Proposal for a Zero Carbon technology roadmap

THE ALTERNATIVE DECARBONISATION FOR EUROPE

The European House Ambrosetti

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The Strategic Study promotes the adoption of a principle of **technological neutrality** in Europe in the field of decarbonisation, in which the synergic and complementary **contribution of all available technologies** needs to be exploited in order to reach the Zero Carbon target

The Strategic Study presents with the utmost authority and according to *super-partes* criteria, a r**eference framework to manage decarbonisation** in Hard to Abate sectors providing a first of a kind technology framework and mapping

All net-zero emissions scenarios and the main long-term strategies of European Member States agree on the need to leverage a plurality of technologies to achieve the international target of limiting global warming to below 1.5°C compared to pre-industrial levels

Share of contribution of each mitigation measure in the Net Zero Emissions 2050 by International Energy Agency (IEA)
(% of total emission reduction), 2020-2050

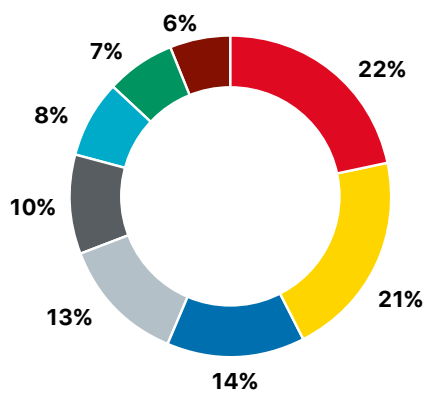
- Electrification
- Wind and solar

→ **43%**

- CCUS and CDR
- Hydrogen
- Bioenergy

→ **29%**

- Behavioral change
- Energy efficiency
- Other fuel shifts



Most of the Intergovernmental Panel on Climate Change's (IPCC) decarbonization scenarios predict an even greater contribution from CCUS, CDR and bioenergy

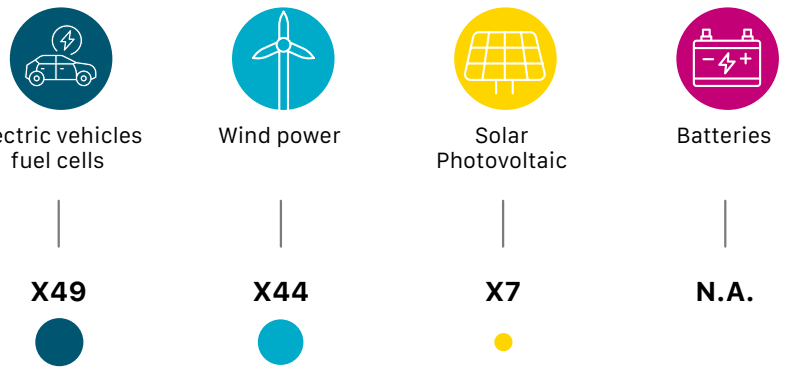
CCUS & CDR and **Bioenergies** needs in European **National Long Term Emission Reduction Strategy (2050)**

	CCUS & CDR	Bioenergies
	CCUS and CDR might absorb **50 Mton CO_2e/yr** (12% of 2019 emissions)	non-electric renewables' (including **bioenergies**) share in energy supply is 33%
	CCUS & CDR absorb **37 Mton CO_2e/yr** (11.8% of 2019 emissions)	**bioenergies**'s share in energy supply is 11%
	CCUS & CDR absorb **95 Mton CO_2e/yr** (22% of 2019 emissions)	**bioenergies**'s share in energy supply is 23%

*Technological dependence must be considered on a par with energy dependence. **Batteries**, **fuel cell**, **solar** and **wind** are highly dependent on rare earths and other imported raw materials, they refer to a **value chain** that is considered at **risk** from the European Commission.*

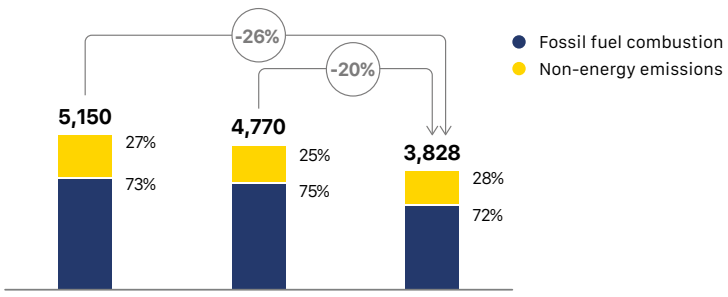
Access to materials and rare earths is proving to be the real area of risk for the European energy transition.

Four technologies are **dependent on high risk/risk supply chain materials**, and their import **demand is expected to increase** from 2015 to 2030 – European Commission



The most strategic and effective way to address decarbonisation is by working on both energy and non-energy emissions, with a focus on Hard to Abate industries, power generation and heavy transports

CO_2e emissions by fossil fuel combustion and other emitting processes in European Union 27
(% and Mton CO_2eq), 1990, 2005 and 2019



*Although the **majority of European emissions are generated from fuel combustion** (72%), there is still a **28% of non-energy emissions** to address to achieve full decarbonisation*

Hard to Abate industries, heavy transports and power generation are the hardest to decarbonise, posing a **technological development challenge** for Europe

Hard to Abate industries

Cement · Iron and Steel · Chemical

Rely on fossil energies for **81%**

51% of emissions generated from **industrial processes**

Heavy Duty transports

Heavy Duty Vehicles · Marine · Aviation

+90% of transports modes rely on fossil fuels

Electrification is **a long term** challenge in Heavy Duty

Electrification **is not an option for aviation**

Power generation

Power generation

A minimum share of fossil fuels (**3.4%** in EU in 2050) will be required to ensure energy system **adequacy** and **flexibility**

Achieving climate neutrality requires leveraging all possible technological levers, combining, on a case-by-case basis, renewable energies, decarbonised carriers and CO_2 capture technologies

1 **ENERGY EFFICIENCY**	Energy efficiency is the first levers that must be considered in order to **decrease energy demand** while fulfilling societal needs
2 **CARBON NEUTRAL ENERGY PRODUCTION**	Low-carbon energy productions that **do not emit** GHG or can capture, permanently store or **compensate** their GHG emissions
3 **PRODUCTION AND USAGE OF CARBON NEUTRAL ENERGY VECTORS**	Production and usage of carbon neutral energy vectors, namely those vectors that **do not emit** GHG apart from biogenic emissions, or can **capture** permanently CO_2 or **compensate** GHG emissions
4 **CO_2 EMISSION COMPENSATION**	**Compensation for unabated emissions**, by subtracting CO_2 from the atmosphere: it can be implemented synergically with the other options
5 **CO_2 INFRASTRUCTURE**	Technologies and infrastructures that enable to transport, use or store the CO_2 captured with: CCUS in **fossil fuel combustion** CCUS in **non-energy emissions or in hydrogen production** CDR for the **capture of atmospheric** CO_2 These technologies also provide the CO_2 necessary to produce **synthetic carbon neutral fuels**

The synergic combination of the five technology levers could enable the carbon neutrality of each emitting activity

The application of this principle to whole value chains allows to achieve full decarbonisation under a Life Cycle Assessment perspective

We have mapped a set of

100

technologies that need to be considered to achieve climate goals

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Alongside an increasing use of renewable electricity there are 3 key technology clusters that need to be exploited to reach the decarbonisation targets

CCUS & CDR

Carbon Capture Utilization & Storage (CCUS) and Carbon Dioxide Removal (CDR) are available, scalable, competitive and safe technologies to accelerate the decarbonisation path

- There are currently **135 CCUS projects** worldwide, **38** are located in **Europe** (28% of total): **43%** of global projects are in an **advanced development** phase, only **20%** are **operational**
- **11 European National Energy and Climate Plans** contain explicit mention of CCUS as a measure to achieve net zero emissions; Among these, the Dutch government has rated **CCUS as the most cost-effective technology** in its "Stimulation of sustainable energy production and climate transition" program

H_2

Hydrogen should be exploited as a Carbon Neutral energy carrier with great potential for decarbonising end-uses when not in competition for access to renewable electric energy

- Hydrogen can be produced from **electrolysis with renewable electricity** or **from natural gas steam reforming with CCUS**
- In Europe, 98% of hydrogen is currently fossil-based. To decarbonise it with renewable electricity, a **47% increase in electricity from RES** production would be required with respects to **2020** levels. In **2030**, Repower EU foresees the production of **20 Mt of H_2** (84% from electrolysis): this requires **34% of the total renewable electricity**, introducing a strong competition with electrification
- **1 kWh** of electricity from RES could either **substitute fossil sources** in electricity generation and save **350-700 g CO_2** or **replace hydrogen produced from fossil sources** with hydrogen from electrolysis and save **94 g** if hydrogen is produced from **natural gas steam reforming with CCUS** or **249 g without CCUS**
- Using renewable electricity for the production of green hydrogen instead for electricity production reduces the decarbonisation potential of RES by more than 3 times

Biofuels & synfuels

Biofuels, whose production is not in competition with food, and syntetic fuels can be a Carbon Neutral solution to replace traditional fuels while minimizing the necessary changes in consumption systems and supply chains

- In Europe, there are **34.9 million tons of waste per year available**, that are currently unexploited for biofuel production
- 34% of Marginal Lands in the EU is suitable for biofuel production (**60 million hectares**)
- **Africa** is the world's **first area for marginal lands (784 million hectars)** that can be exploited for "energy crops" not in competition with food, while bringing important **socio-economic benefits** to local communities, reducing income poverty and improving health, education and living standards
- A worker on a biofuel plantation on marginal areas that cannot be used for food production has a **disposable income 171% higher** than the income of the 'average' worker in the same area

POLICY PROPOSAL #1

- **Envisage the development of a regulatory framework for CCUS** according to a single European market logic, providing the creation of infrastructures with access for all Member States
- Foster the **inclusion of CCUS in the energy and climate planning** of all EU Member States
- Put in place a **policy mechanism that allows to account for negative emissions**, currently not possible under the EU Emissions Trading System (ETS)
- Introduce a **financing mechanism to de-risk industrial investments** in large-scale **CDR** demonstration facilities

POLICY PROPOSAL #2

- **Recognize as sustainable the hydrogen generated from fossil fuel with CCUS when demonstrated that there are no unabated or uncompensated emissions under a Life Cycle Assessment.** This will make it possible to sustain the conversion of current gray hydrogen plants and support the diffusion of hydrogen fuelled technologies in the short-term, facilitating the future uptake of hydrogen from electrolysis
- Promote the diffusion of a **European policy reference standard** to be applied in all Member States to provide **technical** and **regulatory** clarity for companies involved in hydrogen valley and other implementation projects

POLICY PROPOSAL #3

- Ensure that all the feedstocks' sources from **wastes, residues and crops, not in competition with food and feed chains, are considered sustainable** to produce **carbon neutral** biofuels when demonstrated that there are no emissions other than biogenics ones

The extensive application of Carbon Capture Utilization & Storage (CCUS), Carbon Dioxide Removal (CDR), hydrogen, biofuels and synthetic fuels technologies is indispensable to achieve full decarbonisation by 2050

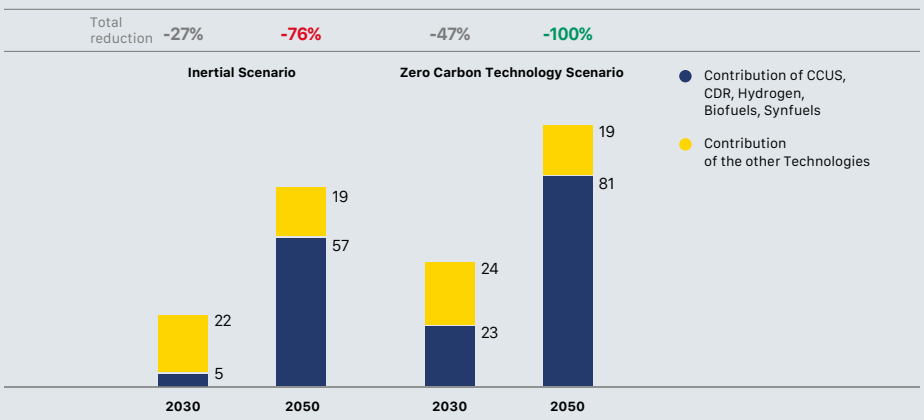
SECTORS ANALYSED

- Hard to Abate industry
- Heavy Duty transport
- Energy sector

DECARBONISATION SCENARIOS:

The difference between the scenarios is the application of the policy proposals developed

- Inertial
- Zero Carbon Technology Roadmap



The cumulative difference between the two Scenarios is **8.8 Gton CO_2** (**+31%** in the Zero Carbon Technology Scenario vs. Inertial Scenario). Considering 2020 emissions, this is equivalent to:

- **6 years** of total emissions of the considered sectors
- **2.5 years** of total emissions of the entire EU27

*Between 2023 and 2050, the **application of the recommended technologies in the analysed sectors** will generate more than **€ 2,700 billion of value added** in Europe, and about **1.7 million employees in 2050***

POLICY PROPOSAL #4

- To incentivize investments in decarbonisation infrastructures and technologies, resources should be allocated according to the **economic efficiency to abate CO_2**, evaluating the potential in comparison with other alternative technologies and according to a **technology neutrality principle**

POLICY PROPOSAL #5

- Introduce a **Carbon Contracts for Difference** model that encourages the investments in Zero Carbon technologies by reducing the risks in the investment phase, in a similar way as done to incentivize the diffusion of electric renewable energies

POLICY PROPOSAL #6

- **Moving beyond the "tank-to-well" emissions calculation** approach and promoting a "**well-to-wheel**" Life Cycle Assessment (LCA) approach in assessing overall fuel emissions
- Recognize, in the European taxonomy, the status of "carbon neutral fuels" to **biofuels** and **hydrogen** produced from fossil sources in **combination with CO_2 Capture technologies**
- Foster the **creation of infrastructure**, such as refilling stations, required for a massive deployment of alternative fuels on roads, ports and airports and **introduce fiscal policies to reduce the price gap with traditional fuels**

Discontinuity in the decarbonisation process will be generated by some breakthrough technologies, the development of which is accelerating thanks to new models of Open Innovation

Research should focus on **magnetic confinement fusion**

- It offers virtually **limitless, clean power;** it could complement renewables by providing electricity during peaks and throughs, it could provide **clean industrial heat**, and it can **generate hydrogen** to replace natural gas
- It produces **no harmful emissions or radioactive waste**, and the elements required are easily attainable and readily available
- As of 2021, **70% of fusion companies** (**36 companies and 33 affiliates**) expect fusion to be commercial in the **2030s**, motivated by some recently achieved milestones:
  - In February 2022, the JET project experiments produced **59 megajoules of energy in 5 seconds** (11 megawatts of power)
  - In the UK, Tokamak Energy achieved important milestones in early 2022: reached a plasma **temperature of 100 million degrees Celsius**, the threshold required for nuclear fusion
  - In September 2021, the MIT CFS generated a **magnetic field of 20 Tesla**, demonstrating that the new technology based on high-temperature superconducting magnets is suitable for the nuclear fusion process and enables small-scale power plants.

POLICY PROPOSAL #7

- Foster the **leadership in research and development of frontier technologies** that will potentially be disruptive in decarbonisation processes, such as nuclear fusion
- Ensure **policy support** (regulatory framework, incentives, ...) **to promote the creation of public-private partnerships** between academia, research centres, industries and public authority to accelerate the developments of such technologies

POLICY PROPOSAL #8

- Provide **clarity on the overall regulatory regime** for fusion energy facilities, considering all the differences with respect to nuclear fission technology
- Ensure regulators have the **technical capability** to regulate fusion energy facilities effectively
- **Maximise public confidence** in the regulatory framework for fusion, envisioning occasions for public debate and discussion
- Create a **platform mechanism through which innovation projects and financial investors** can be brought together