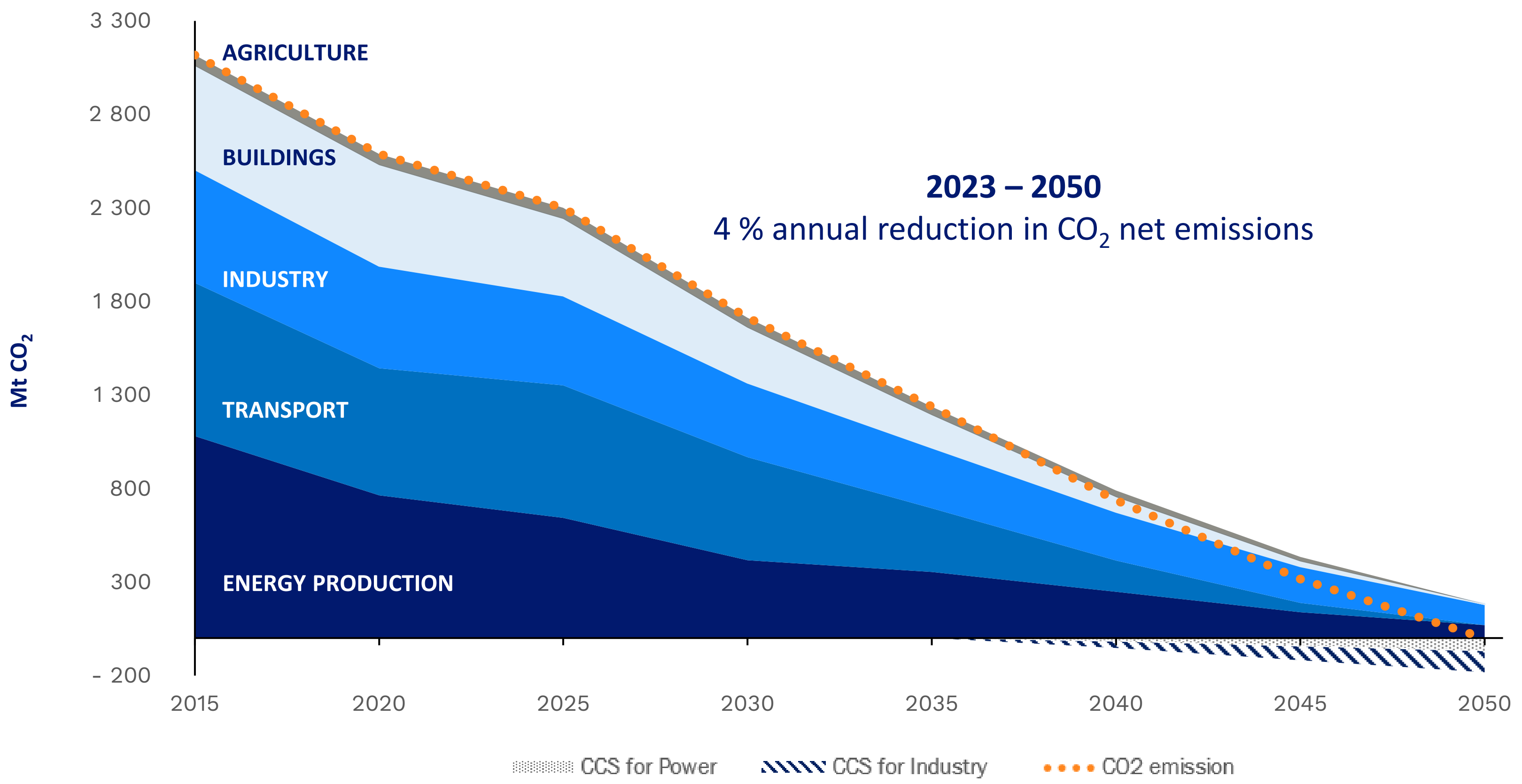
EDF NET ZERO SCENARIO

POWERING CARBON NEUTRALITY IN EUROPE BY 2050

A PATHWAY TO REACH CARBON NEUTRALITY IN 2050

Total CO_2 net emissions

1990 : 3 900 Mt CO_2



REDUCTION IN FINAL DEMAND

-40% final energy demand vs. 2021

DIRECT ELECTRIFICATION

+60% power demand vs. 2021
57% electricity share in 2050

DECARBONIZED PRODUCTION

Wind and solar production **x6** vs 2021
120 - 150 GW nuclear capacity

FLEXIBILITY NEEDS

x2 - 3 at all time scales

EDF NET ZERO SCENARIO:
OPTIMIZING THE PATH TO EUROPEAN NET ZERO 2050

CLIMATE NEUTRALITY BY 2050

A DECARBONIZATION STRATEGY BASED ON 2 PILLARS

Reduce final energy demand

Decarbonize total energy supply

Multi-energy modelling for 15 western European countries

Efficient multi-energy mix, taking into account:

- **Feasibility constraints** (physical, technological, societal)
- **Breakthrough technologies** (CCS, e-fuels) based on our **assessment** of innovation prospects

Efficient electricity mix :

- Based on an **hourly supply-demand balance analysis**
- Taking into account **security of supply** requirements

Optimization based on welfare maximization, cost minimization and system resilience

Our scenario provides an economically efficient pathway towards climate neutrality in 2050, taking into account the feasibility constraints in the various dimensions of the European energy sector's transition.

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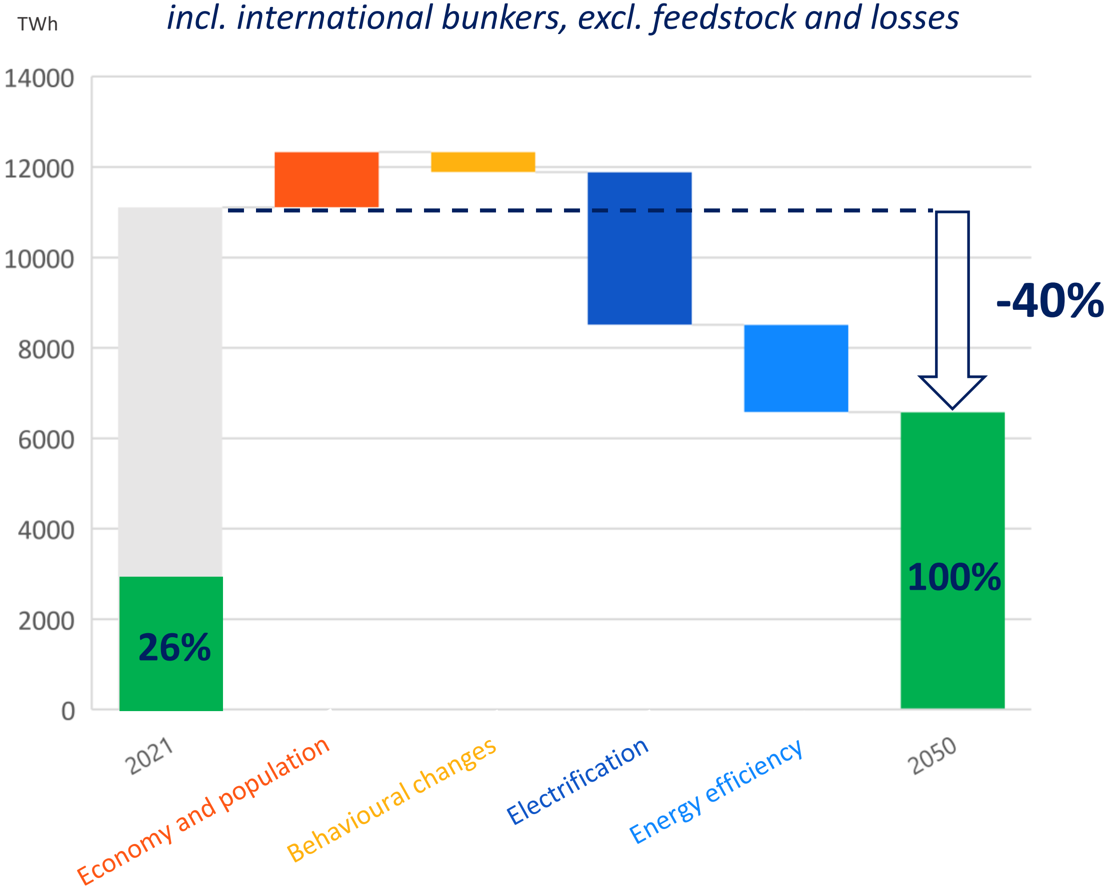
ENERGY DEMAND

4 components in final energy consumption (FEC) evolution

Component	Examples	Share in FEC decrease
General context	Macroeconomics Policies Population …	
Behavioural changes	Lower use of heating Sufficiency on appliances Carpooling …	10%
Electrification	Heat pumps Electric vehicles Electric furnaces …	60%
Energy efficiency	Renovations Efficient technologies New equipments …	30%

Final energy consumption (TWh)
incl. international bunkers, excl. feedstock and losses



In green : share of decarbonized energy

Electrification is the key driver to reduce greenhouse gas emissions and final energy consumption.

ELECTRIFICATION PRIORITIES

Electrification reduces energy consumption

- 70% consumption

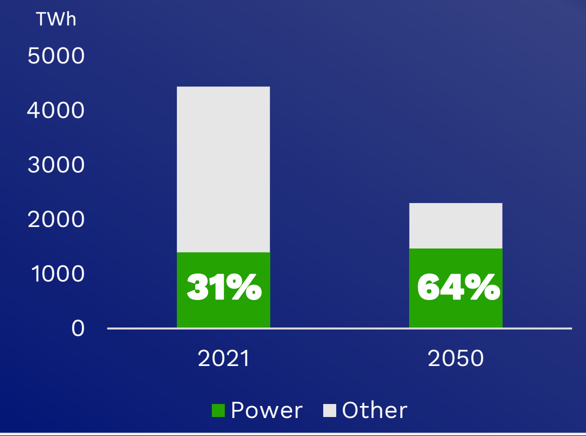
- 67% consumption

Electrification reduces CO_2 emissions (scope 1&2)

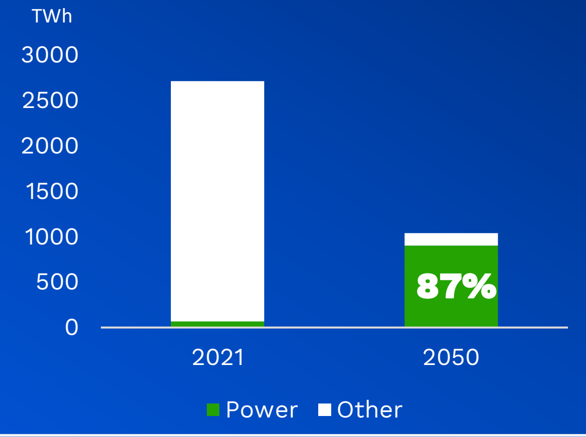
Up to -90% CO_2 emissions
depending on electricity mix

-35% to -95% CO_2 emissions
depending on electricity mix

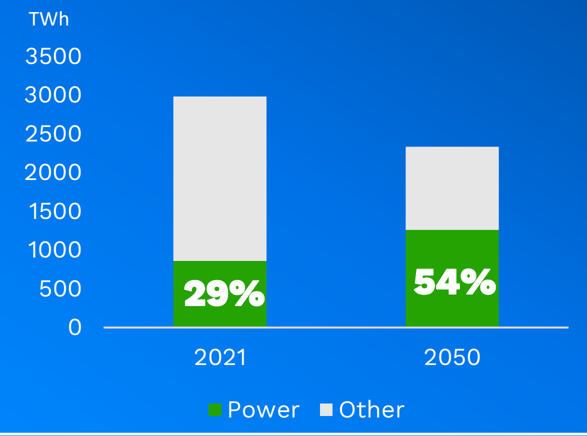
BUILDINGS* (TWh)



TRANSPORT* (TWh)



INDUSTRY* (TWh)



x10
Number of residential heat pumps

x23
Number of electric vehicles

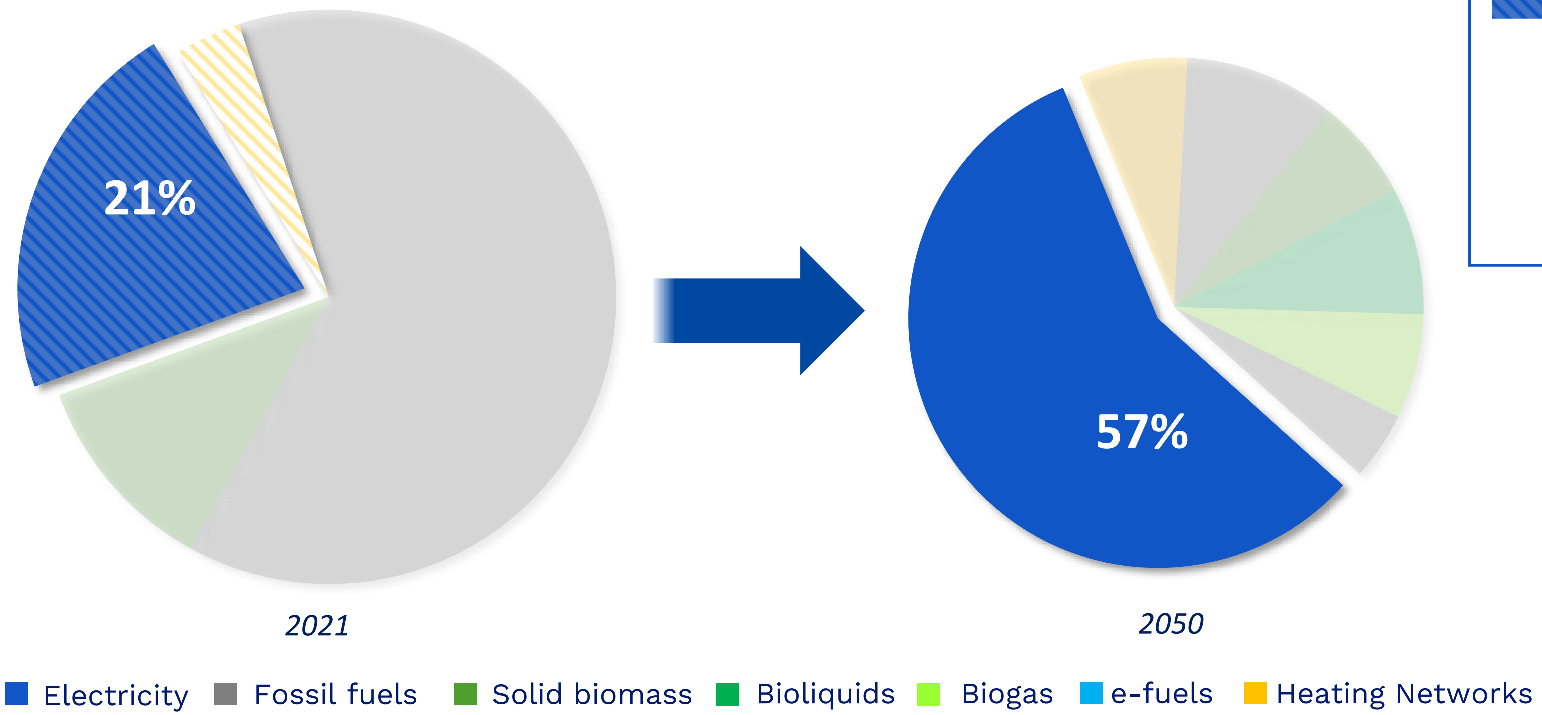
x1.5
In direct electricity consumption in the industrial sector

The key priorities are the massification of electrification in transport, buildings, as well as the acceleration in industry because of the risk of staying locked with fossil fuels.

**Final energy consumption excl. international bunkers for transport*

Final energy consumption

incl. international bunkers, excl. feedstock and losses



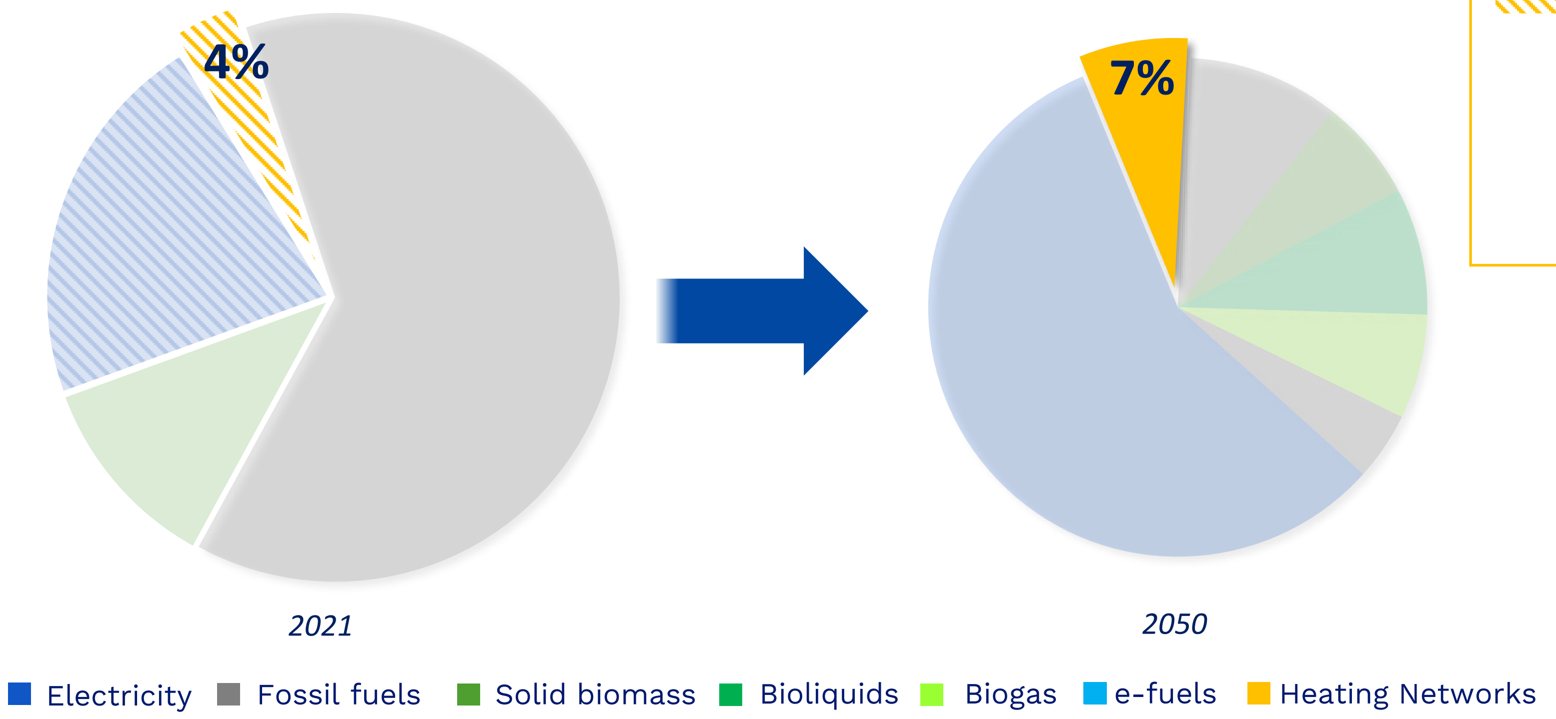
ELECTRONS

60% decarbonized	100% decarbonized
2 370 TWh	**3 750 TWh**
2021	*2050*

ENERGY SUPPLY

Final energy consumption

incl. international bunkers, excl. feedstock and losses



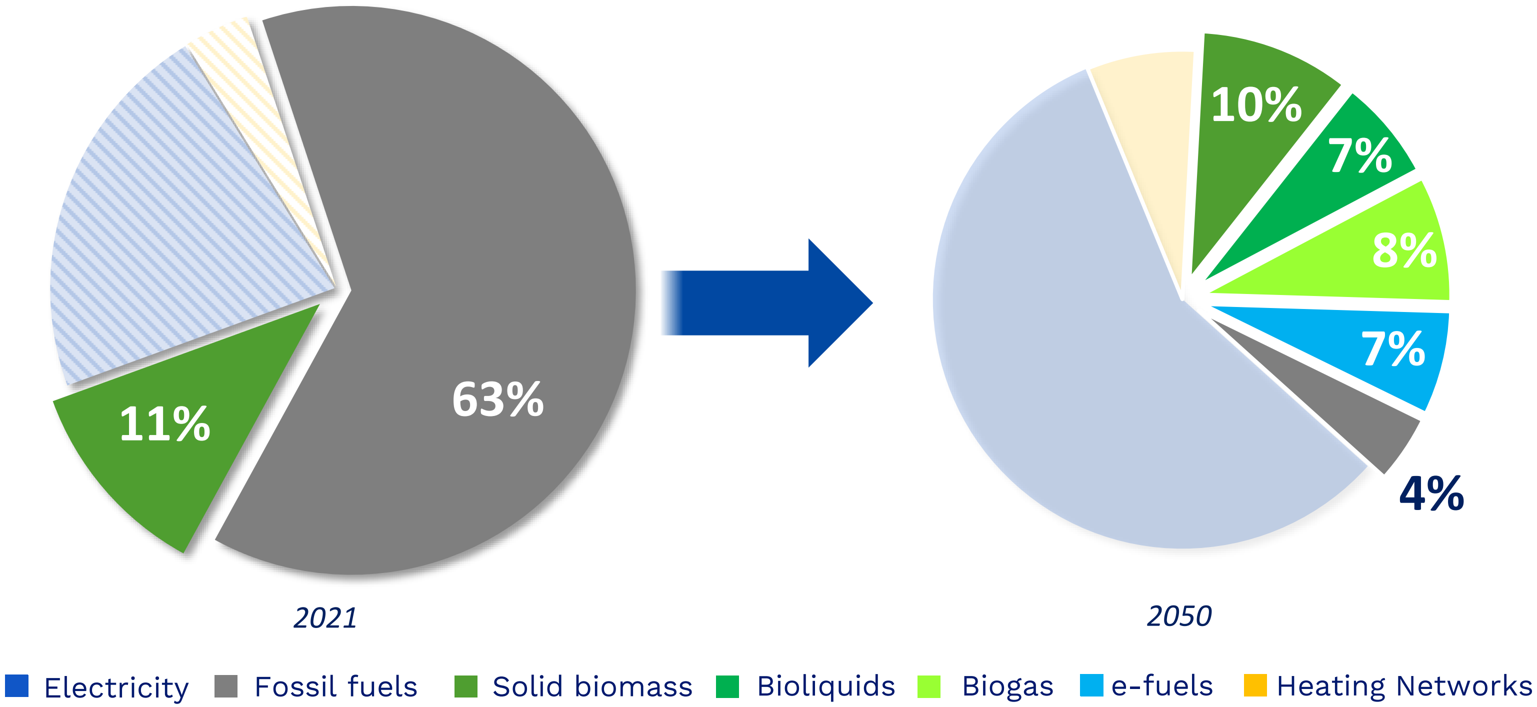
HEATING NETWORKS

36% decarbonized	100% decarbonized
400 TWh	**460 TWh**
2021	*2050*

ENERGY SUPPLY

Final energy consumption

incl. international bunkers, excl. feedstock and losses



MOLECULES

Biofuels

Limited Ressources

Relevant uses in home/industry heating & maritime/aviation

1 250 TWh *2021* | **1 650 TWh** *2050*

H_2 and e-fuels

High energy requirement

Low-carbon CO2 supply

Relevant uses in international transport and industry as feedstock

420 TWh* *2050*

** + 180 TWh for feedstock*

Fossil fuels + CCS

Risk of fossil lock-in

To be coupled with CCS

Relevant uses mainly in industry (process & combustion)

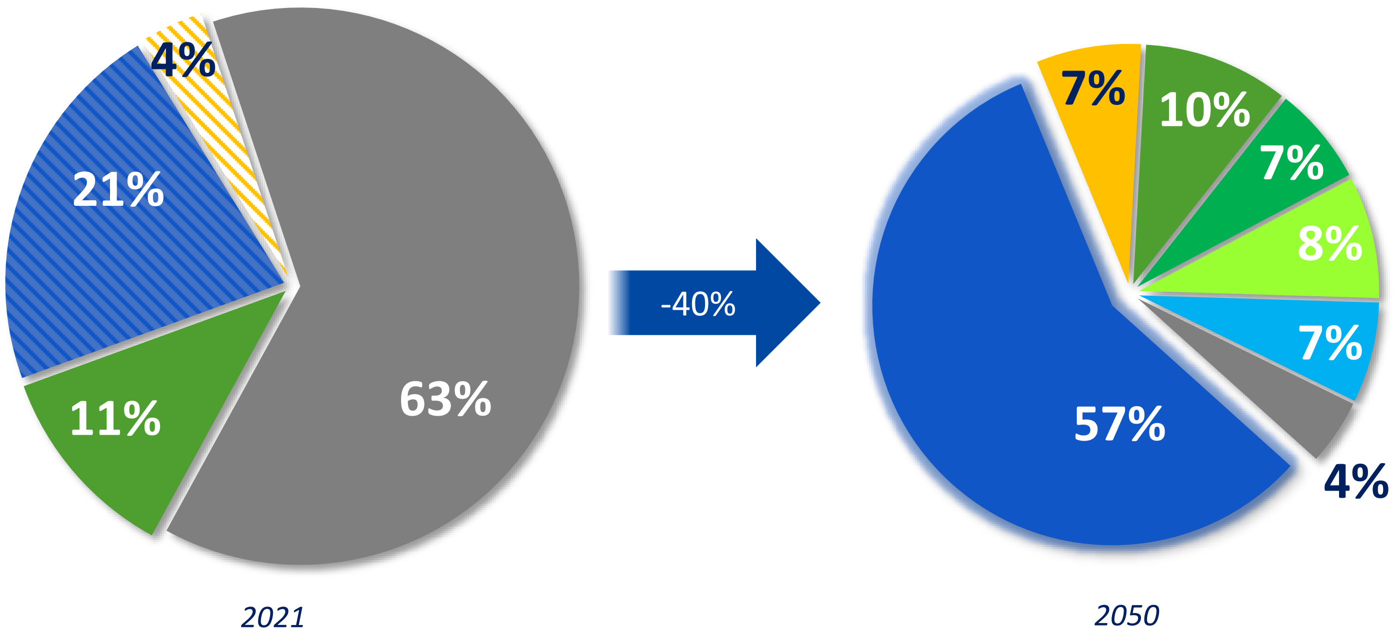
6 870 TWh *2021* | **290 TWh** *2050*

ENERGY SUPPLY

Final energy consumption

incl. international bunkers, excl. feedstock and losses

11 100 TWh | **6580 TWh**



Electricity | Fossil fuels | Solid biomass | Bioliquids | Biogas | e-fuels | Heating Networks

ELECTRONS

60% decarbonized → 100% decarbonized

HEATING NETWORKS

36% decarbonized → 100% decarbonized

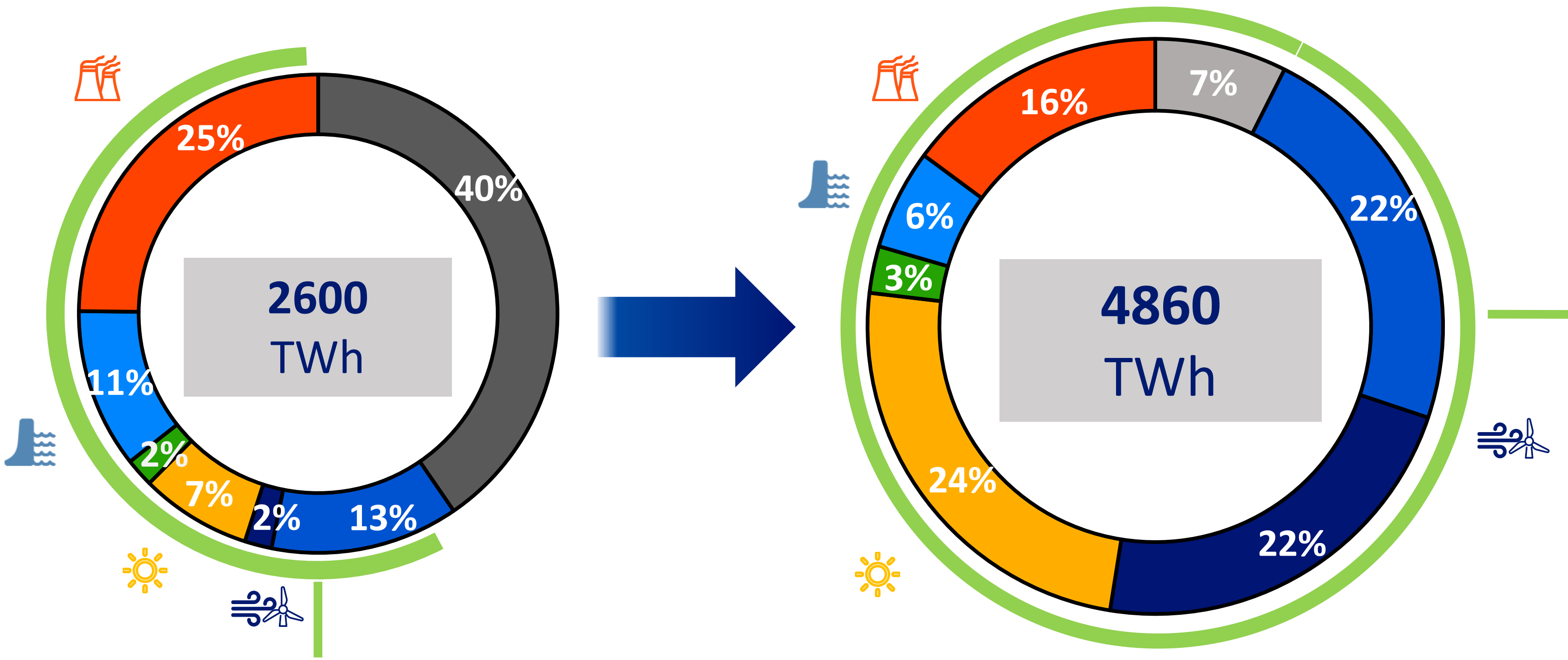
MOLECULES

Biofuels	H_2 and e-fuels	Fossil fuels + CCS
Limited Ressources Relevant uses in home/industry heating & maritime/aviation	High energy requirement Low-carbon CO_2 supply Relevant uses in international transport and industry	Risk of fossil lock-in To be coupled with CCS Relevant uses mainly in industry (process & combustion)

The share of electricity in the energy mix increases to 57% in 2050.
All energy vectors are 100% decarbonized.
Biofuels, hydrogen and derivatives will play an important role for hard-to-abate targeted uses (industry and international transport).

POWER MIX

EU Power mix 2021 | **EDF Net Zero Power mix 2050**



60% decarbonized power production

x1.8 power production to cover the important level of total demand

100% decarbonized power mix

77% of renewables production in the power mix

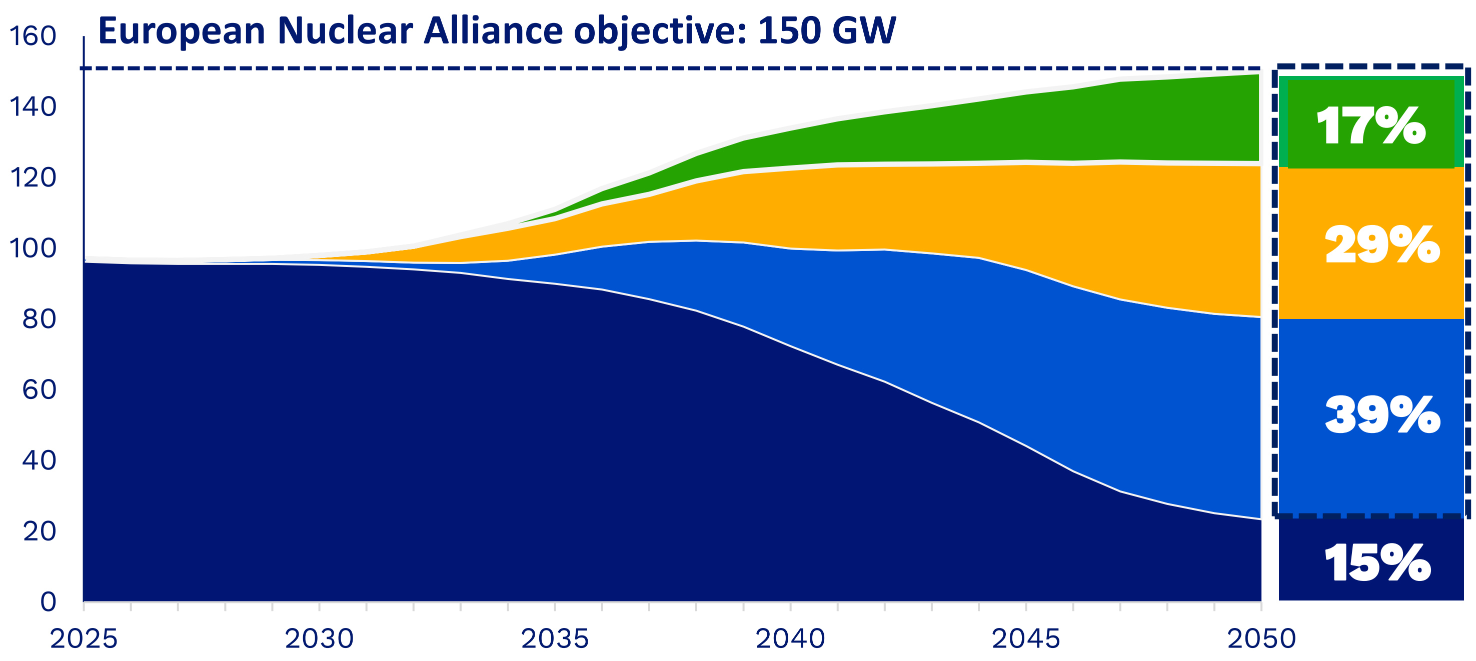
** All the figures are given for EDF Net Zero geographical perimeter*

Fossil | Onshore | Offshore | Solar | Bio & other renewables | Hydro | Nuclear | Decarbonized Thermal

By 2050, the European power mix is made up entirely of decarbonized generation, comprising renewables incl. hydropower, nuclear and decarbonized thermal assets.

NUCLEAR POWER

Nuclear Capacities (EU27)



By 2050, up to **85%** of nuclear capacity come from Long-Term Operations (LTO) or new build

RECOMMENDED ADDITIONAL LEVERS • Long-Term Operations / New Nuclear
EXPECTED ADDITIONAL LEVERS • Long-Term Operation of existing fleet over 60 years • New nuclear programs: large units or SMR
NEW NUCLEAR CAPACITIES already announced • Large Nuclear Units (> 1 GW) • Small Modular Reactors (< 500 MW)
EXISTING CAPACITIES up to 60 years old

Nuclear power makes a major contribution to EU decarbonization, as a decarbonized, energy-dense and dispatchable technology.
Nuclear New Build and LTO will represent 85% of 2050's nuclear capacity and should be an industrial priority.

POWER FLEXIBILITY NEEDS

Intra-day power flexibility needs breakdown

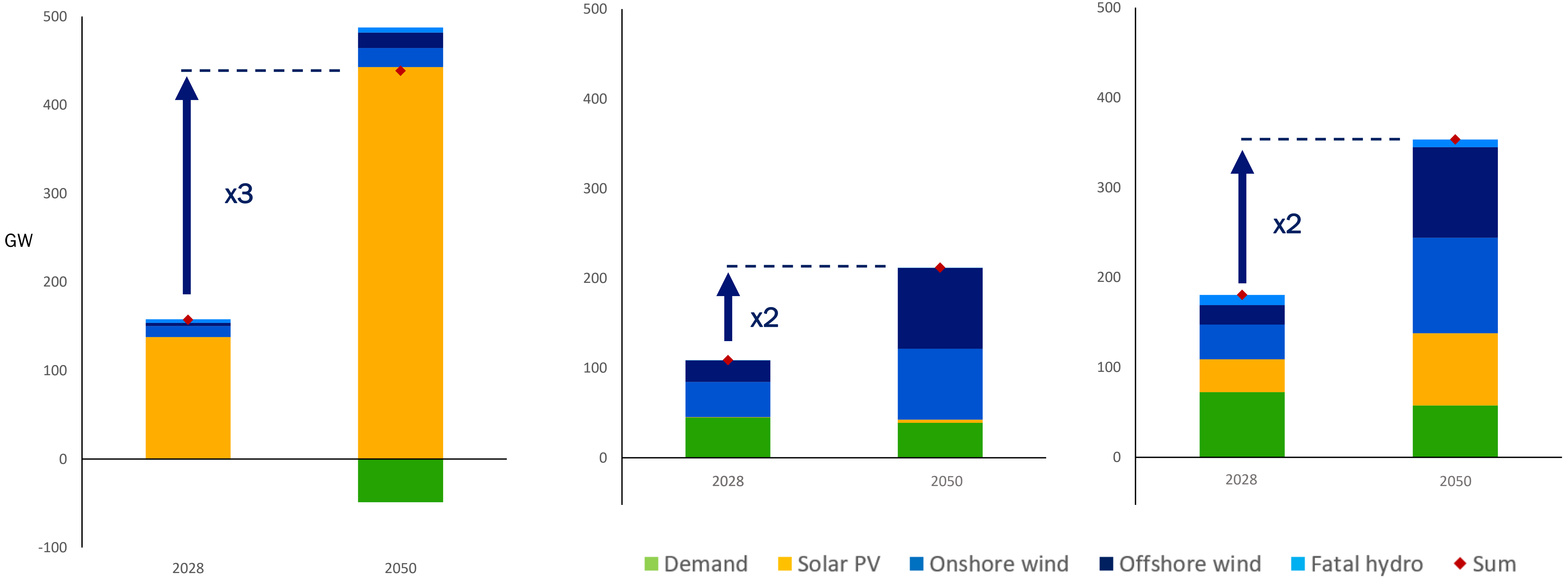
The daily variability of solar production is the main driver of flexibility needs.

Weekly power flexibility needs breakdown

The weekly variability of wind production is the main driver of flexibility needs.

Seasonal power flexibility breakdown

The seasonal variability of renewables production and demand generates flexibility needs.

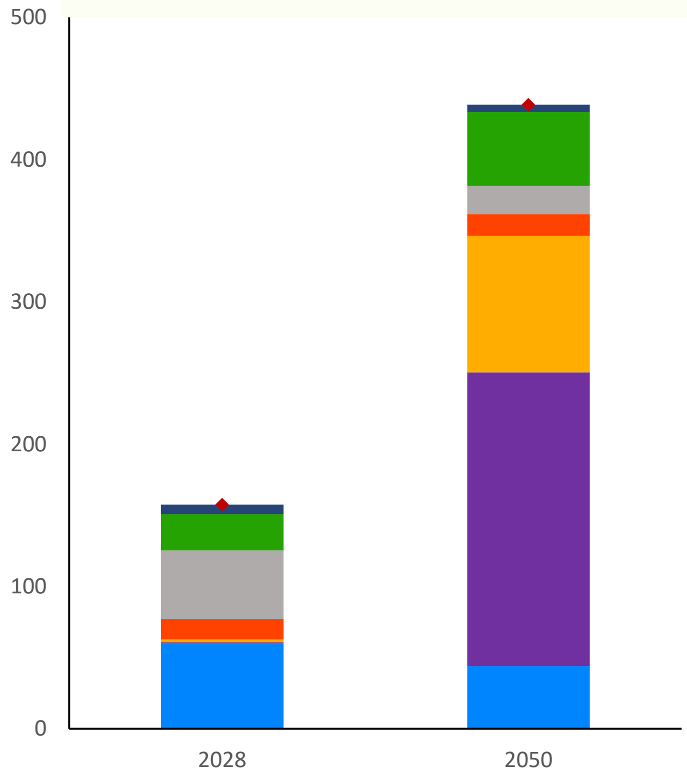


Flexibility needs of the power system increase over all time horizons due to the development of variable renewable energy sources.

POWER FLEXIBILITY SOURCES

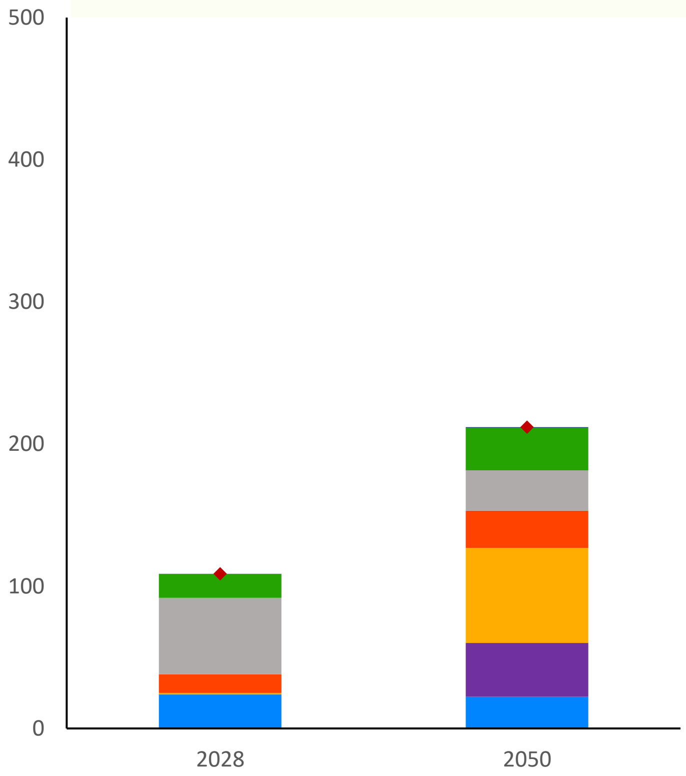
Intra-day power flexibility needs breakdown

Intraday flexibility needs will be mostly covered by demand-side management (e.g. EV smart charging) and daily storage assets (batteries)



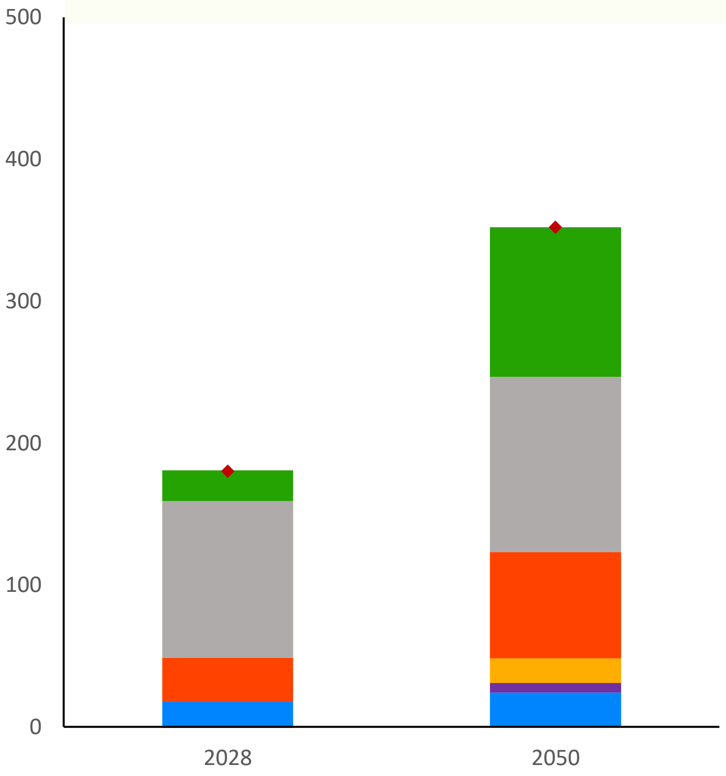
Weekly power flexibility needs breakdown

Weekly flexibility needs will be mostly covered by demand-side management, storage assets and decarbonized thermal fleet.



Seasonal power flexibility breakdown

For the seasonal horizon, flexibility needs will be mostly covered by nuclear and decarbonized thermal fleet.



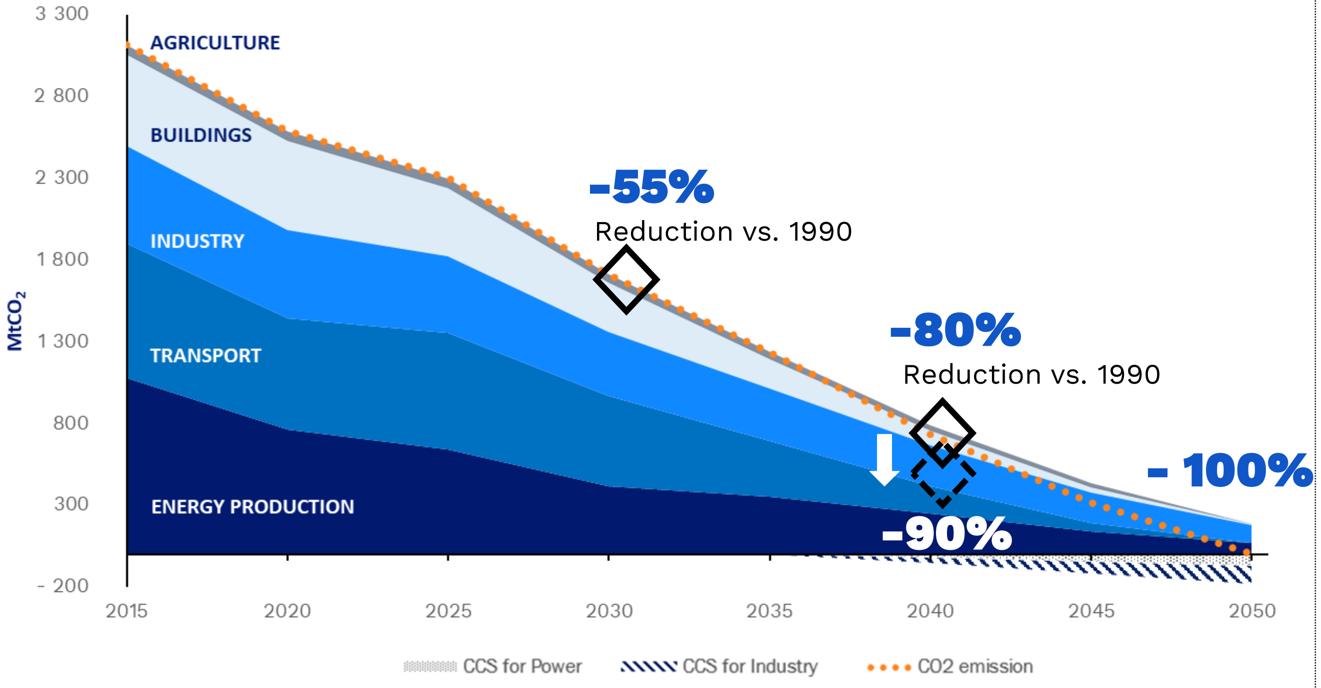
Hydro | Batteries (inc V2G) | Demand response | Nuclear | Thermal | Variable RES | Others | Sum

The needs will be mostly covered by :
- demand shifting/storage assets on shorter time scales ;
- nuclear, decarbonized thermal assets and interconnections on longer time scales.

A PATHWAY TO REACH CARBON NEUTRALITY IN 2050

Total CO_2 direct emissions on our 15 European countries scope

1990 : 3 900 Mt CO_2



Priority actions and levers to reach -80% CO_2 emissions in 2040 would need to be significantly strengthened and complemented to reach -90%

EU ambitious electrification strategy.

Robust CO_2 prices, giving long-term visibility to investors.

Technology-neutral legislation and fair access to EU funds for all zero- and low-carbon techs.

Reliance on Carbon Capture technologies on targeted uses.

Support to key EU industrial value chains to deliver the transition…

…While safekeeping the competitivity of European industry and remaining mindful of the impact of the transition on the standard of living and way of life of European citizens

Our optimized scenario reaches -80% emissions in 2040.
An objective of -90% emissions in 2040 requires significant additional efforts.

WHAT WOULD HAPPEN IF EUROPE REACHED 20% LESS ELECTRIFICATION IN 2050 COMPARED TO THE TARGET REFERENCE SCENARIO ?

CARBON NEUTRALITY NOT REACHED IN 2050 AND DELAYED BY 10 YEARS

A cumulative increase of

6000 Mt CO_2

between 2023 and 2050

INCREASE OF EU POWER SYSTEM COST

Increases the power system costs

+ 20% increase

Weighs on EU public finances

+ 100 Bn€ of subsidies to renewables

REDUCTION OF EUROPEAN ENERGY SOVEREIGNTY

+ 60 bcm of gas

Not delivering on the electrification of the economy would delay carbon neutrality by 10 years, dramatically increasing the cost of the transition and jeopardizing European energy sovereignty.

All figures are given compared to EDF Net Zero Scenario

ROAD TO CARBON NEUTRALITY

ENERGY EFFICIENCY

-40%

FINAL ENERGY DEMAND VS. 2021

DIRECT ELECTRIFICATION

+60%

POWER DEMAND VS. 2021

57%

ELECTRIFICATION IN 2050

DECARBONIZED PRODUCTION

x6

WIND AND SOLAR PRODUCTION VS 2021

120 - 150 GW

NUCLEAR CAPACITY

FLEXIBILITY NEEDS

x2 – 3

AT ALL TIME SCALES

ROAD TO CARBON NEUTRALITY

DEMAND	• **Reduce final energy demand**
	• **Massive and smart electrification** of all sectors
	    • Heat pumps installations
	    • Large scale deployment of electric vehicles

SUPPLY	• **Renewable electricity** massive development • **Nuclear power** lifetime extension and development of new capacities • **Power Flexibility** based on zero-carbon breakthrough technologies (storage & decarbonized thermal capacities) • **Bioenergies**, **CCS** and **e-fuels** for targeted uses
INFRASTRUCTURES	• Investing in **infrastructures** to enable the transformation of the European energy sector • Strong priority on **power grids and interconnections**

REGULATORY

- Robust and predictable **carbon pricing** mechanisms is the keystone to shift towards decarbonized solutions and minimize the cost of transition.
- **Technology neutral** regulatory framework

Achieving carbon neutrality by 2050 requires urgent accelerations in demand, supply and infrastructures of the energy sector, as well as a clear and robust regulatory framework.

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Thank you

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