PROMOTING DECARBONISATION OF THE ENERGY SECTOR FOR A CLIMATE NEUTRAL ECONOMY

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Abstract:

The article starts from the premise that, in the current context, the European Union has assumed the objective of achieving climate neutrality by 2050. Climate change and ambitious global and European CO_2 emission reduction targets require a transition from fossil fuels to renewable sources. In a global context marked by increasing greenhouse gas emissions, the study analyzes various strategies to reduce carbon emissions, including the expansion of renewable energy, energy efficiency and technological innovations. The analysis also explores innovative solutions, such as developing renewable energy sources, improving energy efficiency, and using advanced technologies for carbon storage and use. By adopting a coherent and coordinated approach, we can ensure not only a sustainable energy economy, but also a safer and greener future for future generations.

Keywords: *climate-neutral economy, decarbonisation, renewable energy, energy efficiency.*

JEL classification: *Q56*

Introduction

energy efficiency. In addition, the integration of emerging technologies, such as carbon capture and storage, will play a crucial role in reducing the carbon footprint of the energy sector, while ensuring security of supply and affordability of energy for all consumers. Promoting decarbonisation is therefore not only an environmental necessity but also an economic opportunity.

Achieving decarbonisation through EU objectives for a climate - neutral economy

The European Union (EU) is at the forefront of global efforts to combat climate change. By adopting the *European Green Deal* and an ambitious set of targets, the EU has committed to transitioning to a climate-neutral economy by 2050. This requires a profound transformation of all economic sectors, including energy, transport, industry, agriculture and buildings, through the implementation of sustainable and innovative measures.

To achieve climate neutrality, the European Union aims to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. It will also accelerate the uptake of green technologies such as renewable energy, green hydrogen, carbon capture and the digitalisation of economic processes. These initiatives are supported by financial and social

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strategies designed to ensure a fair and sustainable transition for all regions and social groups. (Table 1)

Table 1:

European Union objectives for a climate - neutral economy

No.	Objective	Details
1	Climate neutrality by 2050	Reducing net greenhouse gas (GHG) emissions to zero by 2050 (as set out in the *European Climate Law*).
2	Reducing GHG emissions by at least 55% by 2030	Compared to 1990 levels, it is an intermediate objective to facilitate the achievement of climate neutrality.
3	Promoting renewable energy sources	Increasing the share of renewable energy to at least 42.5% of total energy consumption by 2030.
4	Increasing energy efficiency	Reducing energy consumption by at least 11.7% by 2030. Includes initiatives to renovate buildings and make industry more efficient.
5	Developing the circular economy	Reducing waste, increasing recycling and reducing dependence on finite resources. Implementing the circular economy action plan.
6	Sustainable transport	Reducing transport emissions by 90% by 2050. Promoting electric vehicles, public transport and sustainable mobility.
7	Biodiversity protection	Restoring degraded ecosystems, expanding protected areas to 30% of EU territory and reducing the use of pesticides.
8	Financial support for the green transition	Mobilizing 1 trillion Euros through the *Just Transition Mechanism* and creating the *Social Climate Fund*.
9	Development of green technologies	Investments in research and innovation for carbon capture, green hydrogen production and digital solutions.
10	The EU's global role	Strengthening the EU's position as a global leader in the fight against climate change. Supporting other countries in the green transition through financing and international cooperation.

Source: data processing authors

To accelerate the decarbonisation process, the European Union supports the adoption of advanced technologies and clean energy sources, such as solar, wind, hydroelectric and green hydrogen. Key technologies include carbon capture, utilisation and storage, the development of batteries for energy storage and the implementation of smart grids. There is also a particular focus on reducing energy consumption by improving energy efficiency in buildings and industry, as well as on promoting the circular economy, which helps to reduce dependence on finite resources.

Table 2:

Key technologies for decarbonising the economy

No.	Technology	Details
1	Renewable energy	Solar, wind, hydroelectric and biomass energy. Includes the use of photovoltaic panels, wind turbines and the conversion of organic waste into energy.
2	Green hydrogen	Production by electrolysis with renewable energy. Used in industry, transportation and energy storage.

No.	Technology	Details
3	Carbon capture, use and storage	Technologies for capturing CO_2 from the air or industry, using it in products or storing it in geological storage for the long term.
4	Electrolysis and energy storage	Development of electrolyzes, advanced batteries (lithium-ion, sodium) and pumped storage systems.
5	Energy efficiency technologies	Advanced insulating materials, heat pumps, LED lighting and intelligent systems for optimizing consumption.
6	Electric mobility and alternative fuels	Electric vehicles, synthetic fuels and advanced bio fuels for road, sea and air transport.
7	Digitalization and artificial intelligence (AI)	Smart power grids, AI for process optimization and climate modelling.
8	Regenerative agriculture and nature-based solutions	Soil carbon storage practices, reforestation and wetland protection.
9	Advanced nuclear reactors	Safe and efficient Generation IV reactors and small modular reactors (SMRs) for power and hydrogen production.
10	Advanced materials and sustainable construction	Ecological cement recycled steel, use of laminated wood and other materials with a low carbon footprint.

Source: data processing authors

The European Union's green transition is not only focused on reducing emissions, but also on protecting biodiversity and natural resources. Initiatives such as restoring damaged ecosystems, reforestation and regenerative agriculture contribute to capturing carbon from the atmosphere and increasing resilience to climate change. The EU is also promoting the development of digital solutions and artificial intelligence-based technologies to improve resource management and reduce energy losses. To ensure a fair and inclusive transition, the EU is investing considerable resources through the *Just Transition Mechanism*, targeting the economic regions most affected by this green transition. In addition, the *Social Climate Fund* provides support to vulnerable households to help them cope with the costs of decarbonisation.

Through these comprehensive measures, the European Union reaffirms its position as a global leader in the fight against climate change and in promoting a sustainable economy. Its objectives are not limited to reducing carbon emissions alone, but contribute to creating a more resilient, innovative and competitive economy, capable of meeting future challenges. In this way, the EU serves as an example for other regions of the world to follow, demonstrating that the transition to climate neutrality can be both an ecological necessity and an economic and social opportunity.

In conclusion, the European Union's decarbonisation objectives are not just a response to the climate crisis, but also a long-term sustainable development strategy, capable of transforming the European economy into a global example of sustainability. These initiatives will have a considerable impact on the global economy, demonstrating that environmental protection and economic growth are not contradictory goals, but, on the contrary, can support each other to create a greener, healthier and more prosperous world.

Supporting the decarbonisation of the energy sector towards climate neutrality

Decarbonising the energy sector is crucial to achieving climate neutrality, as it is one of the largest sources of greenhouse gas (GHG) emissions. Renewable energy and energy efficiency are essential components of the green transition and together they form the foundation of emission reduction strategies in the energy sector. These two areas not only help to reduce carbon emissions, but also support the development of a more sustainable and resilient energy system.

A. Development of renewable energy sources

Renewable energy plays a central role in the decarbonisation of the energy sector, replacing traditional fossil energy sources, which are the main sources of CO_2 emissions. (Table 3)

Table 3

Renewable energy sources

Renewable energy source	Description	Advantages	Challenges
Solar energy	It uses solar radiation to produce electricity through photovoltaic panels or solar thermal power plants.	Decreasing production costs, inexhaustible sources, and high scalability.	Depending on weather conditions, it requires large space for installation.
Wind energy	It uses wind turbines to convert wind energy into electricity.	Abundant sources in areas with strong winds, low operating costs.	Intermittent (wind variability), visual and sound impact.
Hydropower	It uses flowing water to drive hydroelectric turbines, in large or micro-hydropower plants.	High efficiency, energy storage capacity (through dams), stable source.	Ecological impact on ecosystems, high construction costs.
Biomass	Organic matter (wood, agricultural waste) is burned or transformed into biofuels (bioethanol, biodiesel).	Abundant sources, waste can be used, contribute to waste reduction.	CO_2 emissions, competition with food production (in the case of energy crops).
Biogas	Methane gas obtained through anaerobic decomposition of organic waste (food, agricultural waste).	Reduces dependence on landfills, continuous source of energy, helps reduce methane emissions.	Requires processing facilities, emissions from processing facilities.
Geothermal energy	It uses the heat from inside the earth to produce electricity or for heating.	Constant energy sources, high efficiency in active geothermal regions.	Location dependent, large investments in infrastructure.
Marine energy (tides and waves)	It uses water movements (waves, tides) to generate electricity.	High potential in coastal areas, predictable energy sources.	High implementation costs, limited to specific maritime areas.
Green hydrogen	Hydrogen produced by electrolysis using renewable energy (solar, wind).	Zero carbon emissions, versatility in use, efficient energy storage.	High production costs, requires specialized infrastructure for storage and transportation.

Source: data processing authors

B. Improving energy efficiency

Energy efficiency is an essential element in the decarbonisation of the energy sector. By optimizing efficiency, energy needs are reduced, which leads to a decrease in greenhouse gas emissions and promotes a more responsible use of resources. Measures aimed at improving energy efficiency include:

Table 4

Solutions for optimizing energy consumption

Domain	Energy efficiency improvement measure	Description	Advantages	Challenges
Buildings	Thermal insulation	Improving building insulation to reduce heat loss and optimize energy consumption.	Reducing energy consumption for heating and cooling, long-term savings.	High initial costs require renovations and modernization of infrastructure.
Buildings	Efficient hardware (quality hardware, double-glazed windows)	Use of efficient materials (double/triple glazing, insulated doors) to prevent heat loss.	Reduced heating and cooling costs, increased comfort in buildings.	They require initial investment, but bring long-term savings.
Industry	Heat recovery technologies	Using technologies that recover waste heat from industrial processes and redirect it for later use.	Reducing energy consumption, significant savings in the industry.	It requires investment in recovery equipment and technologies.
Industry	Process automation and intelligent energy management	Implementation of control and monitoring systems to optimize energy use in industrial processes.	Reduction of energy losses, increased efficiency in production.	Implementation may require a complex process of integrating new technologies.
Transports	Electric vehicles	Replacing traditional vehicles with fossil fuel engines with electric vehicles that are much more energy efficient.	Reduction of CO_2 emissions and operating costs, higher energy efficiency.	Need for charging infrastructure, higher initial costs for vehicles.
Transports	Promoting public transport and alternative mobility (bicycles, electric scooters)	Reducing the number of individual vehicles by stimulating public transport and other forms of sustainable mobility.	Reducing energy consumption and carbon emissions, decongesting traffic.	The need for infrastructure investments and changing citizen behavior.
Energy	Smart grids	Technologies that enable efficient distribution of electricity, with dynamic monitoring and management of consumption and production.	Reducing energy losses, optimizing consumption, integrating renewable sources.	High implementation and maintenance costs, requires advanced infrastructure.
Energy	Energy storage	Using energy storage	It allows the use of	High storage costs,

Domain	Energy efficiency improvement measure	Description	Advantages	Challenges
	(batteries, green hydrogen)	technologies, such as batteries or green hydrogen, to manage fluctuations between supply and demand.	renewable energy in a more efficient way, reducing dependence on fossil fuels.	technical and economic challenges in implementation.
Agriculture	Efficient irrigation techniques	Using drip irrigation systems or smart technologies to reduce water and energy consumption in agriculture.	Reducing water and energy consumption, significant savings for farmers.	Higher initial costs for implementing irrigation technologies.
Buildings and industry	Efficient lighting systems (LED, smart lighting)	Replacing traditional light bulbs with LEDs and implementing a smart lighting system that adjusts light intensity according to needs.	Reduced electricity consumption, reduced operating costs.	Requires initial investment in equipment and infrastructure.

Source: data processing authors

Optimizing energy efficiency is a fundamental strategy in the transition to a sustainable economy. The measures listed in the table are just some of the solutions that can help reduce energy consumption and carbon emissions. However, implementing these measures requires initial investment and ongoing commitment from all economic sectors, and the long-term benefits can justify these costs.

C. Integrating renewable energy sources with energy efficiency

To ensure an effective transition to a low-carbon economy, it is essential to integrate renewable energy sources with energy efficiency measures. (Table 5)

Table 5:

Synergy between renewable energy sources and energy efficiency

Renewable energy sources	Technologies/Strategies for integration	Benefits of integration
Solar energy	Photovoltaic panels + energy storage systems	Reducing dependence on the electrical grid, integrating with energy management systems for maximum efficiency.
Wind energy	Wind turbines + smart grids	It allows for more efficient distribution of produced energy, reduction of losses and integration into existing electrical networks.
Hydropower	Micro hydropower plants + optimized hydropower efficiency	Efficient use of water for energy production, reduction of losses in energy transportation and distribution.
Biomass	Advanced bio fuel technologies + cogeneration plants	Increasing energy efficiency by using organic waste for simultaneous energy and heat production.

Renewable energy sources	Technologies/Strategies for integration	Benefits of integration
Biogas	Biogas plants + heat recovery systems	Recovering organic waste, reducing methane emissions and improving energy efficiency through the use of heat.
Geothermal energy	Geothermal heating systems + efficient geothermal power plants	Using thermal energy for heating or electricity production in an efficient and sustainable way.
Marine energy (tides, waves)	Tidal power plants + wave capture technologies + energy optimization	Using water movements to produce energy in an efficient way, reducing carbon emissions.
Green Hydrogen	Renewable energy powered electrolysers + energy storage	Storing renewable energy in the form of hydrogen, reducing energy losses and integrating it into various sectors.

Source: data processing authors

Integrating renewable energy sources with energy efficiency measures is a key step in the transition to a more sustainable energy system. These technologies not only contribute to reducing carbon emissions, but also to increasing energy efficiency by optimizing energy consumption and storage. Existing challenges, such as the variability of energy sources and the need for adequate infrastructure, can be overcome through technological innovations and investments in the development of efficient integration solutions.

Conclusions

Reducing carbon emissions in the energy sector is closely linked to the integration of renewable energy sources. These sources represent a sustainable alternative to fossil fuels, having a significant impact on reducing CO_2 emissions. In addition to promoting renewable energy sources, optimizing energy efficiency in the industrial, transport and building sectors is essential for reducing total energy consumption and emissions.

The adoption of advanced energy storage technologies will support the integration of intermittent renewable into the electricity grid and ensure efficient energy storage. These solutions are crucial to addressing the challenges posed by the variability and intermittency of renewable energy sources.

Developing renewable energy sources and increasing energy efficiency are crucial for decarbonising the energy sector and achieving climate neutrality. These two approaches are closely linked and require a strong commitment from governments, the private sector and citizens to facilitate the transition to a sustainable and emission-free energy system. By integrating renewable energy sources into the energy mix and maximizing the efficiency of this energy use, we can significantly reduce our environmental impact and ensure a greener future for future generations.

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