TotalEnergies

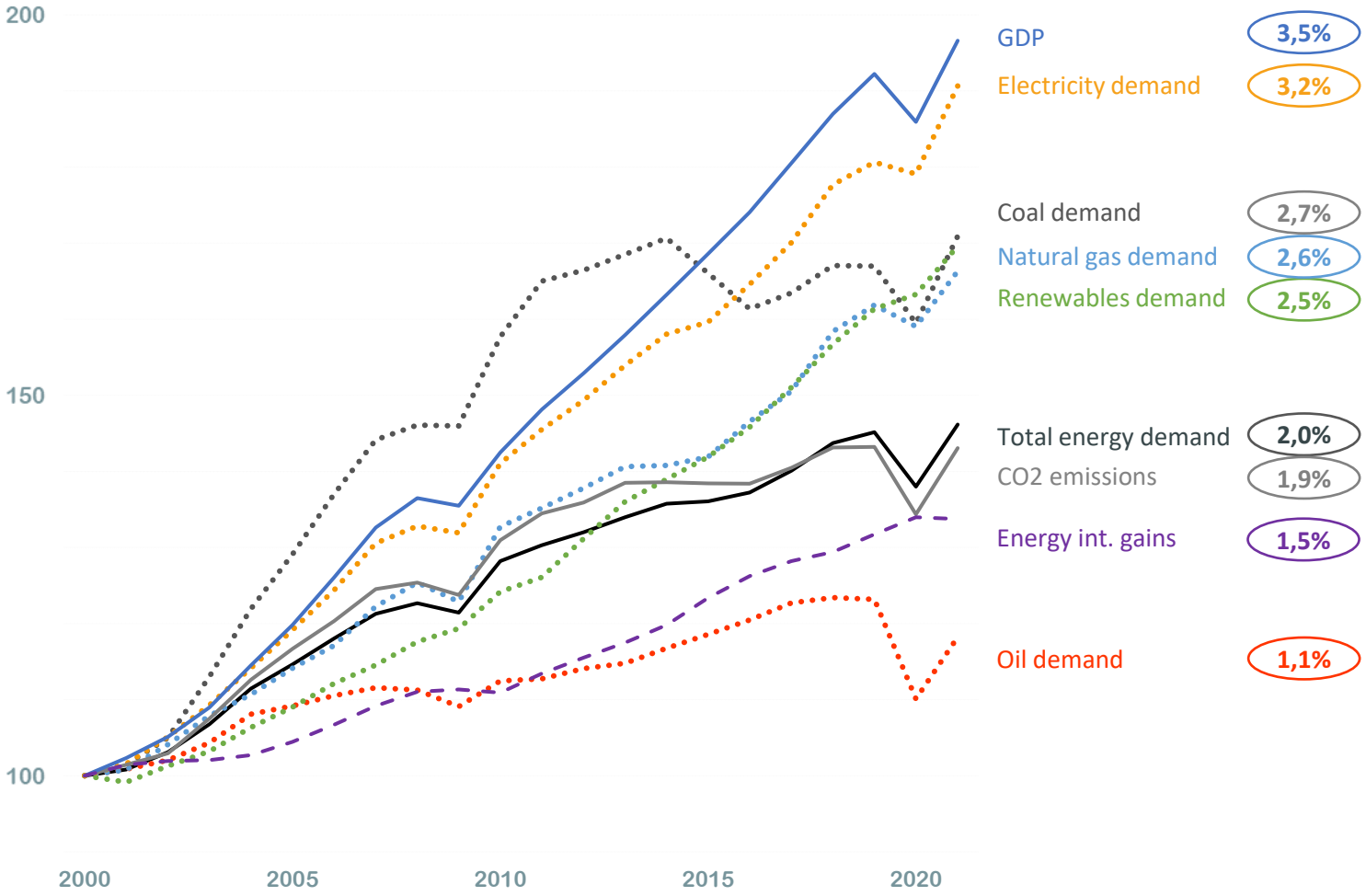
# TotalEnergies
# Energy Outlook 2022

# Energy trends since 2000: transition has started

## GDP growth decoupled from total energy demand and $CO_2$ emissions growth

**Index of key indicators**

2000=100




**CAGR 2000/2019**

| | |
|---|---|
| GDP | 3,5% |
| Electricity demand | 3,2% |
| Coal demand | 2,7% |
| Natural gas demand | 2,6% |
| Renewables demand | 2,5% |
| Total energy demand | 2,0% |
| CO2 emissions | 1,9% |
| Energy int. gains | 1,5% |
| Oil demand | 1,1% |

- → Power fastest growing energy, oil slowest one
- → Coal growth, triggered by China take-off since 2000, slowing since 2015
- → Natural gas and renewables growing at the same speed
- → Energy intensity gains explaining most of the decoupling between GDP and emissions growth

**As in 2000, fossil fuels still make up 81% of the energy mix in 2019**

# Will current market disruptions speed up or slow down the energy transition?

**2021 demand rebound due to stronger than expected economic growth**

+6% energy demand in 2021, vs. +4% anticipated in TEO21

**Energy security and sovereignty back in focus: oil and gas matter**

'Save gas for a safe winter' – Ursula Von der Leyen

**Energy affordability is fundamental: high energy bills becoming a major issue**

European electricity prices topped @1000€/boe

**Short term coal consumption and $CO_2$ on the rise**

Coal demand +7% in 2021, energy-related $CO_2$ +2 Gt

**Higher prices may favor efficiency gains (via substitution or demand reduction)**

2011-2014 high energy prices example: efficiency gains x2

**Renewed ambitions for electrification and REN deployments**

REPowerEU, IRA in the US

**Clean $H_2$ potential gaining traction**

20 Mt Green H2 in EU in 2030 target, strong fiscal incentives in IRA in the US

**COP27 focus on just transition for emerging countries**

Developed countries to deliver the promised 100 G$/y

**Need to preserve energy security & affordability through the transition**

# TotalEnergies Energy Outlook 2022

## Two demand scenarios to 2050

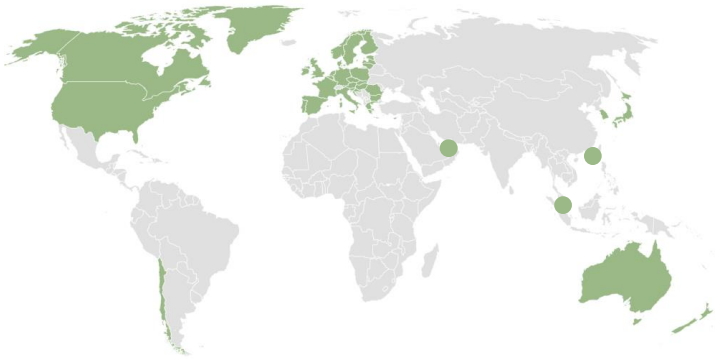
### Momentum

**A forward-looking scenario building on NZ50 commitments**

**40 Net-Zero by 2050 countries** included in our scenario

**Announced targets and NDCs of other countries**, in particular China (2060), Russia (2060) and India (2070)

Same framework as IEA APS



**Temperature rising by 2.1-2.3°C* in 2100**

### Rupture

**A back-casting approach**

**Paris agreement well-below 2°C target achieved,** based on IPCC emissions scenarios

Meeting this target requires **a concerted effort** to **rebuild the energy system** at a global scale

**Temperature increase limited to 1.7°C***

**with a Rupture+ sensitivity resulting in a 1.5°C scenario****

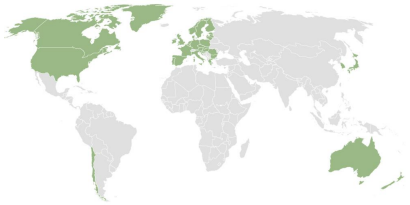


* *At P66, temperature ranges ascertained by comparing energy-related $CO_2$ emissions trajectories with the IPCC AR6 scenarios.*

** *At P50 (same as IEA NZE)*

# Key features of our 2022 scenarios

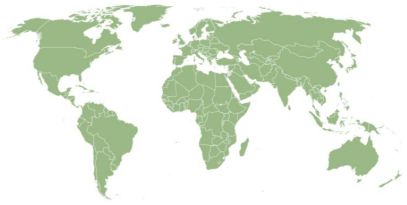
## Momentum: accelerating the ramp-up of greener molecules and electrons



GDP growth : +3.0%/yr
**Energy growth: +0.4%/yr**

- Starts with higher fossil fuels demand and higher emissions – so **more efforts needed**
- **Transport revolution** under way: massive road electrification for Light and Heavy Duty Vehicles; increased Sustainable Liquid Fuels (incl. SAF) ambitions for marine and aviation
- Speeding up **end-use electrification** with strong growth in REN deployments
- **Natural gas** keeping strong role as key transition energy in power and industry, much less in mobility
- **Biofuels and biogas** penetrating selected segments
- **$H_2$ potential** confirmed with ramp up after 2030
- High **polymer recycling** objectives

## Rupture: how to reach well-below 2°C



GDP growth : +3.0%/yr
**Energy growth: +0.2%/yr**

**Necessary dissemination at scale of decarbonization drivers to all emerging economies**

- Speeding up energy switch to reduce emission and increase **energy efficiency**
- Further development of **electricity & renewables**
- **Extension of road transport revolution with higher ZEV* penetration worldwide**
- Higher penetration of **new energy carriers** (clean $H_2$ in industry & transport, e-fuels, biofuels and biogas…)

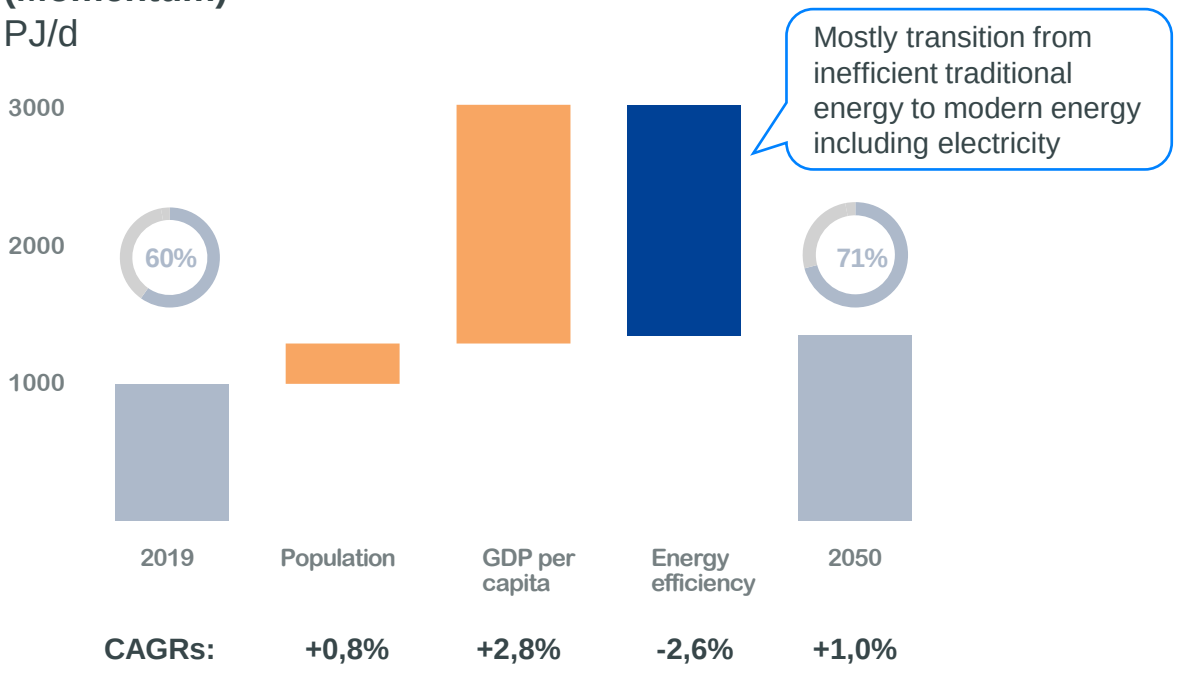
* *Zero-emission vehicle*

# The energy transition must be just

## Meeting the needs of growing populations in developing economies

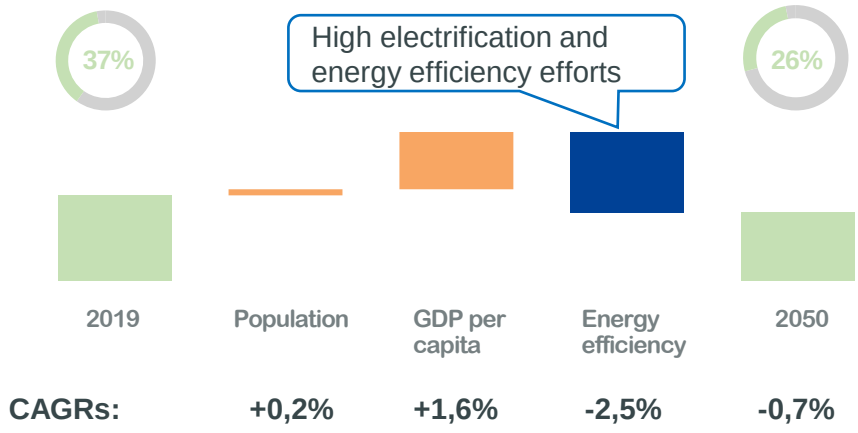
**Changes in Non-OECD primary energy demand 2019-2050 (Momentum)**

PJ/d




**Changes in OECD* primary energy demand 2019-2050 (Momentum)**

PJ/d




- Global energy demand growth of +0.4% p.a. from 2019 to 2050 reflects 2 opposite trends: non-OECD +1.0% p.a. and OECD -0.7% p.a.
- OECD countries need to support the clean transition in developing countries through financing and technology transfers

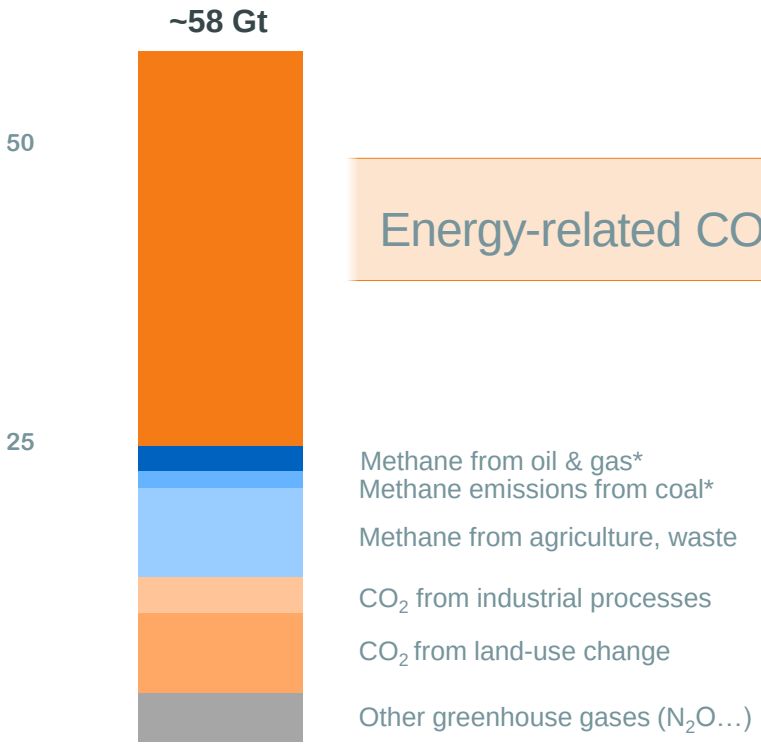
* *Sum of OECD and non-OECD demands not equal to total demand as international transport (bunkers) not reallocated*

# How to curb emissions?

## A comprehensive transformation of our energy production and usage

### Global anthropogenic GHG emissions in 2019

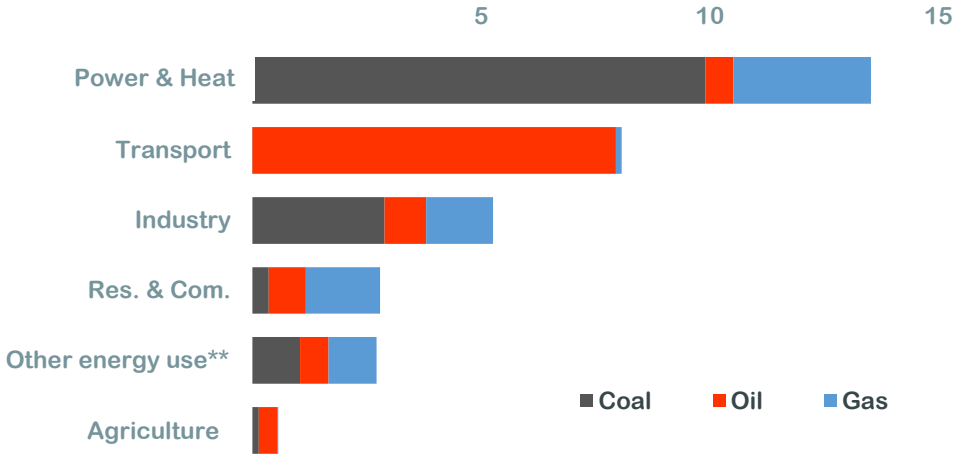
$GtCO_2e$




Energy-related $CO_2$ : **33 Gt**

### Global energy-related $CO_2$ emissions in 2019

$GtCO_2$




**Decarbonization of power and transport are the key priorities**

**Reducing methane emissions is also mandatory**

* *Production & transport of fossil fuels*
** *Includes energy sector own use, transport losses, and energy transformation*

# Key modeling drivers of our scenarios

## Sector-based assumptions

| | 2019 | Momentum 2050 | Rupture 2050 |
|---|---|---|---|
| **Strong electrification of end-use** | ~20% of final demand | ~30% | ~40% |
| **Deep decarbonization of power supply** | 2 100 TWh*<br>(8% of power generation) | 24 000 TWh*<br>(~50%) | 34 000 TWh*<br>(~60%) |
| **Gas going greener** | <1% green gases** in gas supply | ~20% | ~35% |
| **Sustainable mobility** | < 1% BEV & FCEV*** in light vehicles fleet | ~65% | ~80% |
| | ~100% kerosene fueling aircrafts | Sust. aviation fuels (SAF) @ ~45% of demand | SAF @ ~60% |
| **Increasing plastics' circularity** | 7% of gross demand recycled | ~40% | ~60% |
| **CCS to abate remaining emissions** | ~35 Mt (0.1% $CO_2$ emissions) | 3 Gt (~15%) | 6.5 Gt (~50%) |
| **Energy efficiency acceleration** | 1.5%/yr energy intensity improvement since 2000 | +2.4%/yr | +2.6%/yr |

* *Excluding REN generation for green H2*
** *Green gases include Biomethane and H2 but excluding H2 share for liquid e-fuels production*
*** *Battery-Electric Vehicles and Fuel-cell Electric Vehicles*

# Momentum

## Key energy transition levers:

- Revolution in Transport
- Massive growth in clean power
- Increased penetration of clean hydrogen

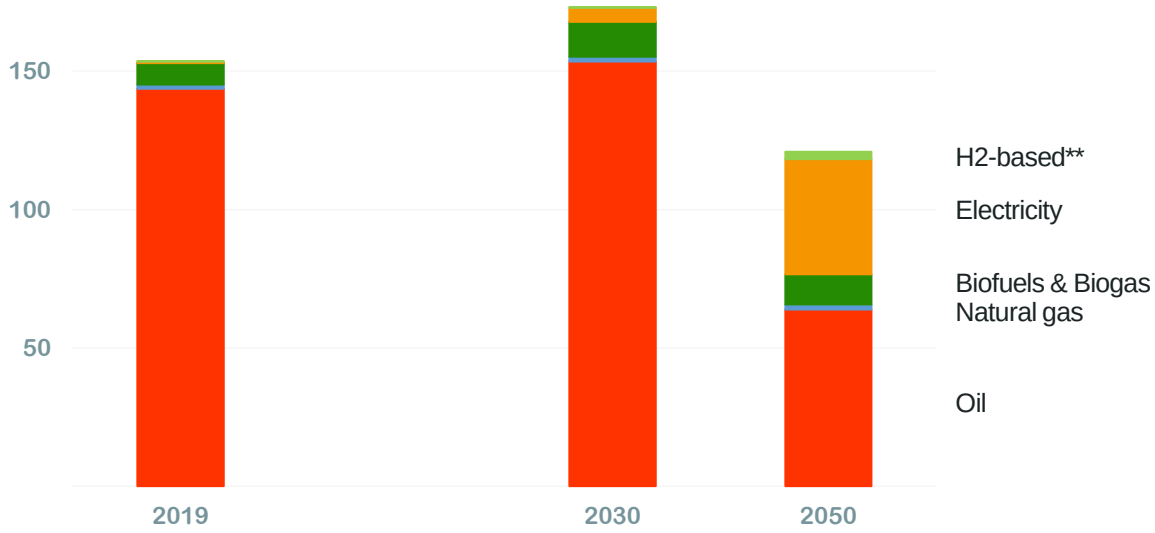
## Momentum wrap-up

# Electrification of Light Duty Vehicles

## Widespread penetration in China and NZ 2050 countries

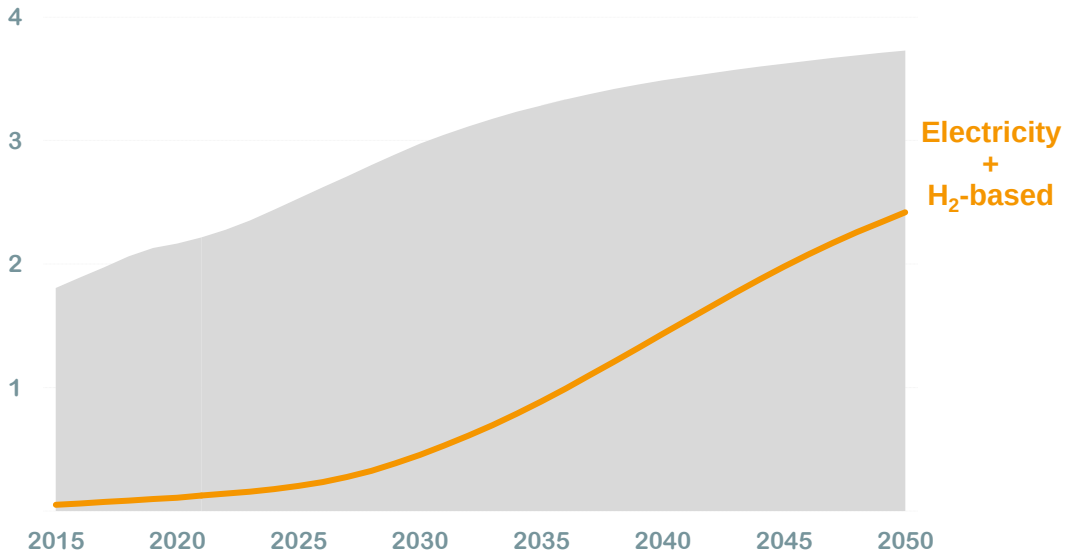
### Light Duty Vehicles* final consumption (Momentum)

PJ/d




### Light Duty Vehicles fleet (Momentum)

Billion




- LDV: 47% of 2019 transport final energy demand and $CO_2$ emissions
- Electricity confirmed as the primary decarbonization driver
- ~ 5 PJd / ~ 1 Mbd oil displaced in 2021, mainly for 2-3 wheelers
- Supplying the additional power required for mobility will require significant infrastructure investments

- Massive Electric Vehicles (EV) penetration supported by Internal Combustion Engine sales ban in 2035 in Europe and part of the US, together with ambitious EV targets in China
- By 2050, ~ 100% of fleet converted to electricity or $H_2$-based fuels in Net-Zero countries, and ~ 55% elsewhere (China ~90%)

* *LDV = Light Vehicles (Passenger cars + Light Commercial Vehicles) + 2-3 wheelers*
** *Includes H2, e-fuels (H2 + CO2)*

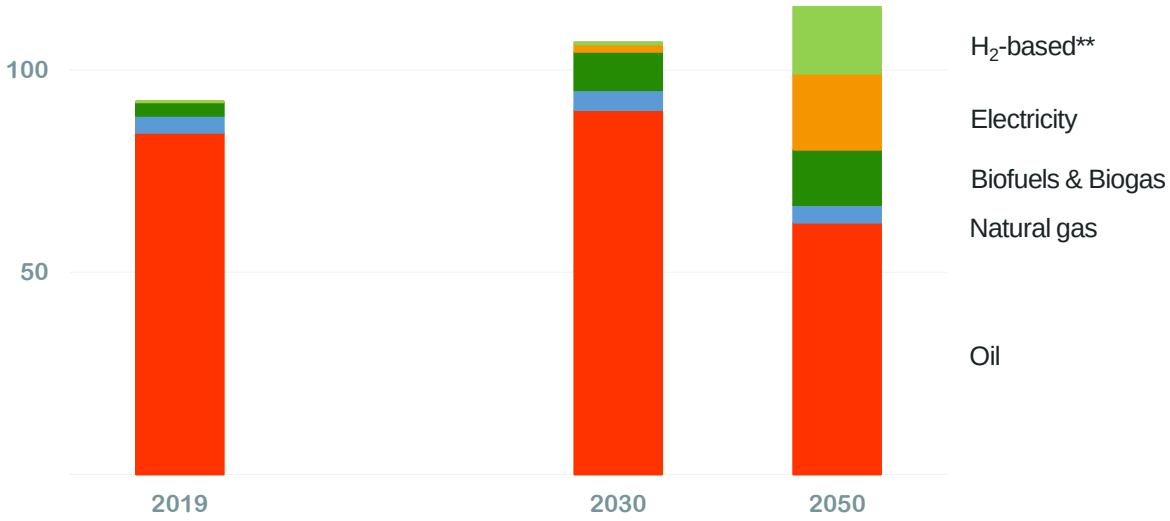


Momentum

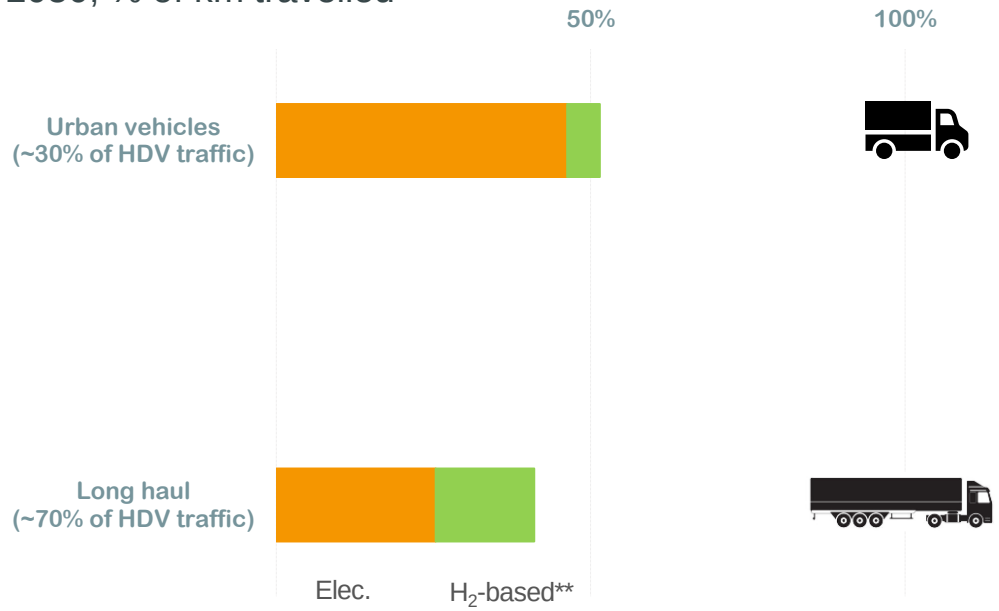
# Mix diversification in Heavy Duty Vehicles

## A full set of clean energies will contribute to trucking decarbonization

**Heavy Duty Vehicles * final consumption (Momentum)**
PJ/d




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




- HDV: 28% of 2019 transport final energy demand and $CO_2$ emissions
- A mix of clean energies (electricity, hydrogen and bioenergies) required to decarbonize trucking; electric powertrains leading the way.
- Even though HDV slower to decarbonize than Light Vehicles, oil share decreased to about half of the energy demand by 2050

- Urban and some regional/long haul application see a rapid battery-based EV trucks development
- Fuel-cells penetration rate more progressive, nonetheless taking an important share especially for long haul trips



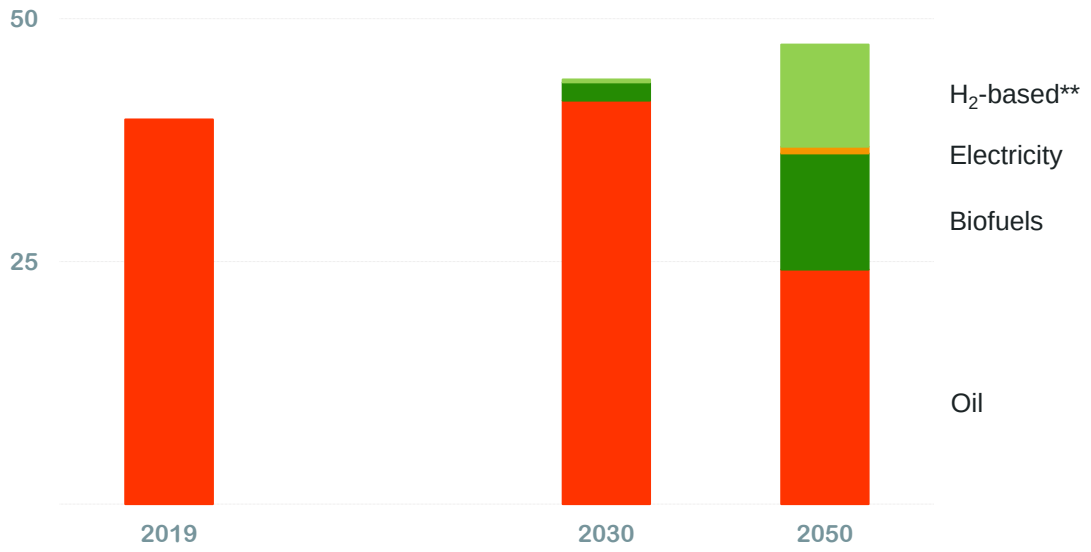
* *Trucks + Buses + Coaches*
** *Includes Fuel cells and $H_2$, e-fuels ($H_2$ + $CO_2$)*

Momentum

# Multiple decarbonization paths for Aviation & Marine

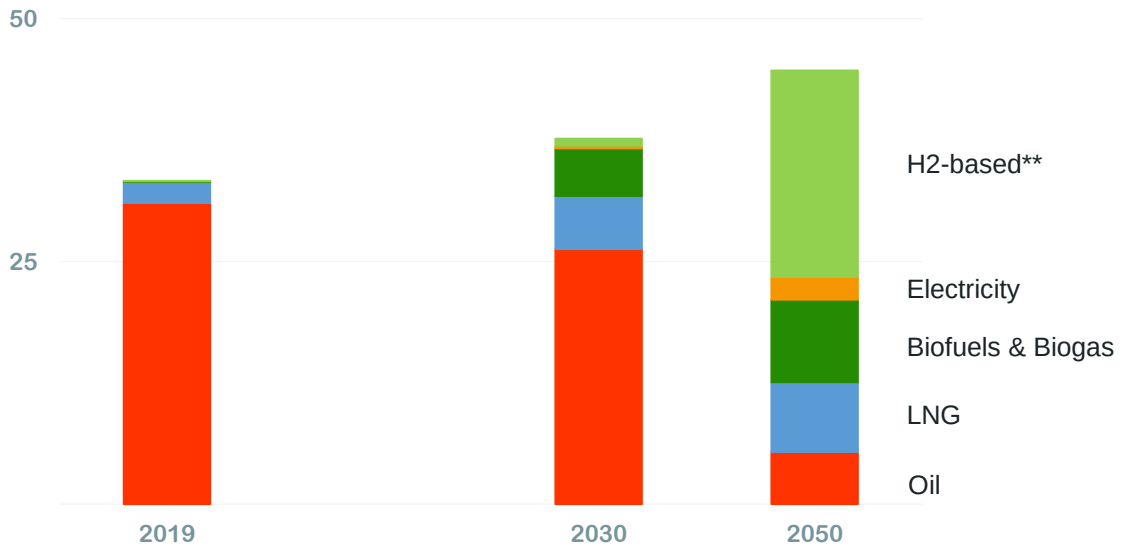
## Bioenergies and $H_2$-based fuels to decarbonize these hard-to-abate sectors

**Aviation final consumption (Momentum)**
PJ/d




- Aviation: 12% of 2019 Transport final energy demand and $CO_2$ emissions
- Drop-in decarbonation solutions (Sustainable Aviation Fuels*) required to decarbonize aviation as electricity and hydrogen will remain limited
- Aviation to capture an increasing share of biofuels supply after 2030 at the expense of road

**Marine final consumption (Momentum)**
PJ/d




- Marine: 10% of 2019 Transport final energy demand and $CO_2$ emissions
- LNG and bioenergies will play a key role as part of the energy transition
- Clean H2-based fuels (e-methanol, e-ammonia,…) deployed after 2035 to substitute oil



* *Sustainable Aviation Fuels = biofuels + e-fuels*
** *Includes H2, e-fuels (H2 + CO2), methanol, ammonia…*

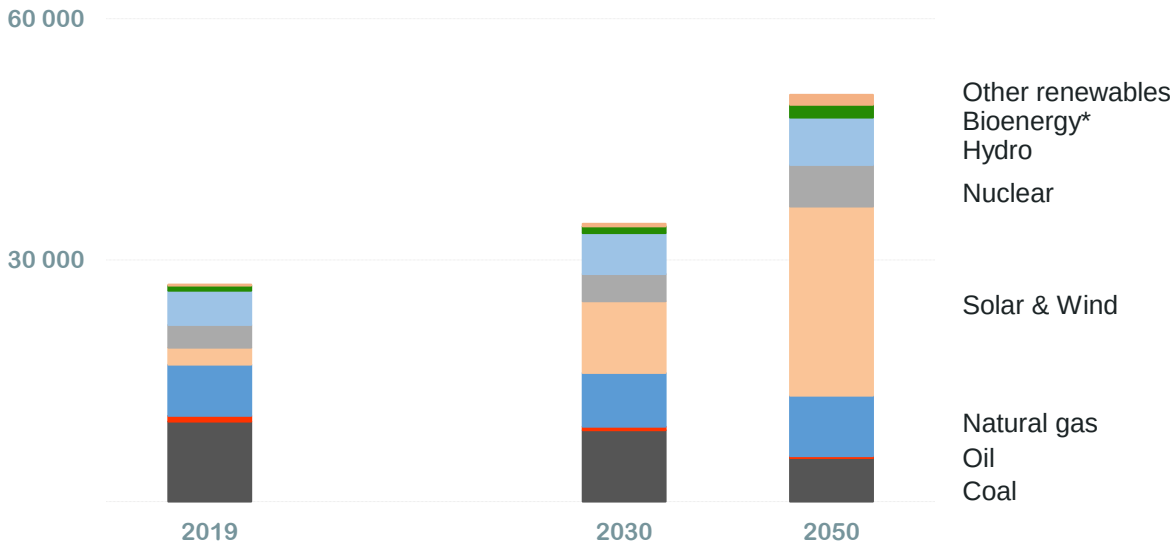
Momentum

# Significant growth of low carbon power generation

## Led by solar & wind

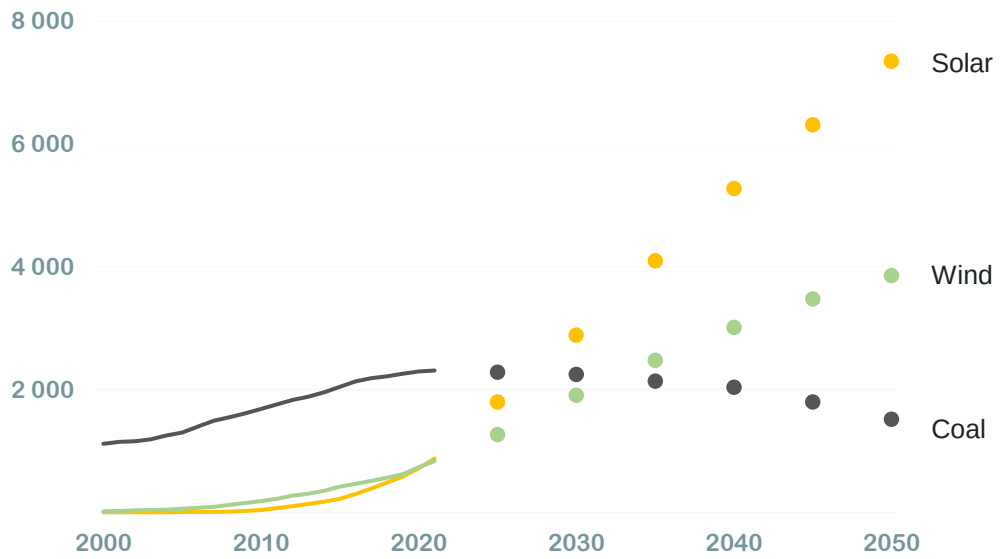
### Power generation, excluding power for Green $H_2$ (Momentum)

TWh




### Power capacities, excluding for Green $H_2$ (Momentum)

GW




- Power demand and generation almost doubling by 2050 (+2% p.a.), with wind & solar representing ~90% of new generation
- Huge decrease of coal-fired generation, complete phase-out in NZ countries
- Despite strong gas-to-REN switch, gas grows in absolute terms to manage variability of solar & wind and demand seasonality
- Renewed investment in nuclear

- Solar & wind capacities multiplied by ~7 in 30 years, representing 60% of all power capacities in 2050
- Coal capacities starting to decrease in the late 20's
- Average power emission factor reduced by ~75% by 2050 (net of CCS)

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

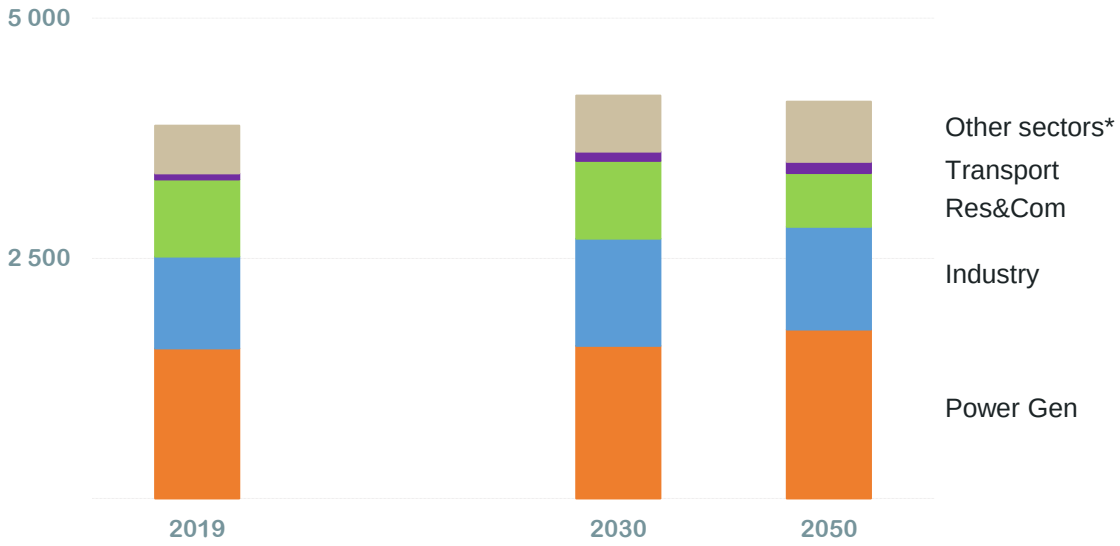


Momentum

# World Oil & Natural Gas

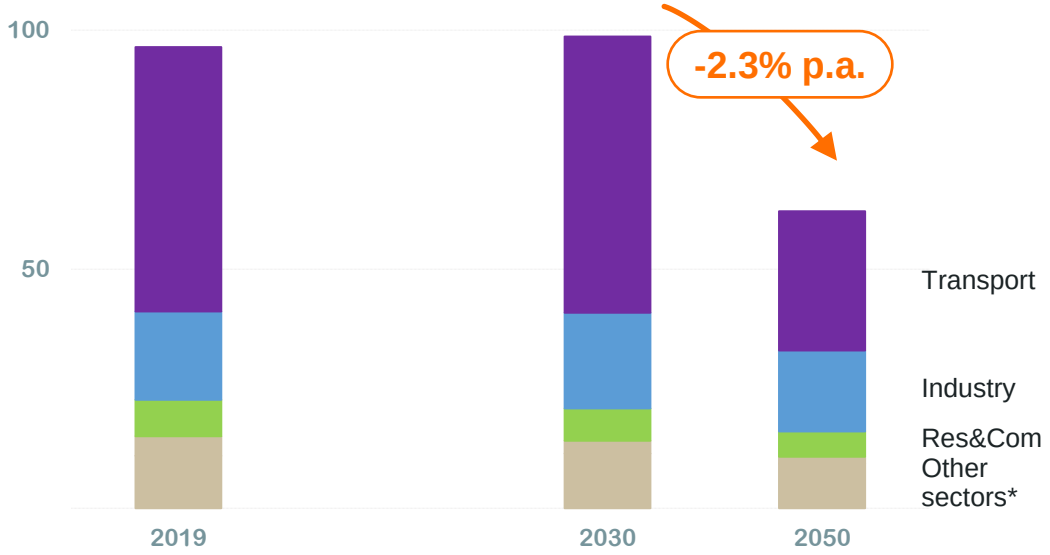
## Natural gas key for energy transition; oil starts decreasing after 2030

**Natural gas demand by sector, excluding gas for Blue $H_2$ (Momentum)**
Bcm




- Natural gas is a key transition fuel, growing by +0.2% p.a. to 2050, with a plateau from the 2030's
- Natural gas to displace coal in Power and Industry
- Gas use in transport remains mainly focused on Marine

**Oil demand by sector (Momentum)**
Mb/d




- Slight oil demand increase until early 2030
- Decrease post-2030 slower than the natural decline of producing oil fields, requiring continued investment

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



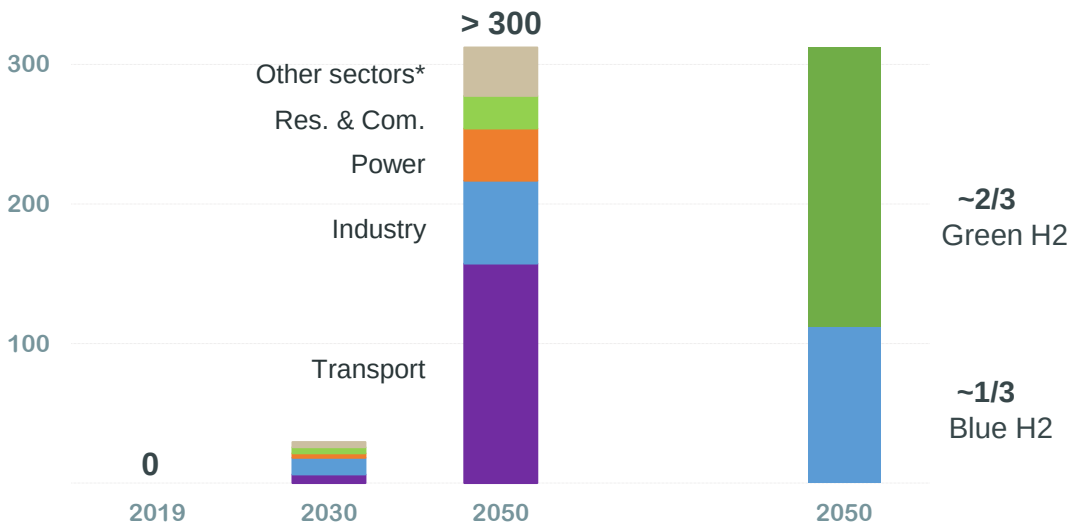
Momentum

# What about clean hydrogen?

## Mostly used for hard-to-abate sectors

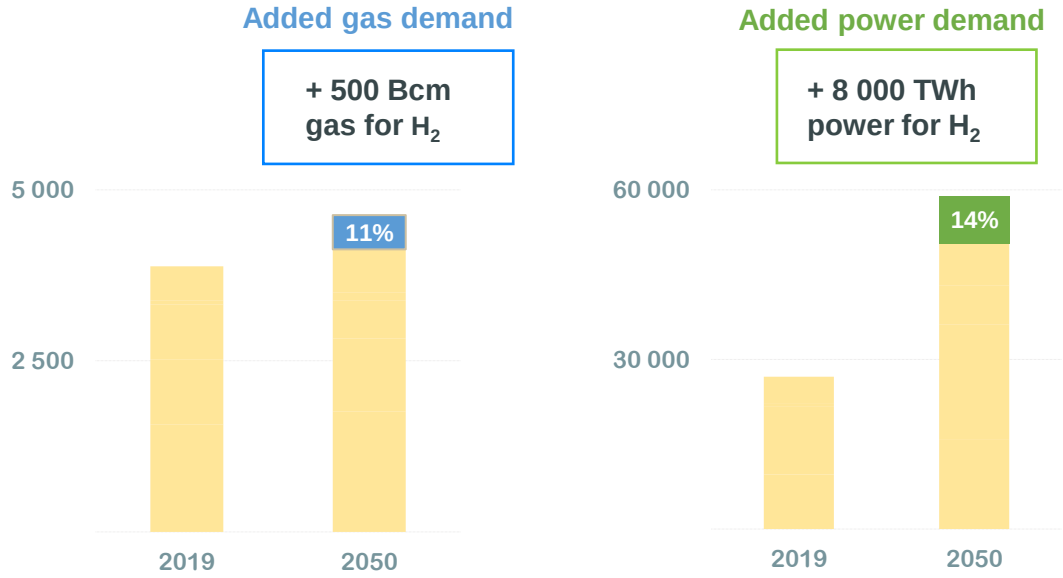
### Clean $H_2$ balance (Momentum)

$MtH_2$




### Nat Gas and Power demand including $H_2$ (Momentum)

Bcm & TWh




- Clean hydrogen demand driven by Net-Zero 2050 countries and China
- Scale-up takes time; significant potential after 2030
- Transport: $H_2$ used in fuel cells and e-fuels (e-ammonia, e-methanol, e-jet)
- EU mostly green $H_2$, US & China blue & green

- Blue $H_2$ and power generation main drivers of gas demand growth
- 110 Mt Blue $H_2$ production will require ~1Gt CCS by 2050
- Green $H_2$ an important driver of strong power demand growth, together with Res. & Com., transport and industry
- x3 of today's solar & wind capacities dedicated to Green $H_2$ by 2050

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

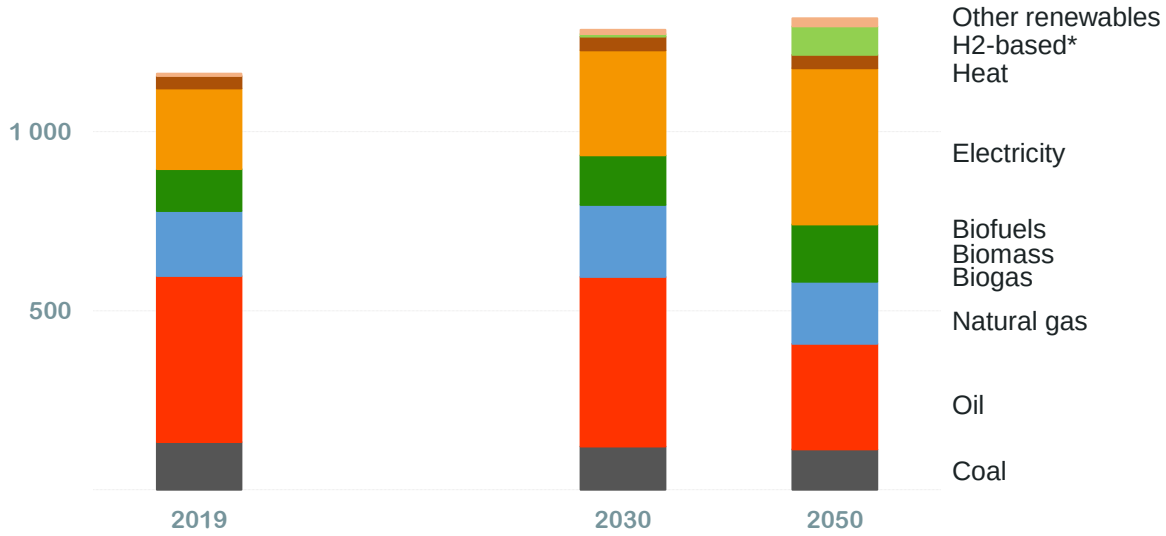


Momentum

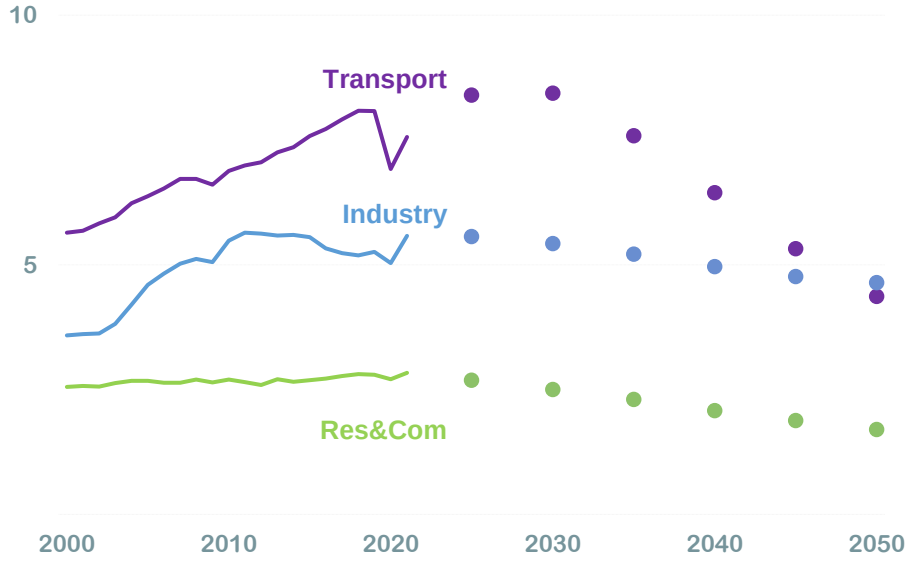
# World Total Final Consumption

## Electricity outstrips oil in the early 2040s

**Total final consumption**
PJ/d




**Energy-related $CO_2$ emissions by sector**
Gt




- Final energy mix more and more diversified
- End-user electrification via clean power #1 driver of all NZ50 policies
- Fossil fuels share down from 2/3 to ~45%

- In momentum, emissions curbed first and foremost from transport, the n°1 end-user emitting sector today

* *Includes H2, e-fuels (H2 + CO2), methanol, ammonia…*

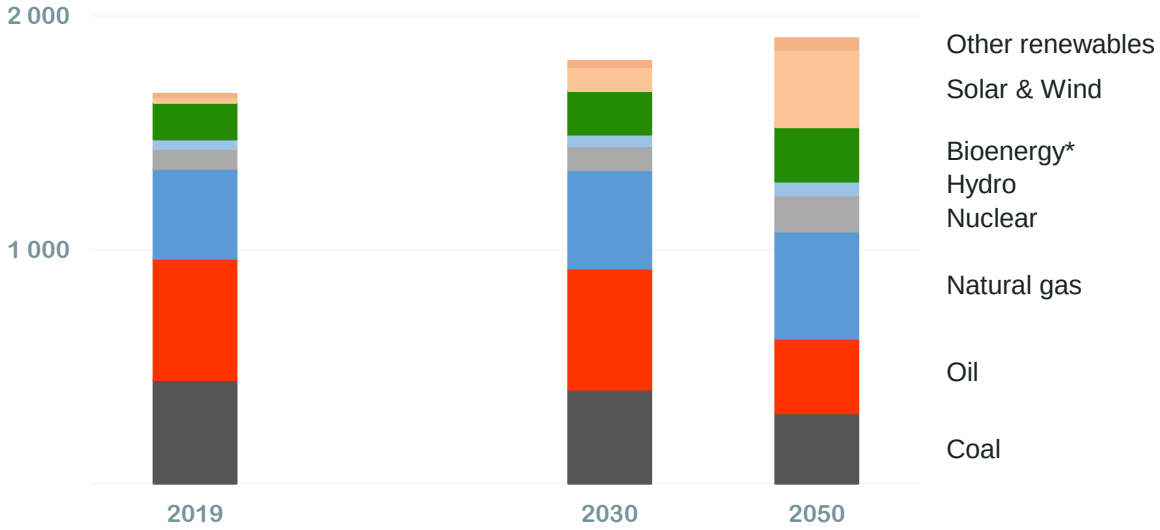


Momentum

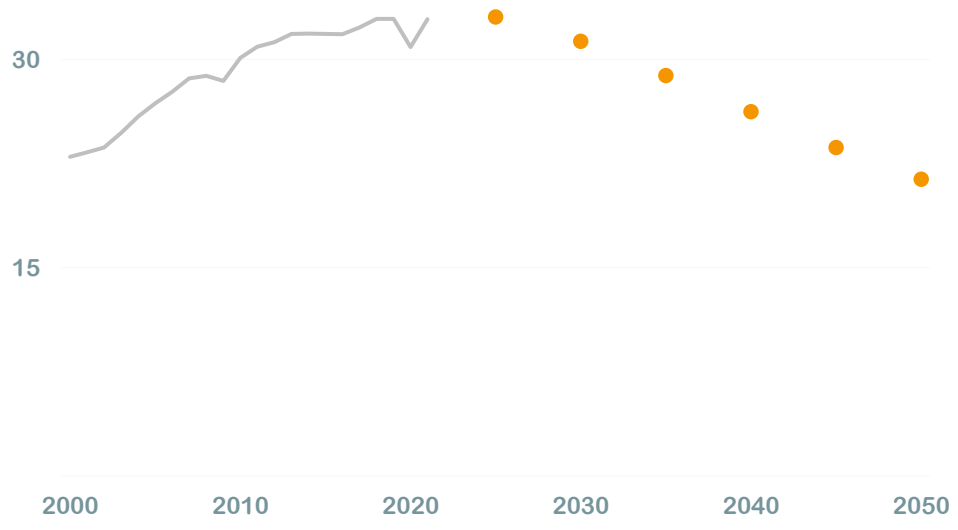
# World energy demand and $CO_2$ emissions

## Great effort towards energy transition but insufficient to meet global targets

**Total primary energy demand**
PJ/d




**Energy-related $CO_2$ emissions**
Gt




- Primary energy demand up by ~15% by 2050
- Renewables & natural gas both growing, playing key complementary roles

- Energy-related $CO_2$ emissions drop by ~35% to reach 21 Gt in 2050 (net of ~3 Gt CCS, mainly in power, blue $H_2$ and industry)
- Temperature would rise by +2.1-2.3°C by 2100 (P66)

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



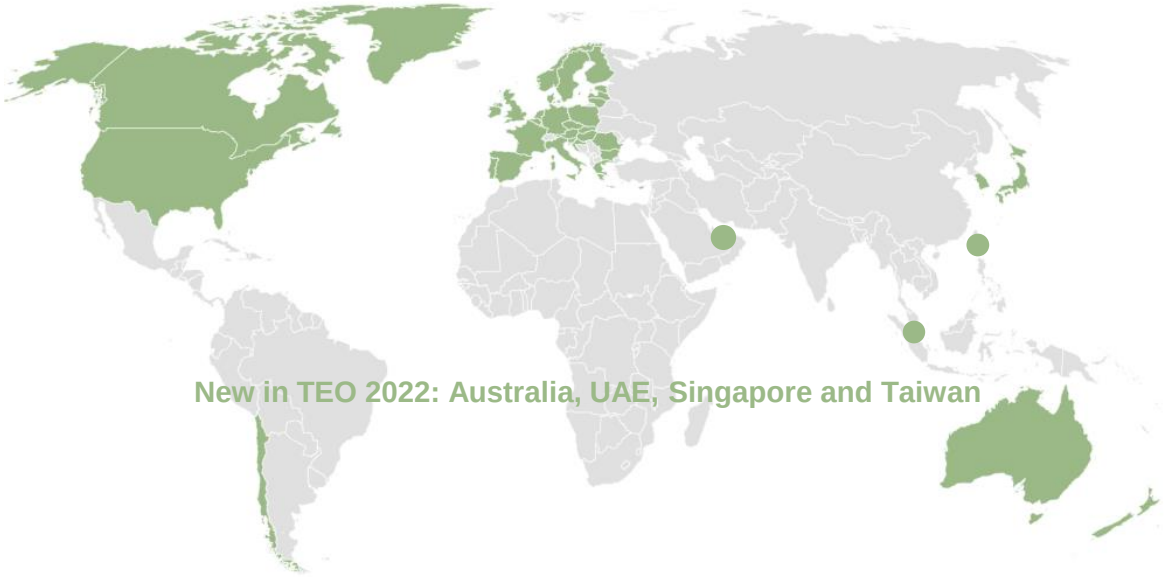
Momentum

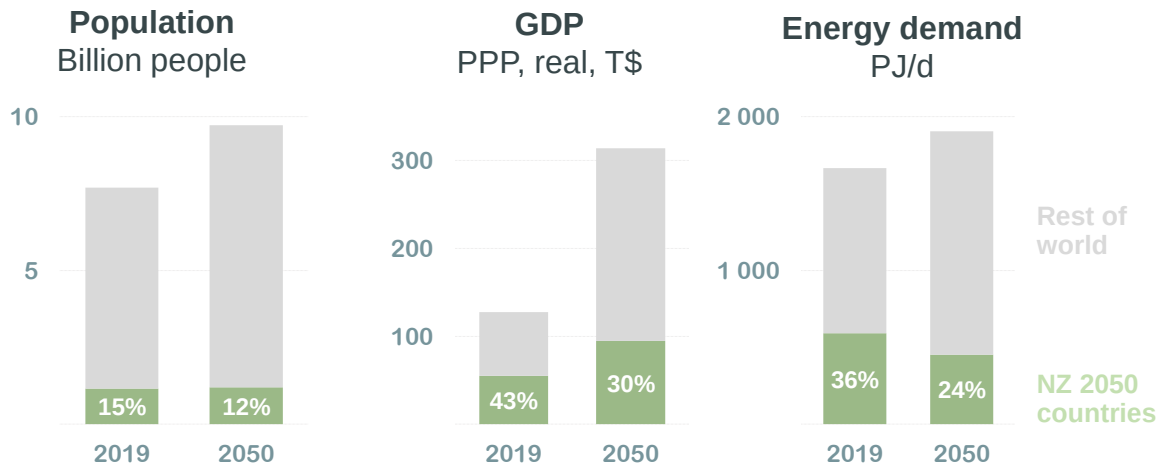
# Zoom

- A closer look at NZE countries
- EU27: progressing its Green Deal
- Africa: a promising energy transition path

# Net Zero by 2050 countries

## At the forefront of the energy transition




## Main game changers in Net-Zero 2050 countries

- → Power generation carbon-neutral by 2040 (net of CCS)
  Renewables @80% of 2050 power generation, natural gas to manage variability
- → Road Transport carbon-neutral by 2050
  ~ 100% of fleet converted to electricity or hydrogen by 2050
- → Electrification with clean power
  Electricity @46% of 2050 final consumption (World: 33%)
- → Leading in clean $H_2$ and green gases penetration
  40% of green gases in 2050 total gases demand



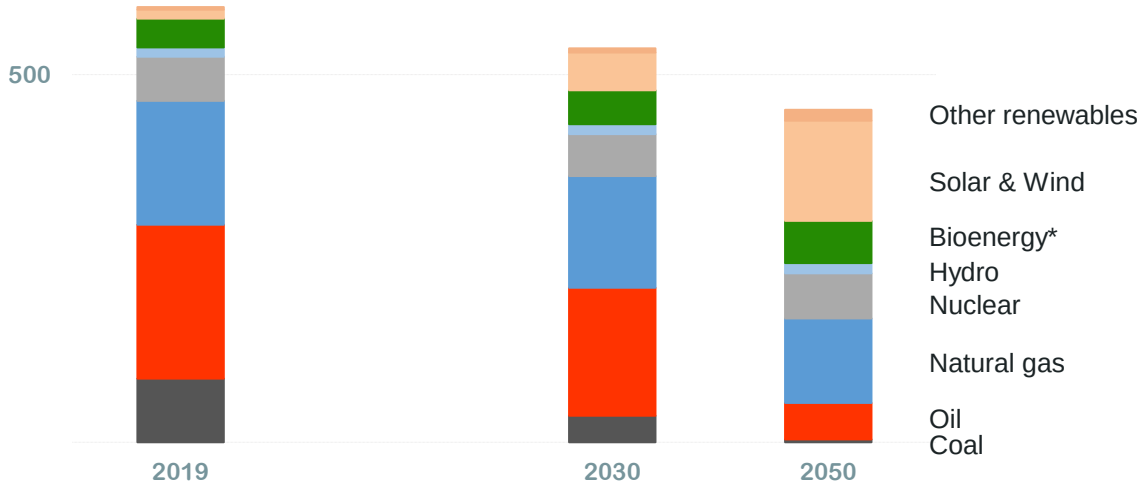
Zoom

# Net Zero by 2050 countries

## Forging the net-zero emissions pathway

### NZ 2050 countries primary energy demand

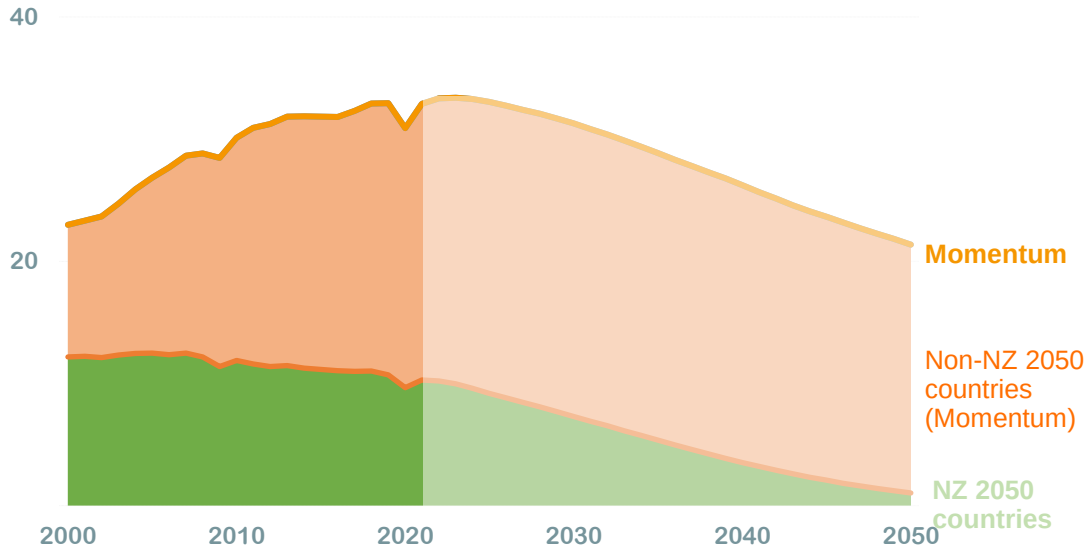
PJ/d




- NZ 2050 countries energy demand to fall by ~25% in 30 years
- Fossil fuels share fall from almost 80% to less than 40% in 2050
- Residual oil demand mainly in transport and petrochemicals
- Natural gas keeping a strong role in power and for blue $H_2$ production

### World energy-related $CO_2$ emissions

Gt




- After 2 Gt of CCS, 1 Gt of emissions remaining in 2050
- Net-Zero countries' efforts far from sufficient
- Full decarbonization of non-OECD countries will not happen without cooperation and support from NZ countries

* *Includes modern use of bioenergy such as biofuels, biogas…*



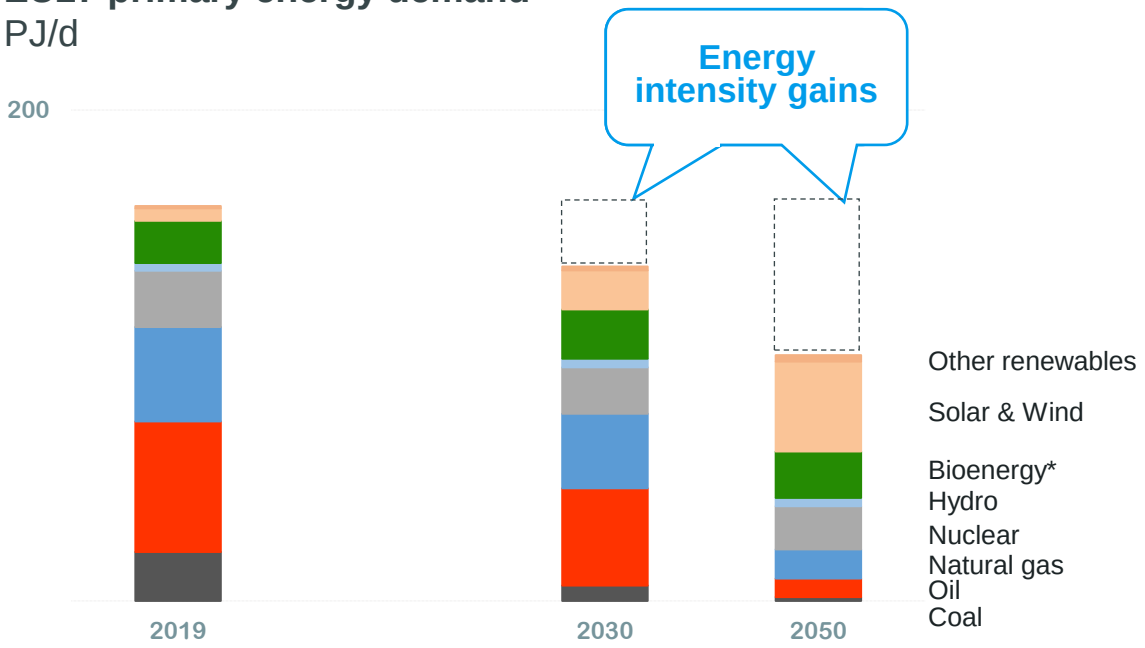
Zoom

# EU27

## Leveraging short-term emergency measures to engage structural transformation

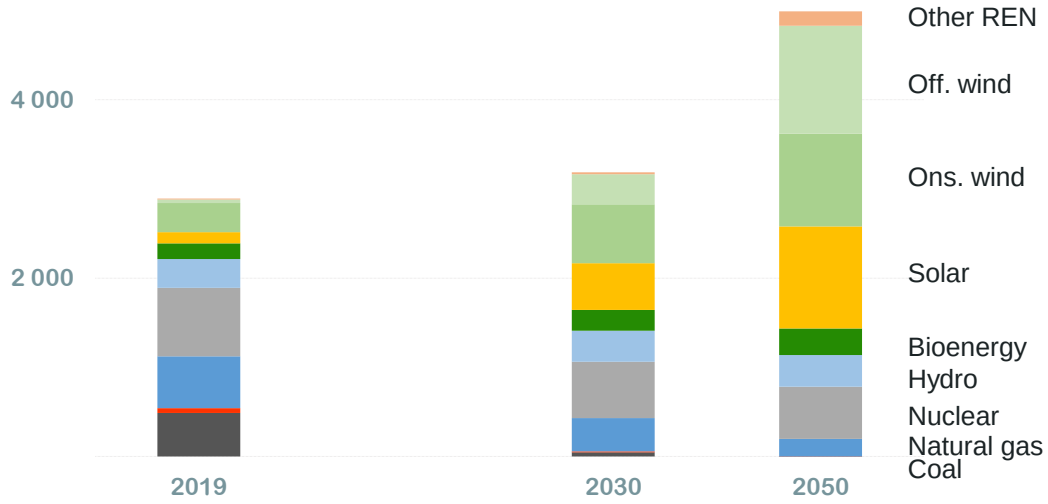
### EU27 primary energy demand

PJ/d




### EU27 power generation (incl. Green $H_2$)

TWh




- EU leading the NZ50 countries in reducing fossil fuels, using bioenergy and deploying REN
- Current energy crisis a unique opportunity to pursue energy efficiency efforts: reduces demand by ~15% by 2030
- Cost of green transition and increased energy security being endorsed by EU governments

- Power generation level & REN capacities consistent with 2030 Fit for 55
- Non-carbon sources reach 95% of EU27 power generation by 2050, driven by a 7-fold increase in Solar & Wind generation
- Very high share of wind generation creates favorable conditions for green $H_2$ production, 30 Mt by 2050 consuming 25% of power generation

* *Includes modern use of bioenergy such as biofuels, biogas…*

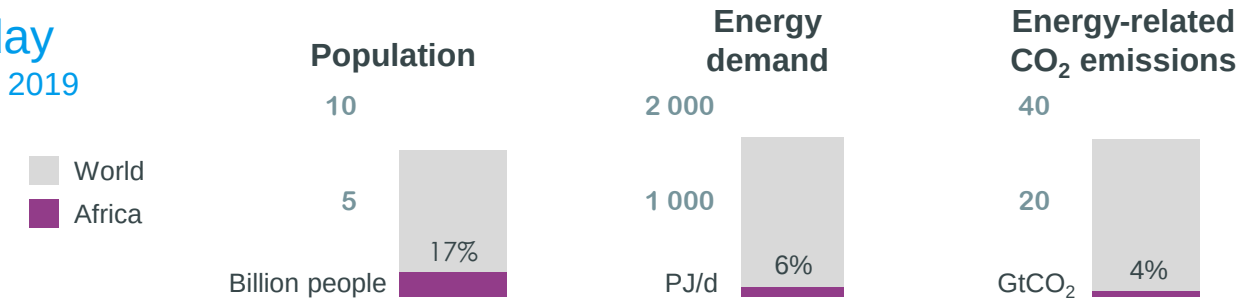


Zoom

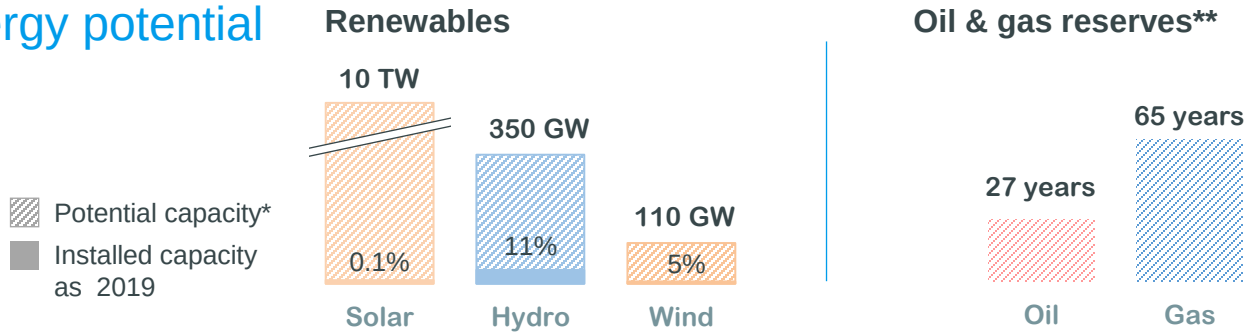
# Africa

## A continent with huge untapped resources

### Today
As of 2019




### Energy potential




### Tomorrow
(Momentum 2050)

| Population | …with electricity | Energy demand | Energy-related $CO_2$ emissions |
|---|---|---|---|
| x2 | x2.5 | x1.5 | x1.5 |

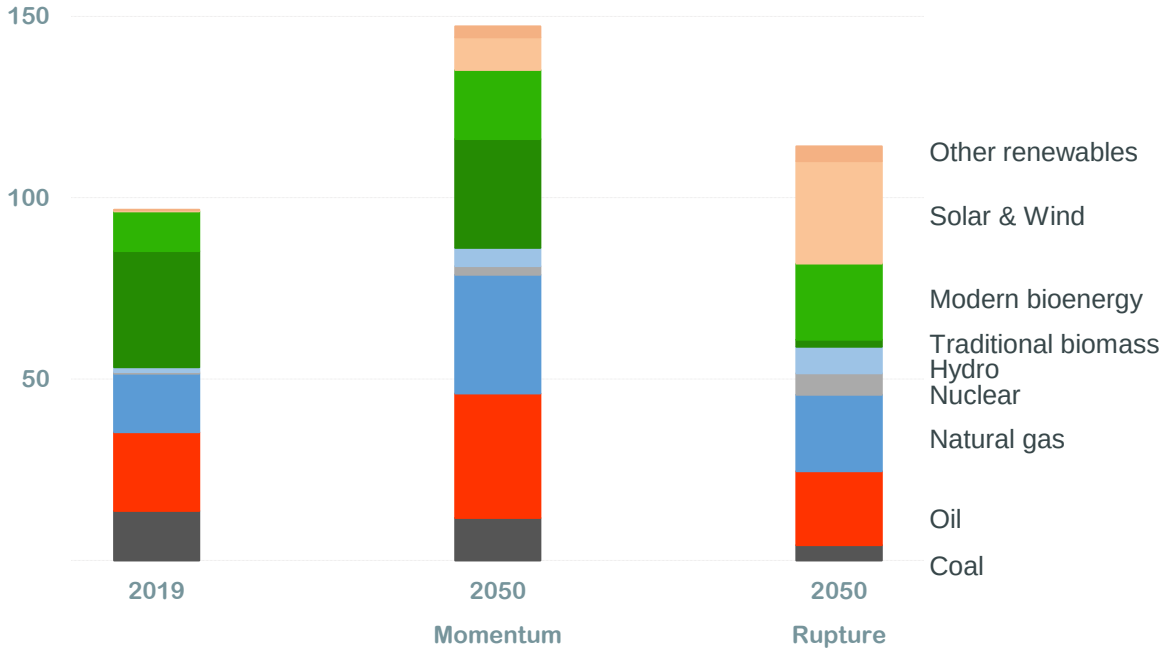
* *Source: African Development Bank*
** *2P + 2C reserves / production in 2019*

Zoom

# Africa

## More energy to improve the living standards of a growing population

**Africa primary energy demand**
PJ/d




### Momentum

- Energy demand growth of 1.4% p.a. to 2050
- Urbanization facilitates partial transition away from inefficient and highly-emitting traditional biomass to cleaner modern energies
- Energy mix leveraging domestic oil & gas resources, with modest impact on $CO_2$ emissions
- Moderate development of solar, wind and hydro

### Rupture

- Energy demand growth of 0.5% p.a. to 2050
- Elimination of traditional biomass thanks to quasi-universal electrification
- Accelerated development of intermittent renewables and hydro, leading to an almost total phase out of coal
- Oil & gas resources continue to play important roles to support economic and social development

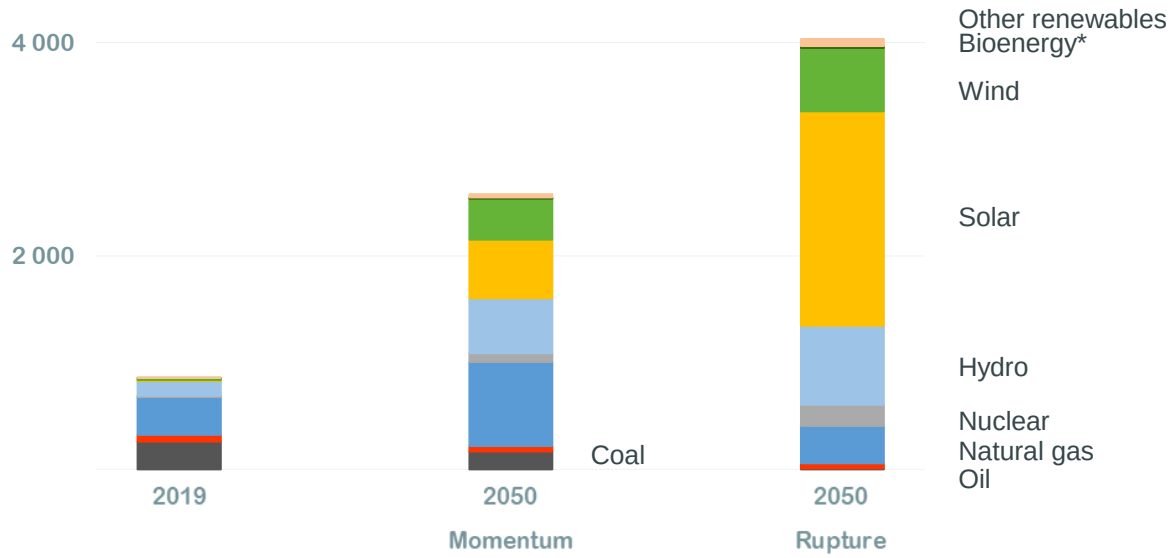


Zoom

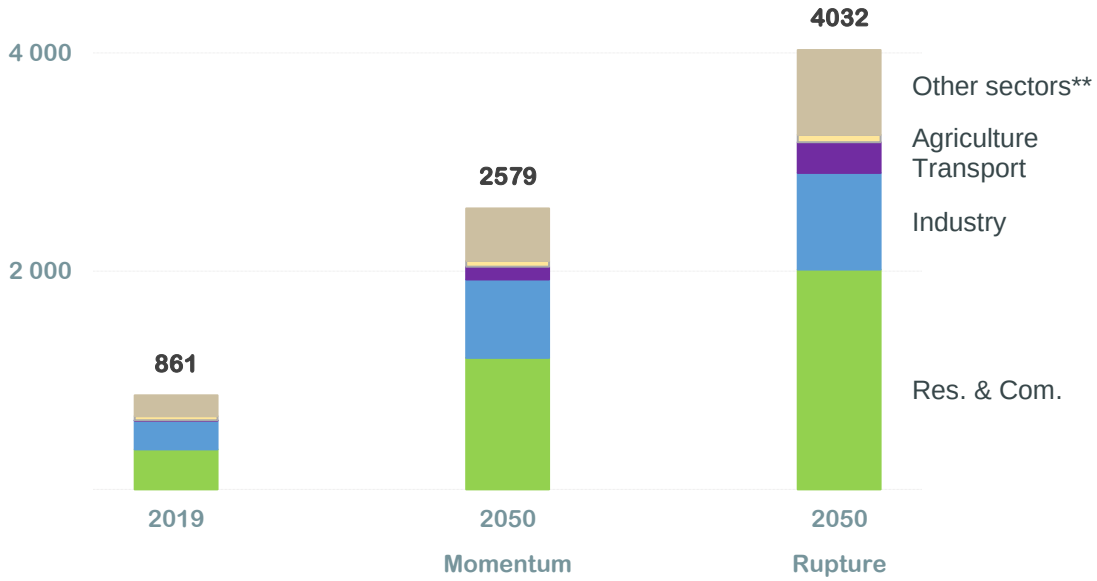
# Africa

## Massive electrification with renewables, driven by urbanization

### Africa power generation
TWh




### Africa power demand by sector
TWh




- Between 2019 and 2050, power generation multiplied by 3 in Momentum and by 5 in Rupture. Solar, hydro, and wind accounting for more than 80% of growth (100% in Rupture)
- Significant financial transfers from OECD countries required to fund clean infrastructure projects
- Strong improvements in power sector governance also mandatory

- Power demand growth of 3.6% p.a. (Momentum) & 5.1% p.a. (Rupture)
- Strong urbanization leading to significant Res&Com expansion, accounting for half of power growth to 2050 in both scenarios

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



Zoom

# Rupture

## Key additional levers:

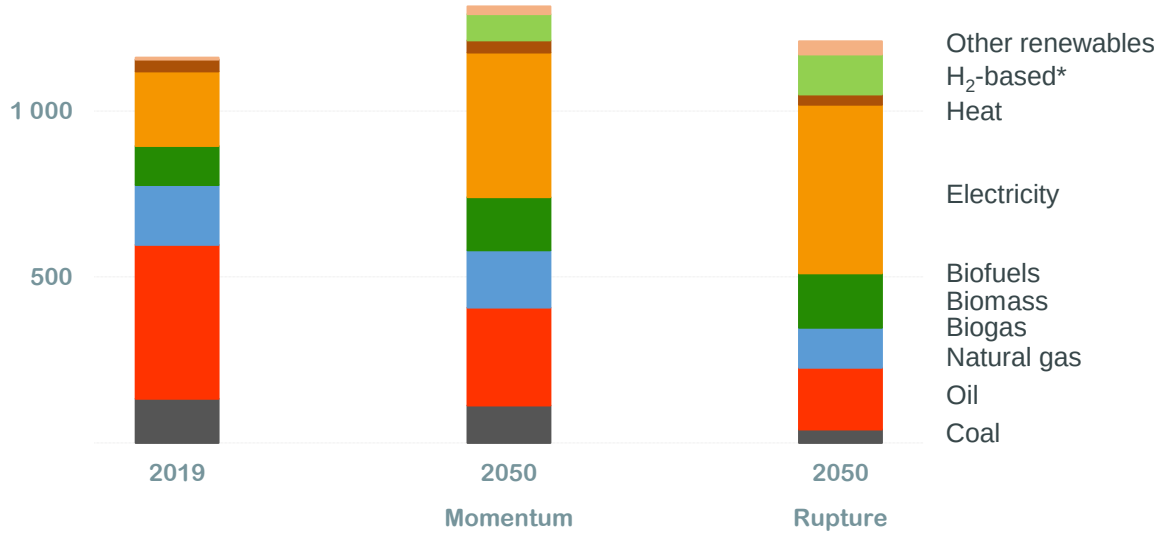
- Accelerated electrification of demand
- Accelerated deployment of REN

## Rupture wrap-up – CO2 emissions

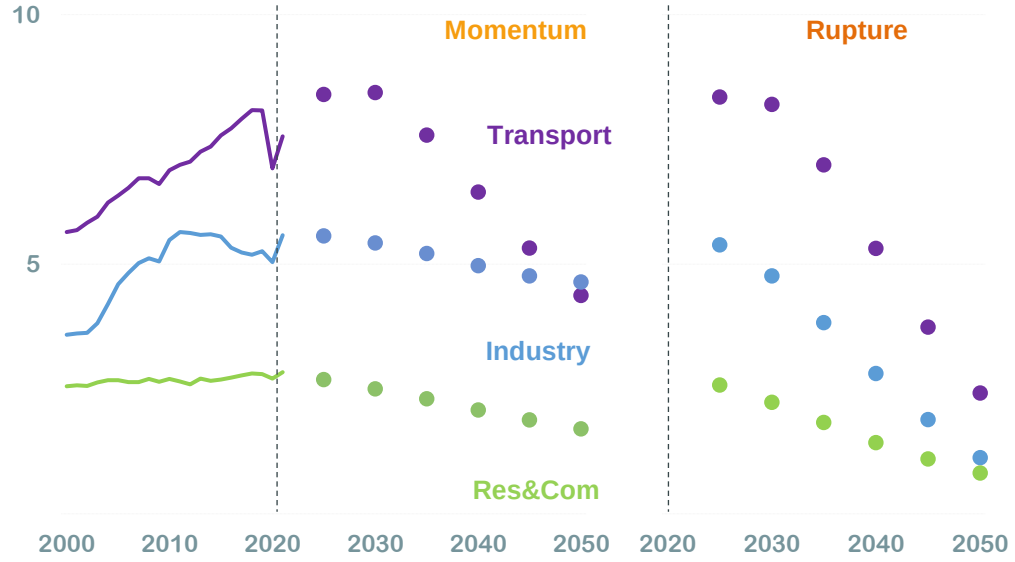
# World Total Final Consumption

## Increased electrification in non-OECD essential to remain well-below 2°C

**Total final consumption**
PJ/d




**CO2 emissions by sector**
Gt




- Electricity, $H_2$-based fuels, bioenergies accounting for two thirds of final energy demand in Rupture 2050
- Almost complete phase-out of coal, strong reduction in oil
- Continued role for natural gas and green gases

- Transport emissions divided by 3 in Rupture 2050 (by 2 in Momentum) with accelerated electrification
- Industry emissions reduced to ~80% of current level in Rupture 2050 (~10% in Momentum)

* *Includes H2, e-fuels (H2 + CO2), methanol, ammonia…*



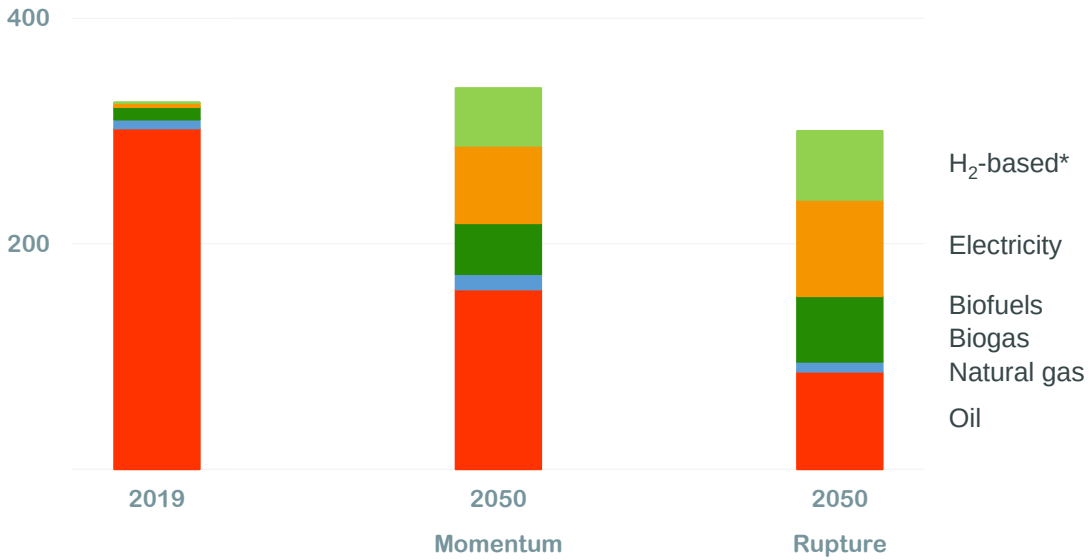
Rupture

# World demand in Transport

## Accelerated substitution away from oil on a global scale

### Transport total final consumption

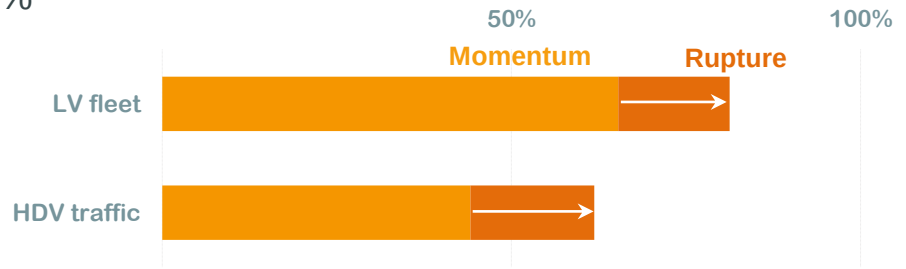
PJ/d




### Electricity and fuel cells share in 2050

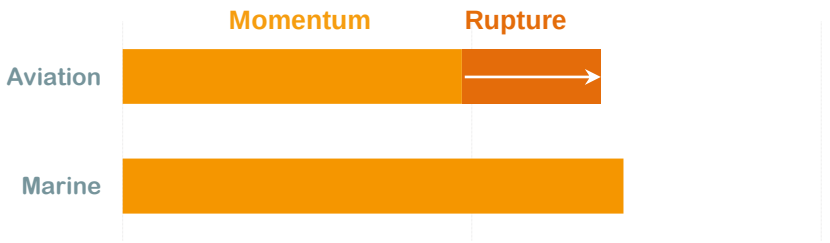
**LV fleet (Billions Vehicles) and HDV traffic (km)**

%




### Non-fossil fuels share of energy demand in 2050

%




- In Rupture, oil represents less than 1/3 of transport final energy demand as alternatives are widely deployed in all segments
- Electricity, together with advanced fuels (bio-based and $H_2$-based) will drive decarbonization.

- Non-fossil share becoming dominant in all transport modes
- 50% $CO_2$ emissions reduction in 2050 for marine (vs 2005) and for aviation (vs 2008)

* *Includes H2, e-fuels (H2 + CO2), methanol, ammonia…*

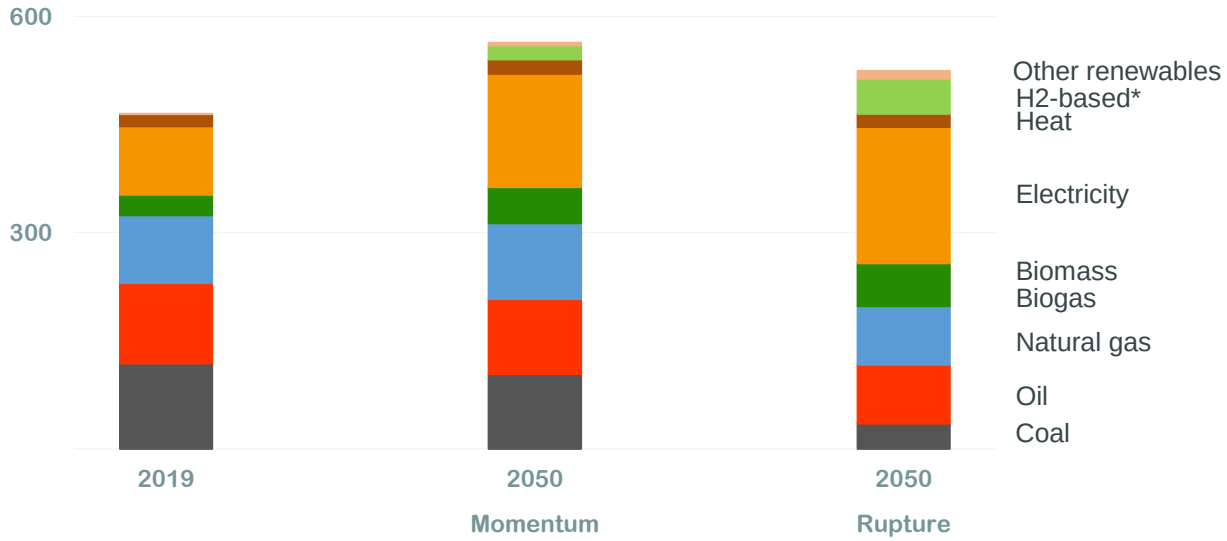


Rupture

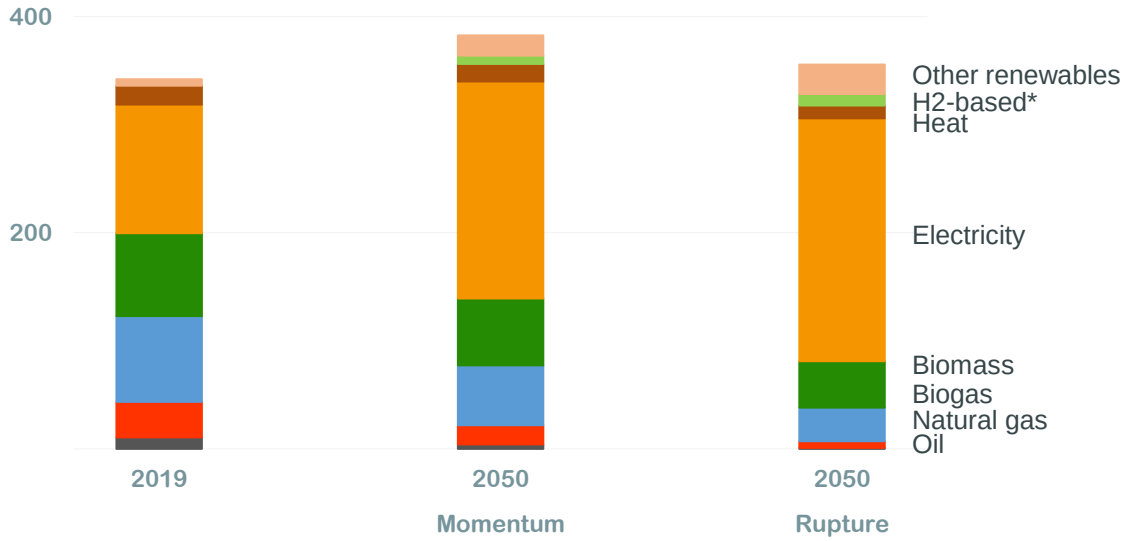
# World demand in Industry and Res. & Com.

## Deep electrification and strong efficiency gains

**Industry total final consumption**
PJ/d




**Res. & Com. Total final consumption**
PJ/d




- Industry deep decarbonization enabled by multiple in-depth changes:
  - Coal-to-gas substitution wherever possible, then gas-to-electricity
  - Adoption of $H_2$ for select processes (ex: steel DRI, fertilizers)
  - CCS for industry in 2050 tripling from 0,5 Gt in Momentum to ~1.5 Gt in Rupture

- Flat Rupture Res&Com demand by 2050 thanks to major energy efficiency gains (buildings, lighting, appliances,…)
- Deep penetration of electricity facilitated by urbanization and massive power networks" development
- Buildings renovation needs to be dramatically accelerated from current rates, requiring targeted support mechanisms

* *Includes H2, e-fuels (H2 + CO2), methanol, ammonia…*



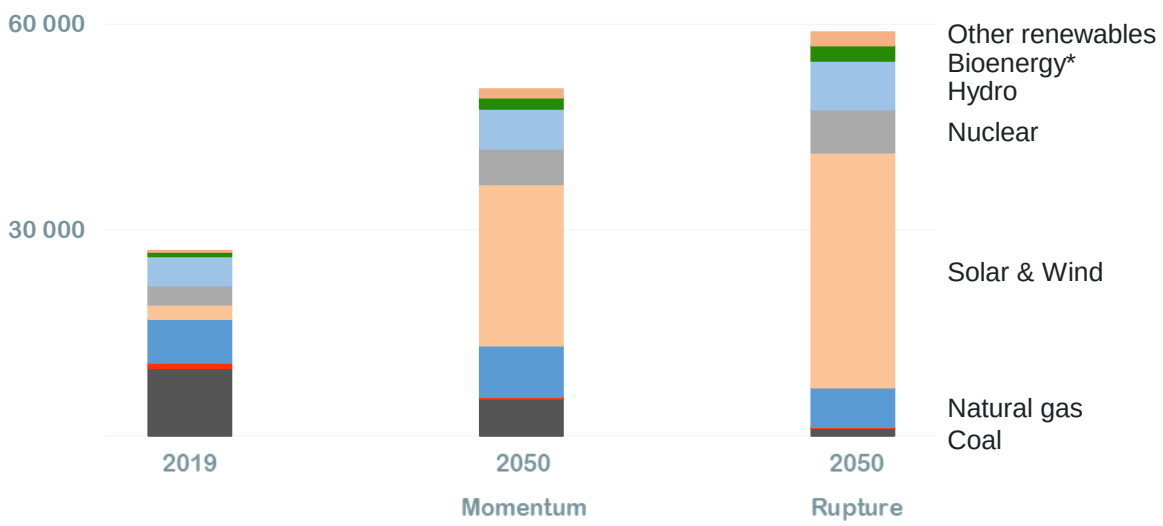
Rupture

# World Power demand and generation

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

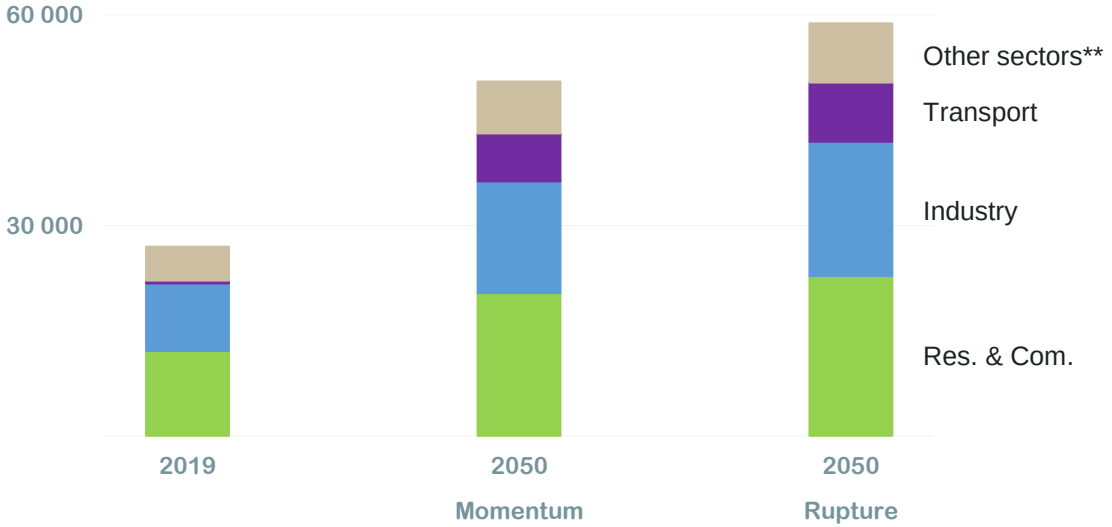
### Power generation, excluding Power for Green $H_2$

TWh




### Power demand, excluding Power for Green $H_2$

TWh




- Solar & Wind generation in Rupture 2050 ~30% larger than total power generation today
- Coal almost disappears in Rupture, natural gas still required to manage variability of renewable energies
- Massive renewable penetration requires deployment of energy storage systems (batteries, electrolysers), flexible power plants, and grid expansion

- Power demand accelerating at 2.5% p.a. to 2050 (vs. 2% p.a. in Momentum), with Res. & Com. and Industry demand doubling by 2050 in Rupture
- Transport electricity demand in 2050 representing almost one third of total power demand today

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



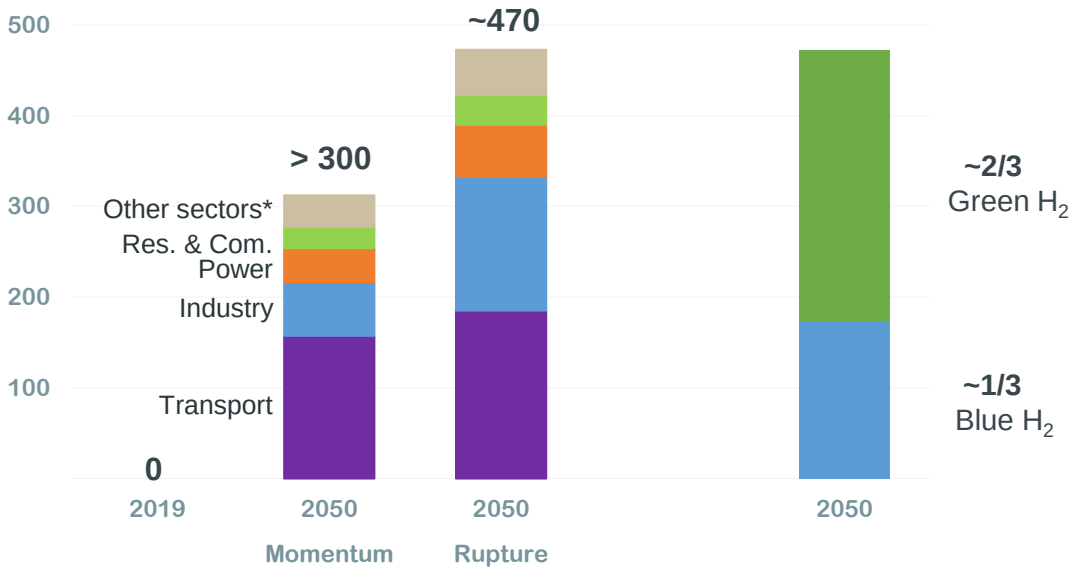
Rupture

# Clean Hydrogen

## Adding ~20% to natural gas and power demand in 2050

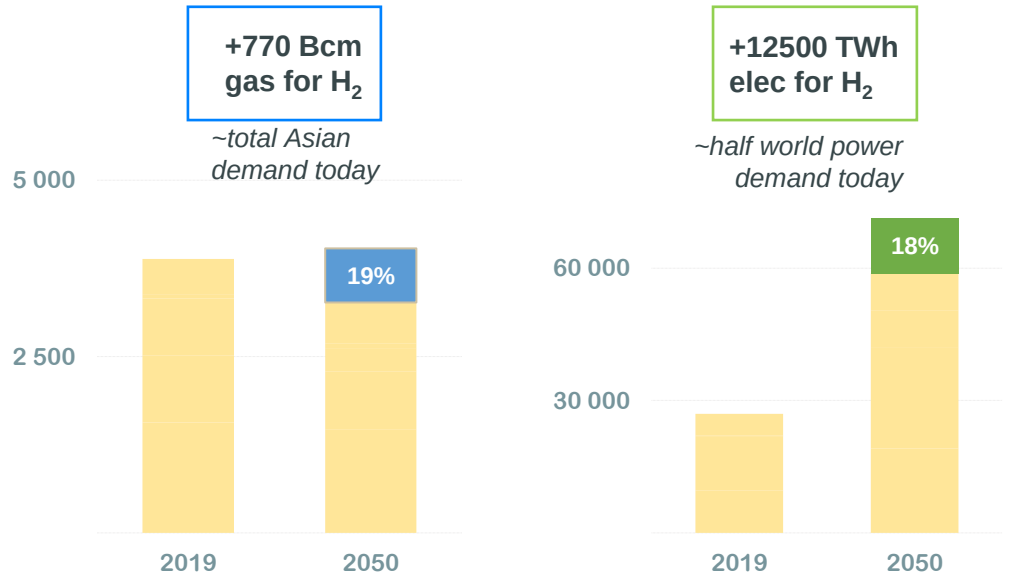
### Clean $H_2$ balance

$MtH_2$




### Nat Gas and Power demand by sector including H2 (Rupture)

Bcm & TWh




- $H_2$ production taking off after 2030 drives up electricity & gas demand with CCS & electrolysis development
- Transport & Industry are the main users of clean $H_2$
- Costs must come down and infrastructure must be built up in order to support $H_2$ adoption and industrial scale up

- $H_2$ becomes a significant growth driver for natural gas demand starting in the 2030's
- Power for Green $H_2$ pushes up power demand CAGR from 2.5%/y to 3.2%/y until 2050

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



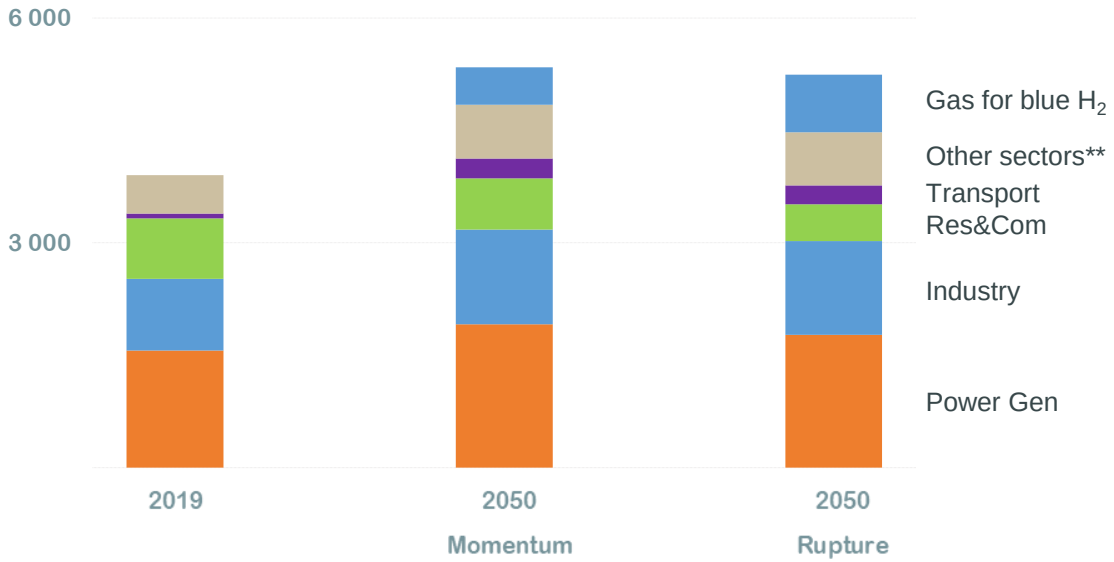
Rupture

# World Gases demand

## Towards low-carbon gases predominance

### Gases demand by sector

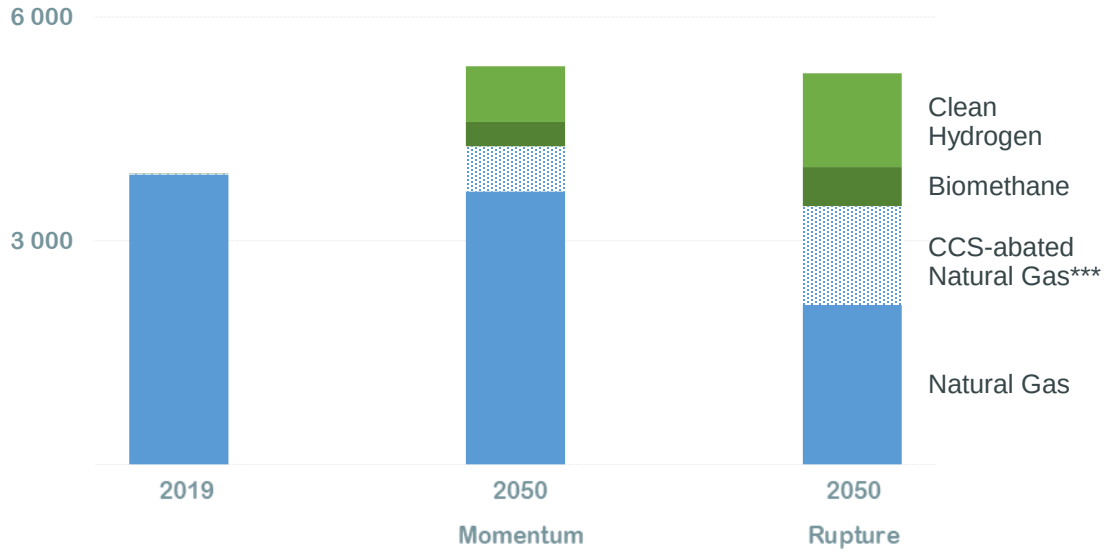
Bcm*




- Nat gas plays its role as a key transition energy in all sectors (except ResCom) and to produce blue $H_2$
- All gases combined growing ~1%/y to 2050

### Gases demand by type

Bcm*




- Green gases and CCS-abated natural gas making 60% of world demand in 2050 in Rupture (1/3 in Momentum)

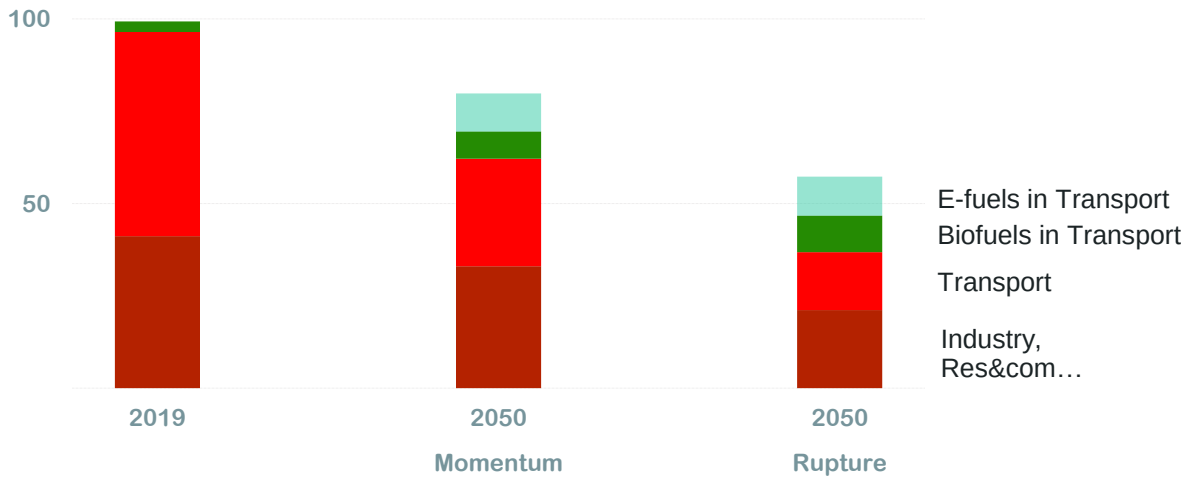
* *For hydrogen: volumetric equivalence of natural gas in energy terms; H2 supply for liquid e-fuels production is excluded*
** *Other energy use, non-energy use and agriculture*
*** *CCS-abated natural gas demand excl. the portion used to produce hydrogen through SMR+CCS*

Rupture

# World Liquids demand

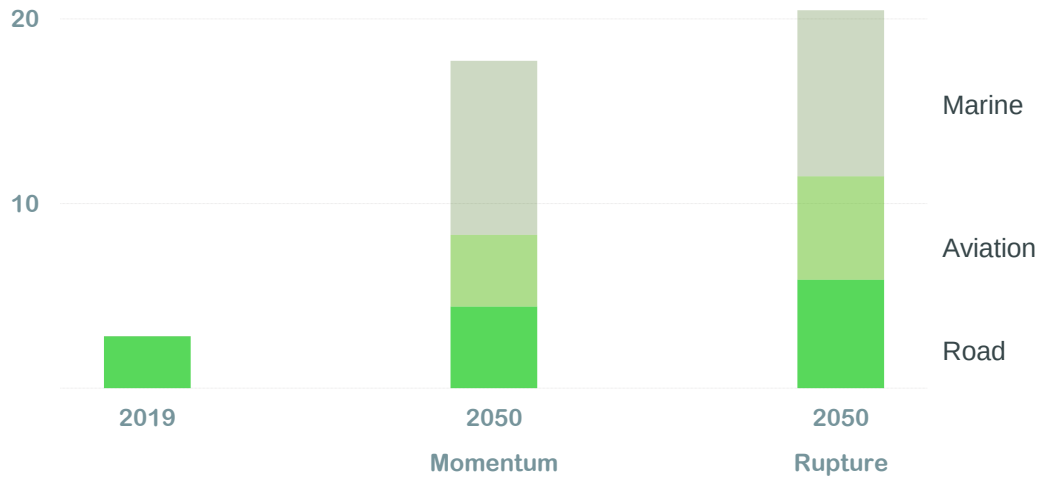
## Demand plateaus over the decade

**Liquids (oil + biofuels + e-fuels) demand by sector**
Mb/d




- Oil demand will plateau until 2030, before reaching 62 Mb/d in Momentum and 37 Mb/d in Rupture in 2050
- Sustainable Liquid Fuels represent more than 40% of Transport liquids demand in Rupture (45% biofuels and 55% e-fuels)

**Biofuels + e-fuels demand in transport**
Mb/d




- Decarbonization of Transport will rely on massive development of Sustainable Liquid Fuels (biofuels supplemented after 2030 by e-fuels)
- E-fuels being a key alternative for marine and aviation sectors will require significant deployment during this decade to meet long-term demand

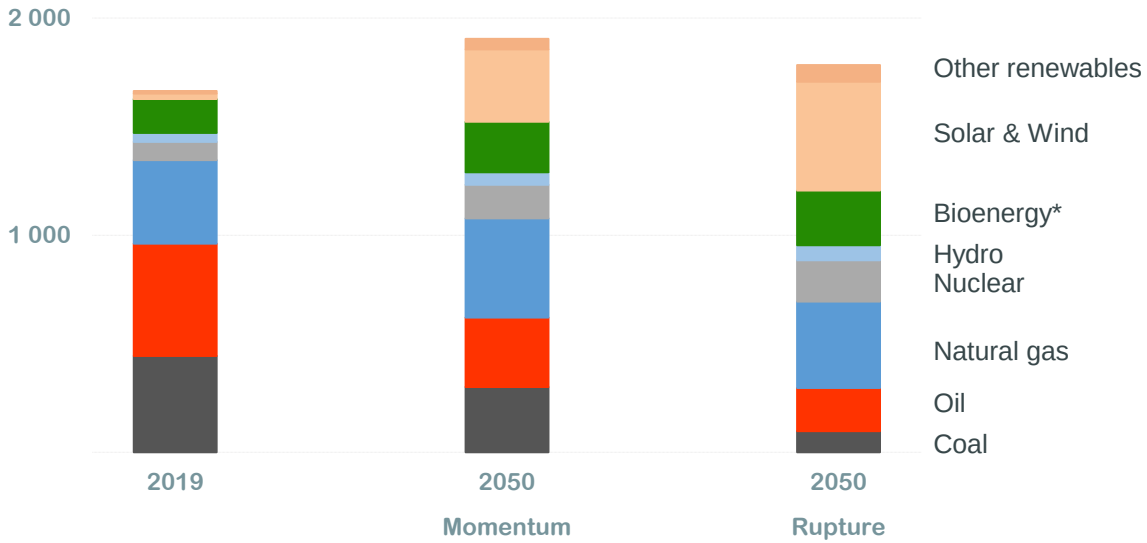


Rupture

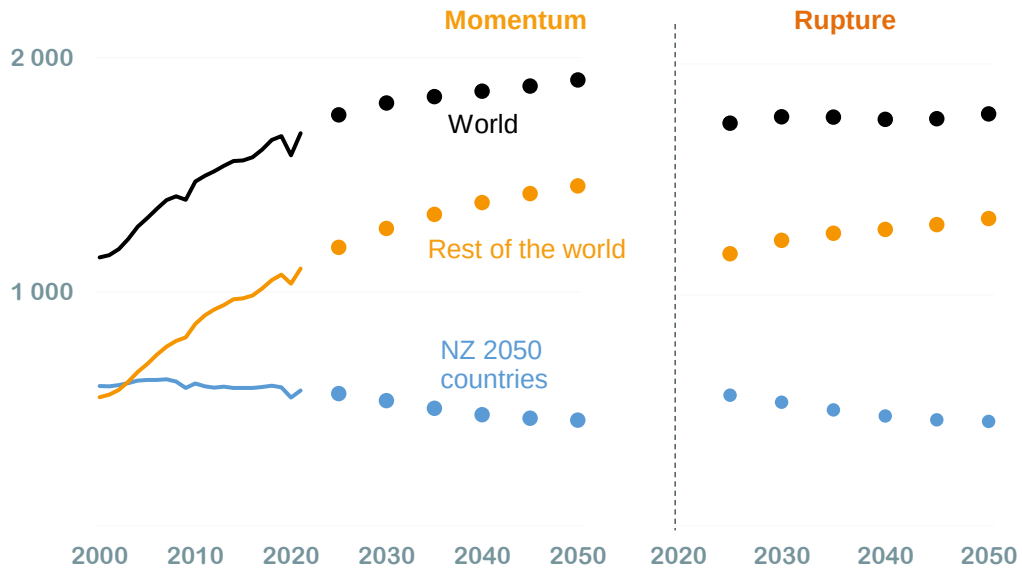
# World Primary Energy Demand

## Greening the energy system will enable sustainable growth for all

**Total primary energy demand**
PJ/d




**Total primary energy demand**
PJ/d




- Rupture displaying a modest energy demand growth to 2050: 0.2%/y
- Coal use divided by 5 in 30 years, oil use by almost 3, while natural gas use, largely abated by CCS, remaining stable (key in power, industry and for blue $H_2$)
- Solar & Wind demand multiplied by 20, growing to more than 25% of the primary mix by 2050

- Primary energy demand up in both scenarios ensuring access to energy in non-NZ 2050 countries with increasing living standards

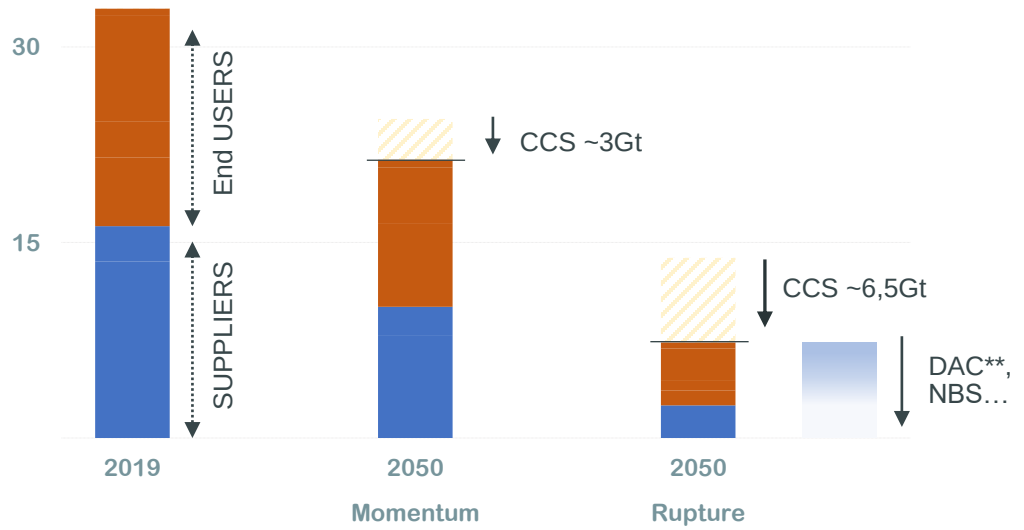
* *Includes traditional use of biomass, waste, biofuels, biogas…*

Rupture

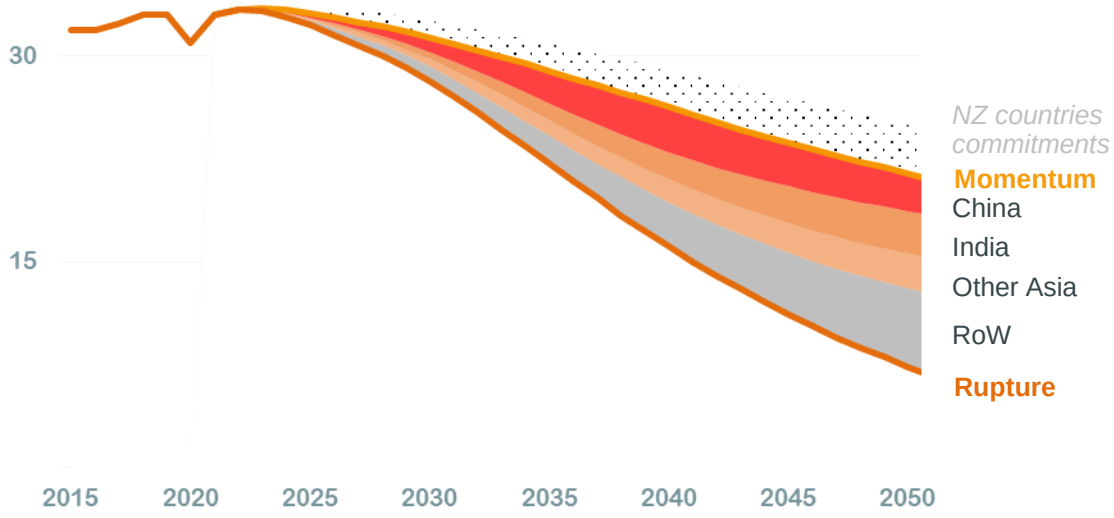
# World energy-related $CO_2$ emissions

## Strong abatements to expect from non-OECD; CCS & NBS* needed for Net-Zero

**Energy-related $CO_2$ emissions**
Gt




**Energy-related $CO_2$ emissions abatements**
Gt




- All sectors hugely decreasing $CO_2$ emissions in Rupture 2050 (Power -90%, Industry -80%, Res&Com and Transport -70% vs. 2019)
- 6,5 Gt of CCS mainly in power generation (50%) and industry (25%)
- Scaling up yet-to-be-industrialized technologies such as DAC*, as well as nature-based solutions, required to lower residual emissions (7 Gt in 2050)

- NZ2050 countries' pledges decreasing 2050 emissions by 3 Gt, requiring strong abatements from non-OECD countries
- Asia represents 70% of cumulative abatements needed to reach well-below 2°C Rupture scenario
- Technical and financial support from OECD countries necessary to reach Net-Zero globally

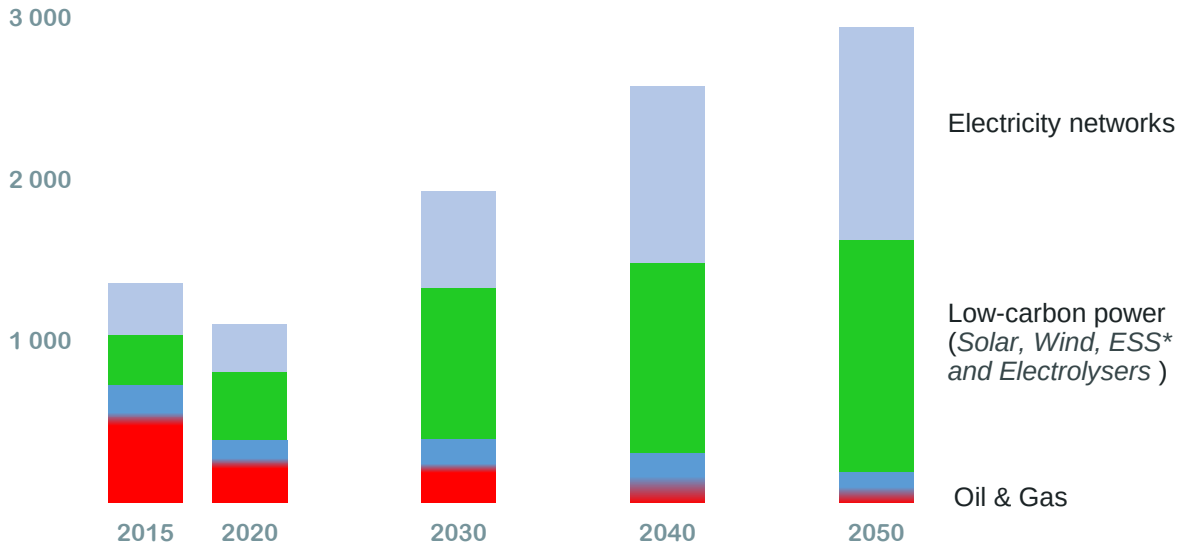
* *Nature-Based Solutions*
** *Direct Air Capture*

Rupture

# A decisive decade for the energy system

## Investment to double by 2030; supportive public policies required

**Investments in Oil & Gas and Low-carbon Power**
G$22 per year

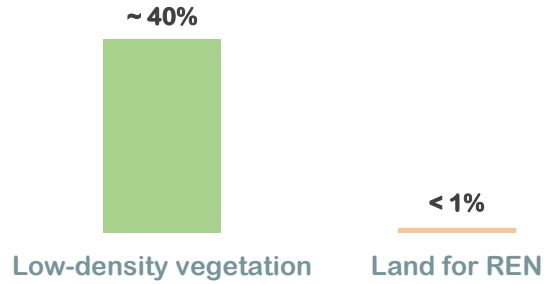



**Global land required in 2050 (solar + onshore wind)**
km²

**~ 500 000 – 900 000 km²**

→ Onshore wind (~ 5 500 GW): 300 000 – 600 000 km²
→ Solar PV (~15 000 GW): 200 000 – 300 000 km²

**Not an issue at a global scale**
2050; % of total land surface




- Investment in new Oil & Gas developments are required until at least the mid 2030s, complementing maintenance spending to satisfy customer demand
- With energy-storage systems requirement and electrolyser deployment, low-carbon power investment is estimated to double by 2030 and to triple by 2050
- Electricity networks investment to become as large as in low-carbon power

**Two distinct realities:**

- **Land-rich countries** (e.g. US, China): challenge may be very long-distances to the demand centers
- **Land-constrained countries** (e.g. Europe): strong public support or even mandates required

* *Energy-Storage Systems*



Rupture

# From well-below 2°C to 1.5°C

## Rupture+ sensitivity

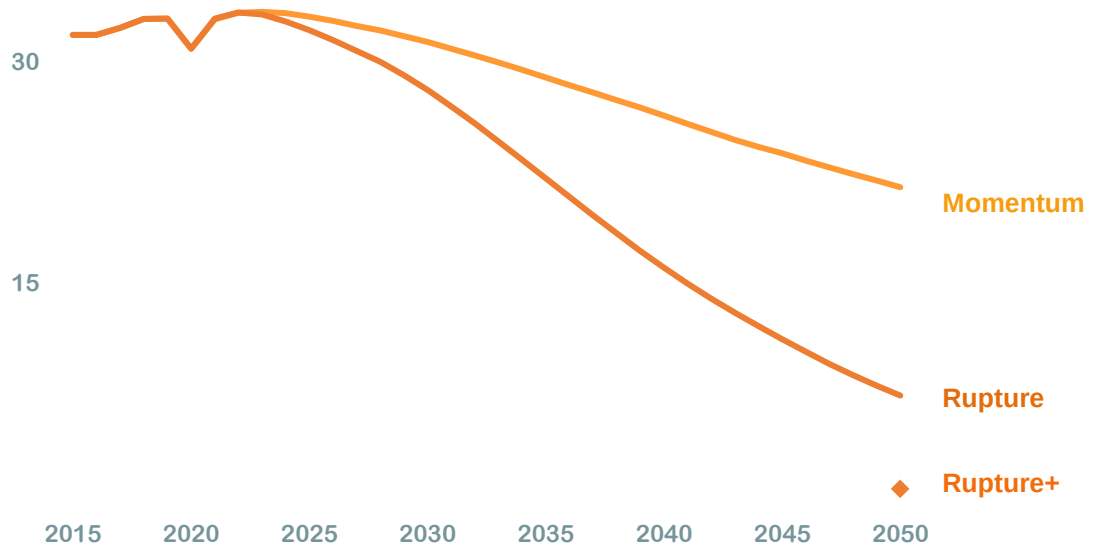
### Rupture+: how to reach 1.5°C

A combination of levers applied on the Rupture scenario from 2035 onwards:

- **Industry :** fossil energy consumption in 2050 halved, replaced by carbon-free electricity and bioenergy for petrochemicals
- **Transport :** 10% more LDVs switch to carbon-free electricity in 2040; 20% more in 2050 ; mainly in non-OECD Asia, CIS, Middle East and Africa
- **ResCom :** fossil energy consumption halved in 2050, replaced by carbon-free electricity
- **Power:** further increase in carbon-free electricity generation; coal completely eliminated from power generation in 2050
- **CCS:** 7,6 Gt $CO_2$ in 2050, consistent with IEA NZE

**Energy-related $CO_2$ emissions**

Gt




**Meeting 1.5°C* requires another step-changes in energy supply & demand, driven by regulation, technology and behavior**

* *At P50*

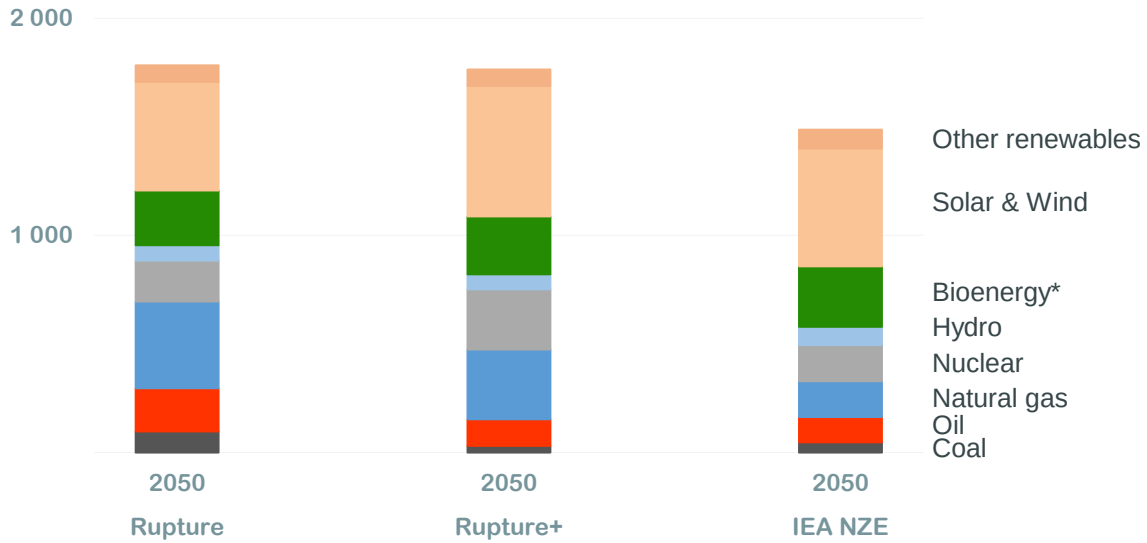


Rupture+

# From well-below 2°C to 1.5°C

## Impact of Rupture+ sensitivity

**Total primary energy demand**
PJ/d




**Oil demand**
Mb/d


- Energy demand is higher in 2050 than in 2019 in Rupture+, as in Rupture
- Oil demand decreases significantly to 23 Mb/d in 2050, close to IEA NZE (24 Mb/d), but with a very different trajectory
- Electricity and low-carbon $H_2$ increase share in transport, pushing up power generation for green $H_2$

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

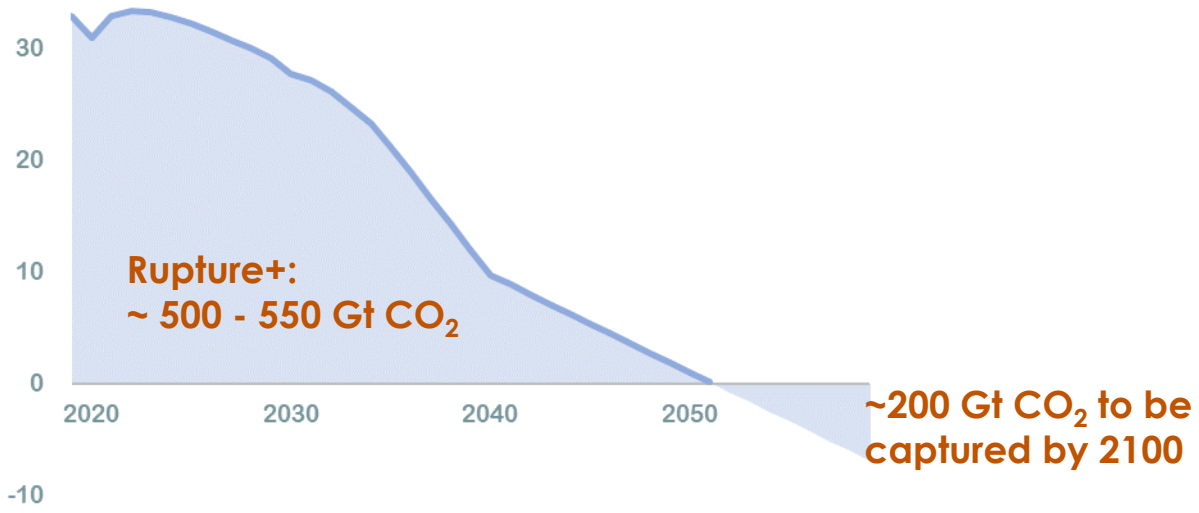


Rupture+

# From well-below 2°C to 1.5°C

## Limited overshoot requires technological innovation

**Energy-related $CO_2$ emissions**
Gt




In Rupture+:

- Energy-related $CO_2$ emissions reach net zero around 2050
- Overshoot to be captured from 2050 to 2100 roughly 200 $GtCO_2$ (+/- confidence interval)
- Overshoot consistent with C1 IPCC scenarios*

**Continued cleantech R&D required to reach Net-Zero targets**

* *C1 = limit warming to 1,5°C (>50%) with no or limited overshoot*



Rupture+

# Key findings of TotalEnergies Energy Outlook 2022

- The short-term trajectory of global energy demand is not going in the right direction. More efforts are needed to decarbonize while ensuring energy security and affordability
- The current crisis is an opportunity to increase and anchor energy efficiency measures, which are critical to achieve the Paris agreement objectives
- In the OECD, the electrification of end-user demand is a structural evolution that helps reduce emissions and increase energy efficiency. Significant investment in clean power and electrical grids is essential for the success of this electrification
- In non-OECD countries, in particular in Africa, switching away from traditional biomass to modern energy will improve energy efficiency while providing affordable energy access, better living standards and economic development to growing populations
- Natural gas plays a key role in the energy transition: it ensures firm power to complement renewables and replaces coal in all sectors of final demand. Gas will become greener over time and its growth will be accompanied by carbon capture and methane emissions control solutions
- $H_2$ and Sustainable Liquid Fuels are promising decarbonization drivers but will not scale up before 2030; in the meantime, renewable diesel and biogas will develop
- The current decade is decisive: investment in low carbon power must double to 2030 to reach 1.5 T$/year. Meanwhile, investment in new oil and gas developments is required until at least the mid 2030s to satisfy customer demand, even in a well-below 2°C scenario
- The energy transition also requires massive investment in clean tech R&D

# Appendix

# World primary energy demand and power generation

World primary energy demand (PJ/d)

| | | MOMENTUM | | | | RUPTURE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2030 | 2040 | 2050 | CAGR 19/50 | 2030 | 2040 | 2050 | CAGR 19/50 |
| Coal | 444 | 402 | 353 | 302 | -1,2% | 342 | 193 | 98 | -4,8% |
| Oil | 518 | 516 | 416 | 319 | -1,6% | 492 | 344 | 199 | -3,0% |
| Natural gas | 385 | 422 | 449 | 458 | 0,6% | 423 | 426 | 399 | 0,1% |
| Nuclear | 83 | 102 | 118 | 155 | 2,0% | 105 | 133 | 189 | 2,7% |
| Hydro | 42 | 50 | 54 | 58 | 1,0% | 55 | 63 | 70 | 1,7% |
| Solar | 11 | 49 | 103 | 165 | 9,2% | 67 | 162 | 265 | 10,9% |
| Wind | 14 | 54 | 108 | 168 | 8,3% | 67 | 156 | 235 | 9,5% |
| Bioenergy* | 156 | 186 | 218 | 232 | 1,3% | 186 | 225 | 252 | 1,6% |
| Other renewables | 13 | 25 | 37 | 48 | 4,4% | 36 | 59 | 76 | 6,0% |
| **Total** | **1665** | **1806** | **1857** | **1904** | **0,4%** | **1772** | **1760** | **1784** | **0,2%** |

World power generation ('000TWh)

| | | MOMENTUM | | | | RUPTURE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2030 | 2040 | 2050 | CAGR 19/50 | 2030 | 2040 | 2050 | CAGR 19/50 |
| Coal | 10 | 9 | 7 | 5 | -1,9% | 8 | 3 | 1 | -6,8% |
| Oil | 1 | 0 | 0 | 0 | -3,5% | 0 | 0 | 0 | -5,5% |
| Natural gas | 6 | 7 | 7 | 8 | 0,5% | 7 | 7 | 6 | -0,3% |
| Nuclear | 3 | 3 | 4 | 5 | 2,0% | 4 | 4 | 6 | 2,7% |
| Hydro | 4 | 5 | 5 | 6 | 1,0% | 6 | 6 | 7 | 1,7% |
| Solar | 1 | 4 | 9 | 15 | 10,4% | 6 | 14 | 23 | 12,0% |
| Wind | 1 | 5 | 11 | 17 | 8,3% | 7 | 16 | 24 | 9,5% |
| Bioenergy* | 1 | 1 | 1 | 2 | 2,9% | 1 | 2 | 2 | 4,1% |
| Other renewables | 0 | 0 | 1 | 1 | 7,7% | 0 | 1 | 2 | 9,2% |
| **Total** | **27** | **35** | **46** | **59** | **2,6%** | **37** | **53** | **71** | **3,2%** |

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

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