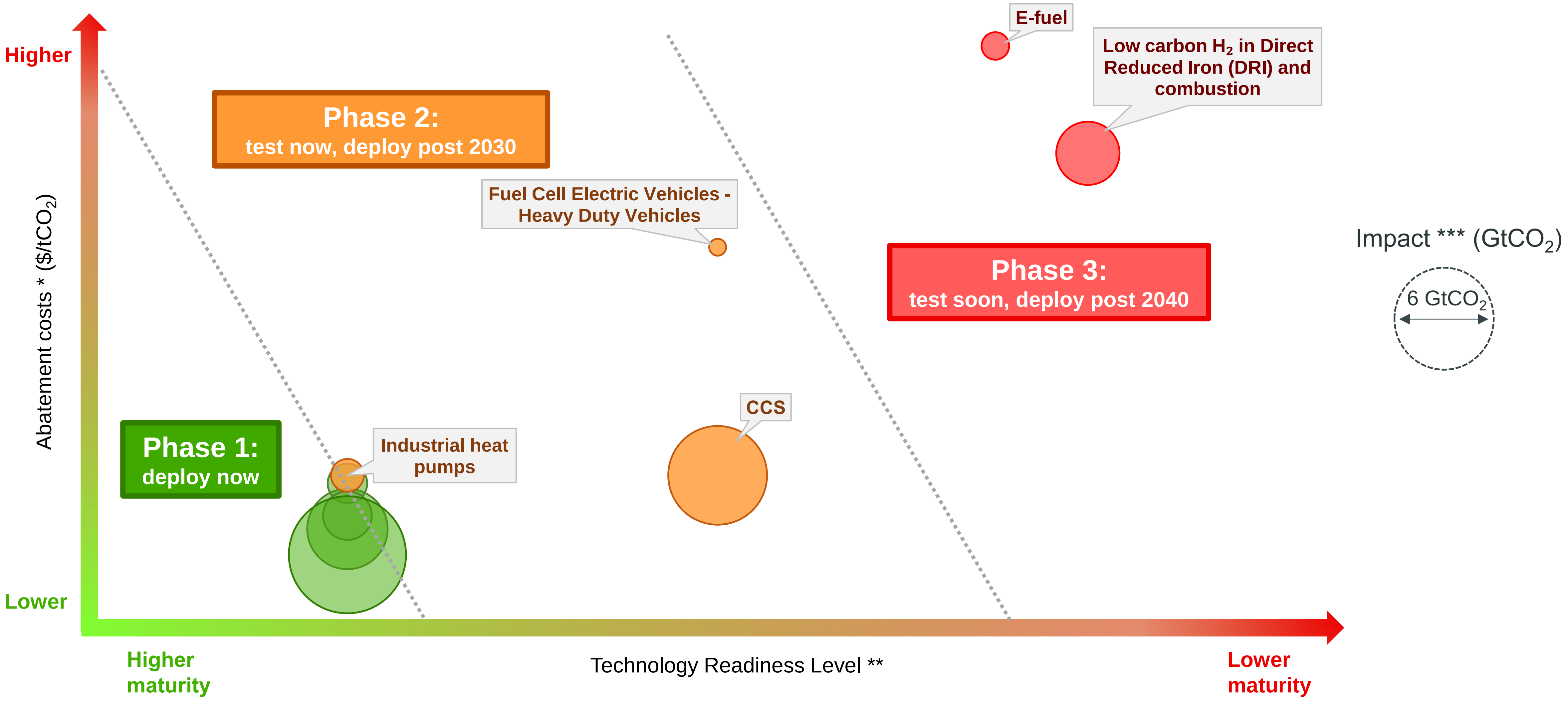



- These technologies are already mature and manufactured at scale
- They are competitive or close to competitiveness with the highly emitting technology they replace
- Accelerated deployment will further improve their cost and performance

** Abatement costs estimated using TTE model and external sources*
*** TRL: sourced from the IEA Clean Energy Technology Guide*
**** Impact: estimated using 2023 $CO_2$ emissions*

# From Trends to Momentum and Rupture

## Decarbonation technologies should be deployed globally following cost and technology merit curve



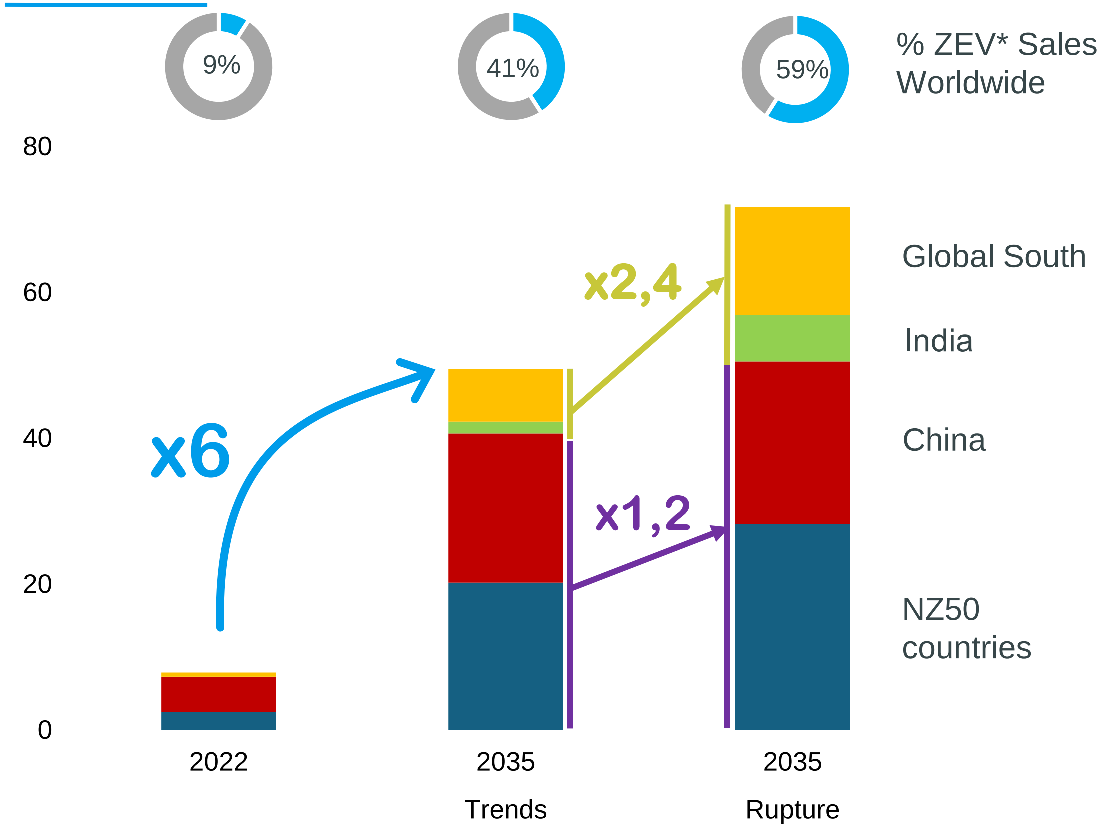



* Abatement costs estimated using TTE model and external sources
** TRL: sourced from the IEA Clean Energy Technology Guide
*** Impact: estimated using 2023 $CO_2$ emissions

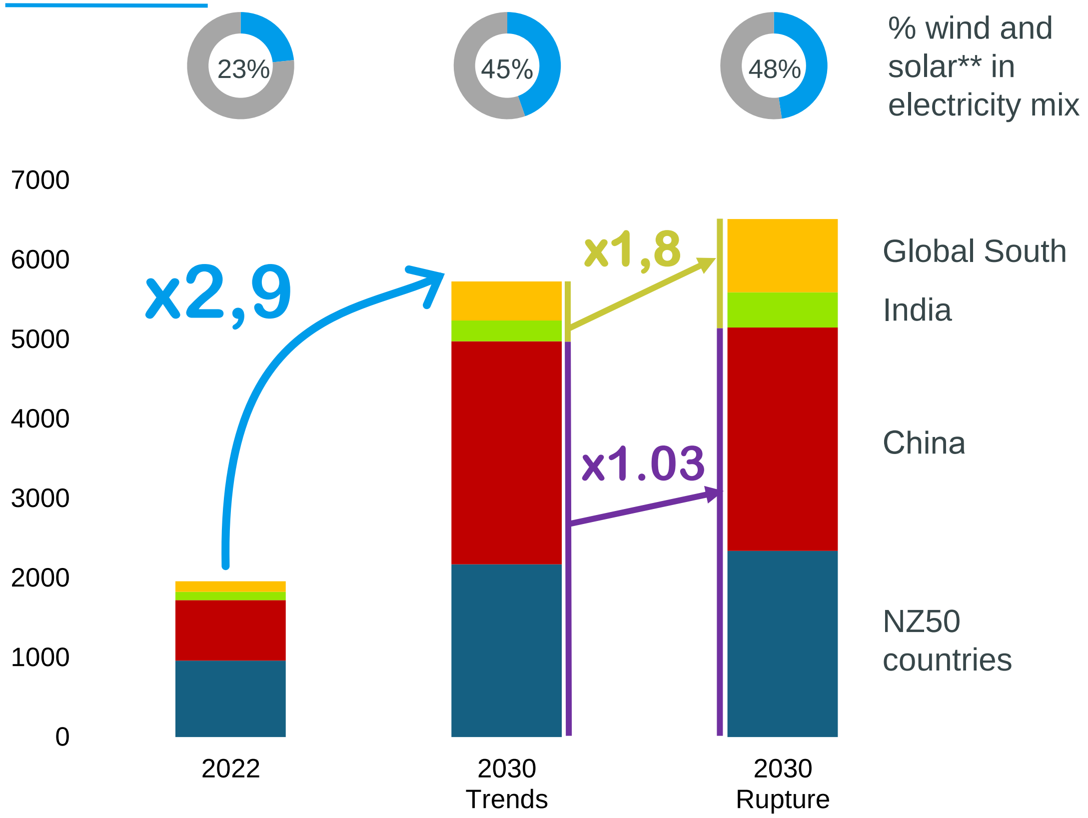
# Two examples of global deployment of "low hanging fruits"

## Significant acceleration in India and Global South to move from Trends to Rupture

**Light Vehicles ZEV* Sales**
M units




**Wind and solar ** installed capacity**
GW

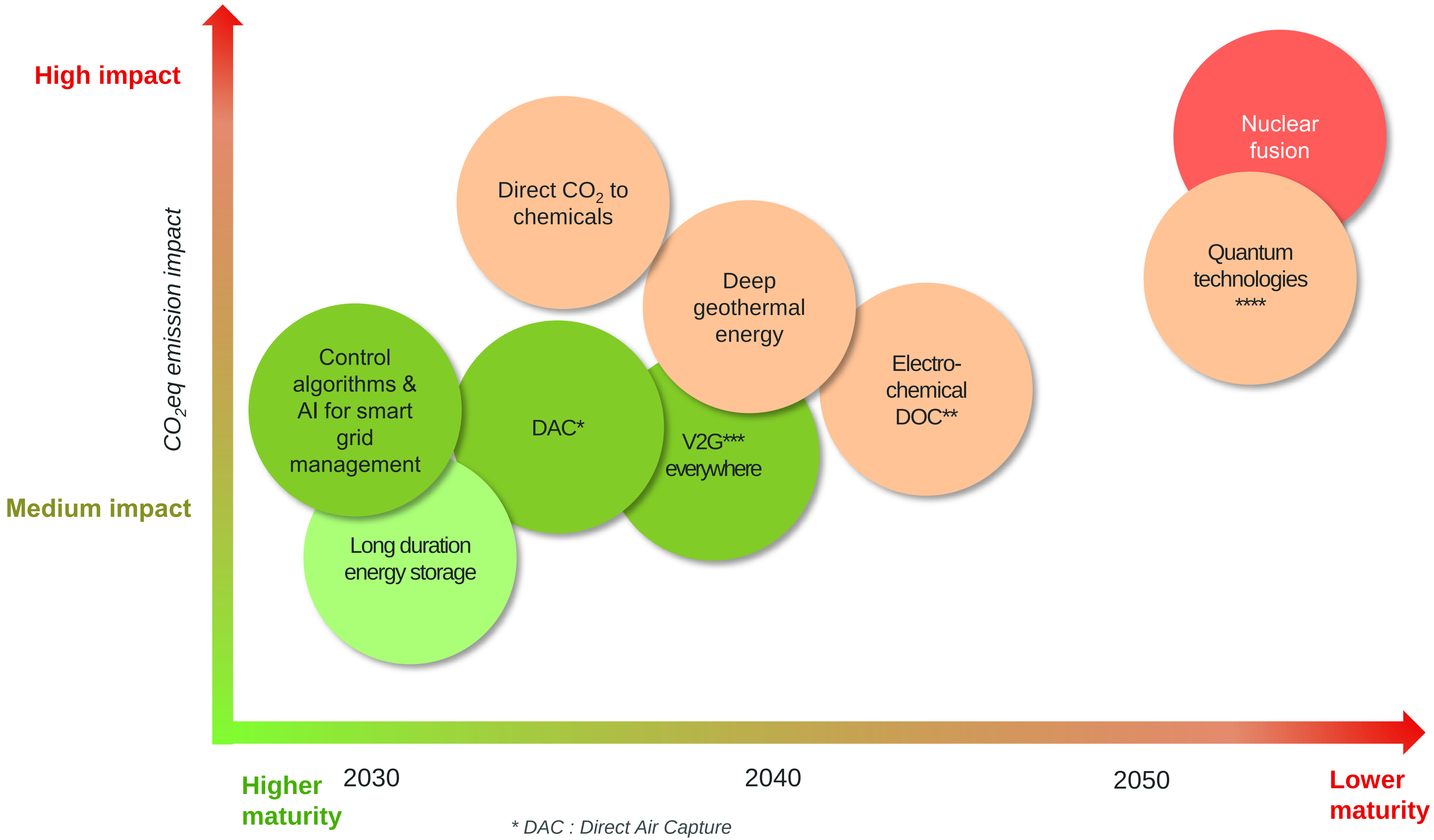





** ZEV : Zero Emission Vehicles : FCEV + BEV*
*** Distributed generation is excluded from this analysis*

# From Trends to Momentum and Rupture

## A few disruptive technologies could facilitate the transition




** DAC : Direct Air Capture*
*** DOC : Direct Ocean Capture*
**** Vehicle to Grid*
***** Quantum technologies may be used in batteries and solar panels to improve their efficiency*

Infrastructure

# The infrastructure bottleneck

## US and Europe electricity transmission grid examples

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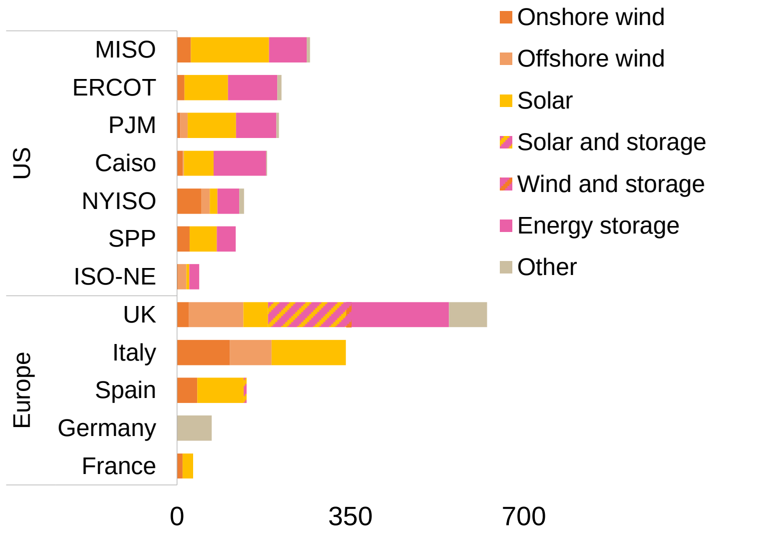
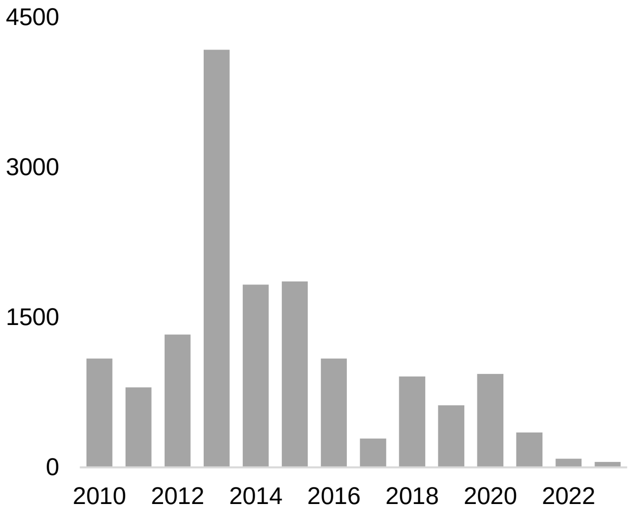
### Grid connection queues as of Jan. 2024*
GW



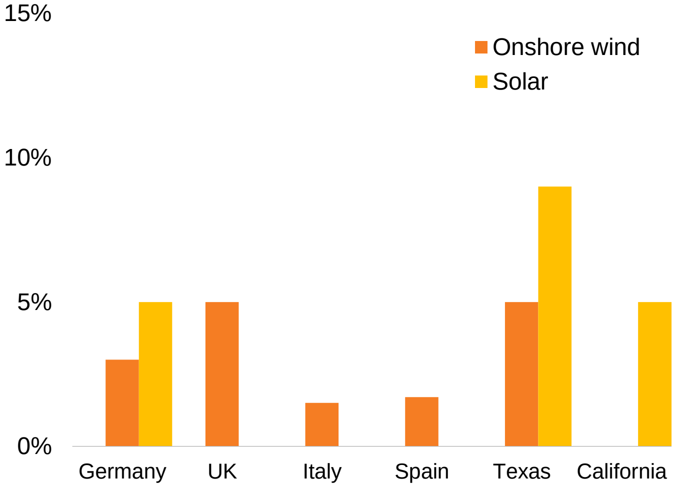

**Processes need to adapt to multiple smaller projects**

### US lines of 345+ kV lines added**
Miles




**Challenge of acceptability (NIMBY***)**

### Share of generation curtailed in 2022-23*
%



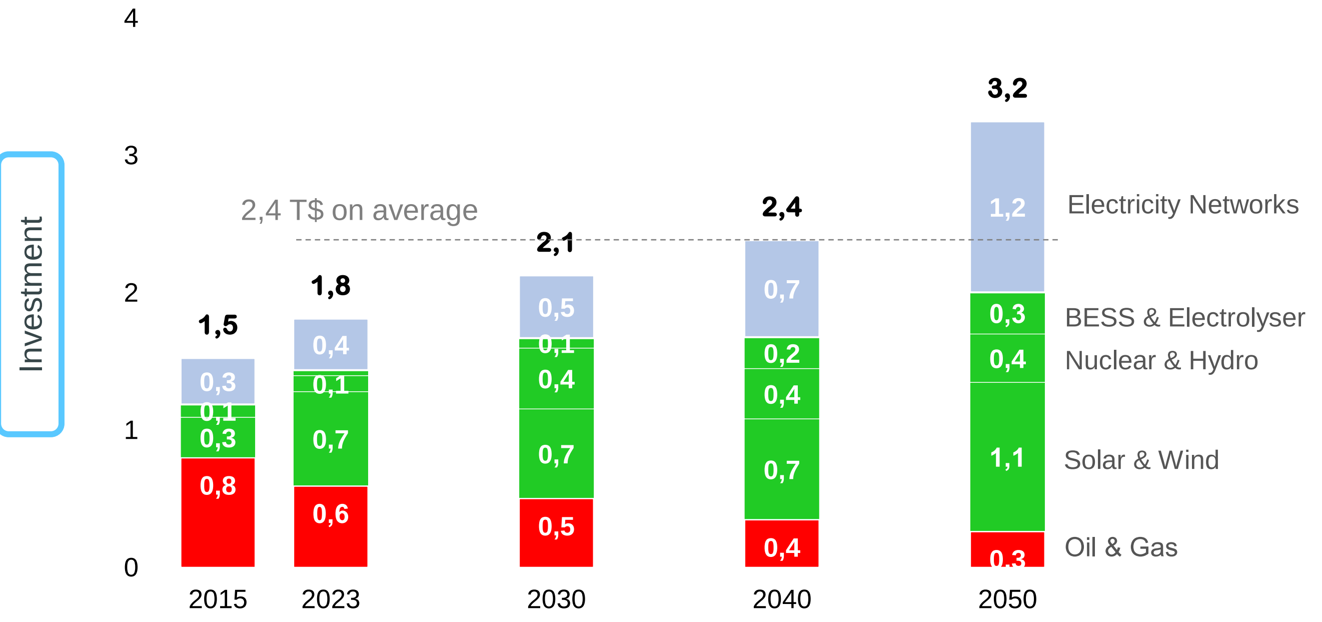

**Insufficient grid capacity**

**Renewables connection lower than potential, and when connected, production can be curtailed, reducing incentives to invest**

** BNEF 2024 Power grid investment outlook, Aurora for Germany connection queue – Estimation of curtailment due to grid constraints*
*** Grid Strategies – high voltage transmission lines*
**** "Not In My BackYard"*

# Significant investment required

**Annual energy system investment* (Rupture scenario)**
Trillion $_{2023}$ per year




- Annual investment in energy systems appears manageable
- However, total investment, including demand-side investment and supporting infrastructure could be ~3 times larger
- This investment program faces severe headwinds: higher interest rates, ageing population, increased defense spending

** Not including demand-side investment : buildings, industry, Evs and charging equipments, $H_2$ and $CO_2$ supporting infrastructure*
*Sources: TotalEnergies analysis, WoodMackenzie, S&P IHS, IEA WEO23*

# From Trends to Rupture : which priorities ?

## Cost-effective decarbonation technologies are available; their deployment needs to be scaled up

Priority must be given to the large-scale deployment of existing, competitive decarbonization technologies

- Facilitate the substitution of fossil fuels by electricity in final demand: electric vehicles, heat pumps, etc.
- Replace coal with renewable energies combined with gas in electricity generation
- Accelerate the reduction of methane emissions from fossil fuel production

To achieve this, public policies need to focus on :

- Allocating subsidies and defining mandates according to the cost-and-maturity merit curve, to minimize costs for citizens, and thereby strengthen societal commitment
- Eliminating bottlenecks in developing supporting infrastructure, in particular electricity grids, and accelerating connection to this infrastructure
- Strengthening international cooperation to deploy the cheapest technologies available and develop financial instruments in developing countries

**To sustain energy demand, improve living standards and reduce emissions, it is essential to move from region-specific decarbonization plans to global deployment of technologies following their cost & maturity merit curve**

# Main messages

1. Reliable and affordable energy access is essential to Human Development, and yet remains widely unequal across countries.

2. Over the last 20 years,

   a. the energy transition has started globally
   b. most of the energy demand growth was driven by increasing living standards
   c. the US shale revolution has transformed the energy landscape in the U.S. and worldwide
   d. A few technologies to decarbonize energy supply are now mature, and start to be deployed

3. We have developed three scenarios to 2050, differentiated by their depth of decarbonization: Trends, Momentum and Rupture.

   a. The " **Trends**" scenario, which takes into account current trajectories and our anticipation of technological developments and public policies according to their current trends, leads to a temperature rise of +2.6°-2.7°C by 2100, which is higher than the target set in Paris.

   b. The "**Momentum**" scenario assumes that countries committed to achieving net carbon neutrality by 2050 reach their objective and yieldsa temperature rise of +2.2-2.3°C by 2100, which is still higher than the target agreed in Paris.

   c. The **"Rupture"** scenario proposes a path to remain well-below +2°C by 2100 (+1.7-1.8°C). To achieve that objective, existing decarbonation technologies are deployed rapidly and globally: advanced economies support the Global South's energy transition.

4. Green electrification is the core of the energy transition: it reduces emissions and losses in the energy system (from 60% today to ~40% in Rupture).

5. Moving from Trends to Rupture requires pragmatically deploying decarbonization technologies globally following their cost and technology merit curve. Priority should be given to

   a. facilitating global substitution of electricity for fossil fuels in final demand: EVs, heat pumps – in every country, and
   b. substituting renewables and flexible gas for coal in electricity generation – in every country
   c. accelerating the reduction of methane emissions from fossil fuel production

6. This in turns would require policy makers focus on

   a. Allocating subsidies and setting mandates following the cost and technology merit curve, to minimize cost to their citizens, hence build societal engagement.
   b. Eliminating bottlenecks in developing supporting infrastructure, in particular electricity grids, and accelerating connection to this infrastructure
   c. Strengthening international cooperation to deploy the cheapest available technologies, and develop financial instruments in developing countries

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**Outlook**

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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