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OPEN LETTER

# $CO_2$ emissions: A challenge but also a big opportunity for Spain

[version 1; peer review: 2 approved with reservations]

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## Abstract

Spain is among the 11 virtuous European countries that achieved the 2020 European targets, including the reduction of energy consumption and greenhouse gas emissions, as well as the implementation of renewable energy. Yet, about 250 Mtons CO2 equivalent were still emitted in 2020 and is out of the question that the current efforts are not sufficient to reach net-zero emissions by 2050. This Policy Brief aims to describe the current situation, critically analyze the trends, and give recommendations to the policy makers based on the ten-year experience of our group on CO2 emissions research.

## Keywords

Carbon Capture and Utilization, CO2 emissions, Climate change

**Open Peer Review**

**Approval Status** ? ?

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## What is the current situation?

October 2022 was one of the hottest in history, raising another time the interest on global warming. The clock is ticking, and strong actions have to be taken now to reduce emissions and prevent a further increase of the average temperature to more than 1.5°C above pre-industrial level, with the related negative impacts on our life[1]. Spain reduced its carbon emissions by 30% in the period 2005–2019 (we excluded data from 2020 onwards, as biased by the pandemics), well above the European average[2]. This means a reduction from nearly 400 Mtons in 2005 to around 300 Mtons in 2019. This was mainly achieved by cutting emissions from the energy sector, linked to the flourishing of renewable energy (solar and wind power). However, the road towards net-zero by 2050 is still long. Reducing emissions will be increasingly difficult when approaching the objective, as sectors such as transportation and certain carbon-intensive industrial processes, are difficult to decarbonize.

## Where are these $CO_2$ emissions from?

Emissions in Spain are dominated by the burning of fossil fuels, particularly in the transport, energy supply and industry sectors (Figure 1). Industrial emissions mostly derive from the manufacturing/construction sector (cement and steel factories). Domestic transport emissions are mainly associated with cars, whereas international transport emissions derive from aviation and maritime (around 7% each).

## What are the next steps planned?

The Spanish government is aiming at reducing ETS (European Trading Scheme), and non-ETS emissions by 61% and 26%, respectively, by 2030 (in comparison to 2005).[3] The primary objectives are to achieve energy security and flexibility, pursue energy savings, and foster the energy transition by achieving a target of 42% share of renewable energy, mainly solar and wind power. By 2030, 74% of the electricity demand must be covered by renewable sources. A hydrogen roadmap[4] has also been approved, being renewable hydrogen a key player to achieve decarbonization. For the transport, policies will be directed towards increasing its efficiency, promote the use of public transport and low-impact vehicles, both electric or powered by advanced biofuels, by means of incentives and the introduction of low emissions zones in every city above 50,000 inhabitants. Building renovation and energy upgrade are planned to improve energy efficiency in both the public and private residential sectors. A great effort will be also directed towards research and innovation to accelerate the deployment of highly efficient and low-carbon technologies.

## What else can be done?

According to the National Energy and Climate Plan (NECP)[5] projections, the current measures will allow to cut emissions by nearly 50% in comparison to 2005. However, this is not sufficient to achieve a full decarbonization by 2050. Great efforts have been directed towards decarbonization of the electricity production, which will result in 83% lower $CO_2$ emissions from this sector. Further actions must be directed towards the decarbonization of the other most impactful sectors.

Despite the measures adopted, transport will be the most polluting sector by 2030, generating 57,7 Mton$CO_2$ eq according to the forecast. In particular, the foreseen 28% reduction in the use of oil and its derivatives appears not sufficient. Besides pursuing electrification on transport, the development of advanced biofuels, both in gas (methane, hydrogen) and liquid (biodiesel, ethanol, methanol, butanol) is crucial, in particular for those sectors that cannot be electrified, such as maritime transportation and aviation. The production of advanced biofuels must be pursued from waste materials, and in particular from agricultural waste abundant in Spain (e.g. from the olive, cereals and wine production sectors), to avoid competition with food production. The current plan sets an objective of 3.5%

[1] IPCC (2014). Climate Change 2014: Mitigation of Climate Change. In Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. https://doi.org/10.1017/CBO9781107415416

[2] European Environmental Agency, https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

[3] EPRS (2021). Climate action in Spain. Lead author: Henrique Morgado Simões with Gema Andreo Victoria. Climate Action Research and Tracking Service, Members' Research Service. PE 690.579 – April 2021

[4] Ministerio para la Transición Ecológica y el reto Demografico, https://www.miteco.gob.es/en/ministerio/planes-estrategias/hidrogeno/default.aspx

[5] https://energy.ec.europa.eu/system/files/2019-06/ec_courtesy_translation_es_necp_0.pdf

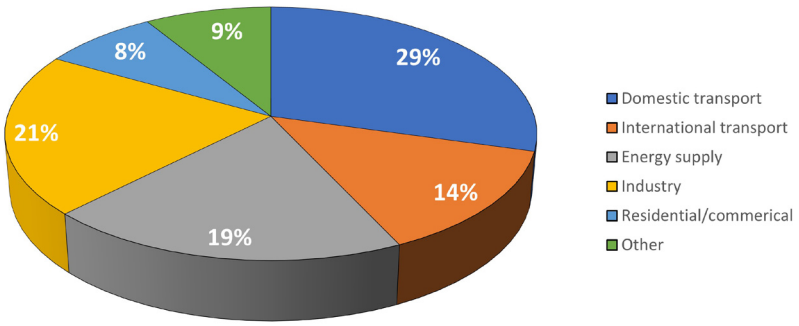



**Figure 1. $CO_2$ emissions in Spain in 2019.** Source: European Environment Agency.

energy for transportation from advanced biofuel, which is the bare minimum requested by the EU. Increasing this percentage will promote circular economy, as well as reducing energy dependency (still forecasted at 59% in 2030), and $CO_2$ emissions (by displacing fossil fuels). Big companies such as Repsol already started to move towards this direction[6], and the expected impact is huge (nearly 4 tons of $CO_2$ displaced per ton of advanced biofuel produced).

Industry will remain one of the most polluting sectors in the country, with an expected 55.9 Mton$CO_2$ eq emissions by 2030. Around 60% of those emissions will be related to combustion processes, and the remaining 40% will come from the manufacturing process itself (for example, from chemical reactions such as calcium oxide production from carbonates in the cement industry, or crude iron reaction with oxygen to produce steel). While combustion related emissions can be mitigated by reducing energy consumption or by using energy with a lower carbon footprint (primarily renewable electricity and $H_2$), process emissions are, in most cases, unavoidable. The reforestation actions included in the Spanish Forest Plan 2022–2032[7] will increase the $CO_2$ sink capacity of the environment, which will however remain insufficient to counteract the generated emissions. Considering this, the lack of attention on carbon capture, utilization and storage (CCUS) technologies in the Spanish NECP, other than a short mention in the Research, Innovation and Competitiveness dimension, appears evident.

CCUS solutions are part of the decarbonation strategy of other European countries such as Ireland[8] and Germany[9], and are considered by the EU essential bridging technologies to achieve a net-zero economy by 2050. Both public and private investment in CCUS have been growing over the few last years. Within the EU Innovation Fund, the EU has set a budget of € 3 billion for large scale CCUS project in 2023[10], and further calls for projects will come in the next years. Furthermore, private investments on these technology are starting to flourish, and are expected to reach € 150 billion by 2030[11], suggesting that some of these technologies might reach the market in the next seven years. Most of the investments will be directed towards installation of full-scale plants to decarbonize electric power generation, and carbon intensive industries such as cement, steel and petrochemical industry.

According to the NECP 2030 scenario, nearly 100 Mtons $CO_2$ will still be emitted in Spain from electric power production plants an carbon intensive industries, and the way to Net-Zero appears hard. At the same time, these emissions represent an opportunity to attract public funding and private investments in the order of billion Euros. Hence, the efforts must be directed towards the development of decarbonization networks that include the necessary expertise to deliver such innovative and difficult projects. Collaboration between universities, research centers, industries, energy suppliers and investors is essential to achieve the 2050 decarbonization targets and turn $CO_2$ into a business opportunity.

## Our research on CCUS technologies

Research on CCUS technologies has been flourishing over the last few years, and novel technologies are under development with the aim of reaching the market by 2030. For over ten years, CCUS technologies have been a pillar of our research group in the Laboratory of Chemical and Environmental Engineering (LEQUIA)[12] at the University of Girona. Our portfolio includes both national and European level projects dedicated at mitigating emission by transforming $CO_2$ to biofuels and chemical commodities. Among the ongoing projects, the EU funded ATMESPHERE[13] (Advanced Technology for Microbial Electro-Synthesis of Platform cHemicals and Efficient in-situ Recovery via Electrodialysis) aimed to develop a novel biorefinery concept (Figure 2) that uses $CO_2$ from carbon intensive industries as a raw material for the production of hexanoic acid, a valuable chemical that finds application in the energy, food and chemical industry, and can be also upgraded to hexanol, an advanced biofuel.

Technologies like the one developed in the ATMESPHERE project have the potential to simultaneously tackle greenhouse gas emissions and promote circular economy by converting $CO_2$ to commodities that would be otherwise produced from

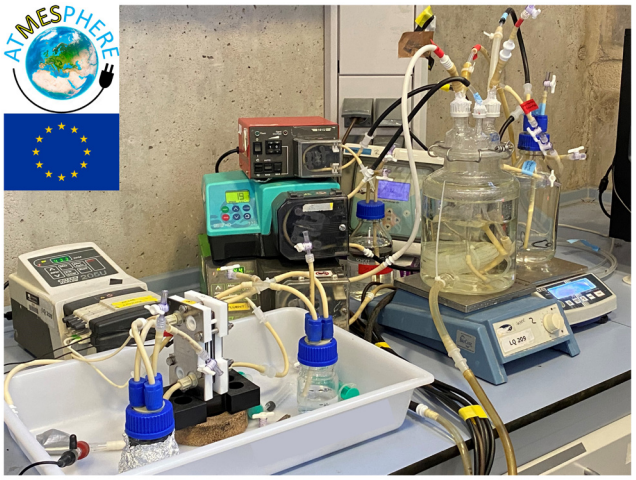



**Figure 2. Lab-scale biorefinery to convert $CO_2$ emissions to valuable caproic acid, developed within the framework of the EU-funded ATMESPHERE project.**

[6] https://www.repsol.com/en/press-room/press-releases/2022/repsol-starts-construction-of-spains-first-advanced-biofuels-plant-at-its-cartagena-refinery/index.cshtml

[7] https://www.miteco.gob.es/es/biodiversidad/temas/politica-forestal/plan-forestalespanol20222032_tcm30-549821.pdf

[8] https://energy.ec.europa.eu/system/files/2019-02/ireland_draftnecp_0.pdf

[9] https://energy.ec.europa.eu/system/files/2019-03/ec_courtesy_translation_de_necp_0.pdf

[10] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6489

[11] https://www.iea.org/reports/ccus-in-clean-energy-transitions/accelerating-deployment

[12] http://www.lequia.udg.edu/

[13] https://cordis.europa.eu/project/id/101029266

fossil sources. Thus, their strategic relevance for achieving the NECP objectives, and in particular the 2050 objectives, is not debatable. Supporting these innovative projects now could make the difference to achieve a cleaner industrial production in the next decades, with positive impacts on environment, economy, and population well-being.

## Ethics and consent

Ethical approval and consent were not required.

## Data availability

No data are associated with this article.

# Open Peer Review

## Current Peer Review Status: ? ?

**Version 1**

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The authors presented a clear overview of Spain's progress toward the 2020 targets while emphasizing the need for additional measures to achieve net-zero emissions by 2050 and outline the urgency of addressing sectors that are difficult to decarbonize. The text could be further improved by clarifying why advanced biofuels and CCUS technologies are preferred over other alternatives, providing a stronger justification for their prioritization in Spain's decarbonization strategy. In addition, the sources from which the values used for predictions in different scenarios were extracted are sometimes unclear.
The brief acknowledges both the progress made and the challenges still ahead, including the need to consider alternative solutions such as advanced biofuels and CCUS technologies (less emphasized in current policy). The text lacks opposing perspectives on the feasibility, cost, or long-term sustainability of biofuels and CCUS technologies. These solutions are presented as the "best" options without addressing potential challenges or limitations, which diminishes the effectiveness of the analysis and discussion.
The brief backs up its claims with numerous references, including European Environment Agency data and the National Energy and Climate Plan (NECP). However, the NECP data used is from 2019, and more recent plans or updated data could be incorporated to provide a current perspective.
The text uses accessible language, avoiding overly technical terms while explaining complex topics like decarbonization and CCUS technologies, making it suitable for policy makers and the general public.
The next steps are discussed, emphasizing increased use of renewable energy, transport electrification, and the development of biofuels and CCUS technologies as essential components of Spain's strategy to meet its net zero targets. Specifying which technologies will be prioritized in different sectors for implementation would further enhance the text.

**Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)**
Yes

**Does the article adequately reference differing views and opinions?**
Partly

**Are all factual statements correct, and are statements and arguments made adequately supported by citations?**
Partly

**Is the Open Letter written in accessible language? (Please consider whether all subject-specific terms, concepts and abbreviations are explained)**
Yes

**Where applicable, are recommendations and next steps explained clearly for others to follow? (Please consider whether others in the research community would be able to implement guidelines or recommendations and/or constructively engage in the debate)**
Partly

***Competing Interests:*** No competing interests were disclosed.

***Reviewer Expertise:*** Carbon capture and conversion, developing (bio)electrochemical technology for carbon utilization and conversion, electrochemical CO2 conversion and its integration with biological processes

**We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.**

Reviewer Report 17 May 2024

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I think this is a reasonable presentation of the current plans for decarbonization in Spain, although with some caveats (see below). I agree that a wider discussion about the potential role that CCUS may play is warranted, and largely absent from current government documents.

Comments:

In section "What is the current situation" the authors mention that the reduction in CO2 emissions from 2005 "was mainly achieved by cutting emissions from the energy sector, linked to the flourishing of renewable energy (solar and wind power)". I think this explanation should be expanded. The reduction in emissions from 2005 to 2019 was driven first by the economic crisis, which basically crashed the construction sector (and the freight transport associated with it). This has been shown e.g. in Mendiluce (Ref-1). Of course, the increasing share of renewables in the electricity sector, and even more, the phase-out of coal, also contributed.

In section "What are the next steps planned?" I think a better reference would be the updated NECP from 2023. The figures shown belong to the 2019 NECP. Anyway, I think that just a description of the NECP may not be a good approach, given that, particularly the update, is considered by many as quite unrealistic.

Finally, I think that the reference to the CCUS technology mentioned should be put in the right context: what would be the scaling potential, for what type of processes can it be used, what is the real market for hexanol?

**References**

1. Reference Source

**Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)**

Partly

**Does the article adequately reference differing views and opinions?**

No

**Are all factual statements correct, and are statements and arguments made adequately supported by citations?**

Partly

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Yes

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Partly

***Competing Interests:*** No competing interests were disclosed.

***Reviewer Expertise:*** Economics and policy of the energy transition

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**