Sixth Impact Evaluation of the Green OATs Evaluation Council: "Environmental energy subsidies" Programme

The Green OATs Evaluation Council is in charge of evaluating the environmental impact of eligible green expenditure financed by the Green OATs, the French sovereign green bond. This document summarizes the opinion of the Green OATs Evaluation Council[1] on the assessment report on subsidies used to promote renewable energy sources.

Main observations:

- ➔ The Green OATs Evaluation Council welcomes the evaluation, and notably the quantitative analysis of the contribution of renewable energies in France on climate change mitigation, and quantitative and qualitative estimate on all others environmental impacts of renewable generation (biodiversity, water and soil pollution, climate change adaptation).
- ➔ This evaluation is part of the general effort to improve reporting practices in the green bond market. It is rigorous in scrutinizing the impacts under study and includes all required caveats.
- ➔ The quality of the evaluation meets current academic standards. The Green OATs Evaluation Council is satisfied with the methodology of the report. This sound study is based upon a transparent and robust research program and methodology. It provides valuable insights.
- ➔ The Green OATs Evaluation Council endorses the results of the report and notes in particular that the associated expenditure contributes to the achievement of France'sobjectives in terms of climate change mitigation.

1. Introductory remarks

The Council notes that France aims to reduce emissions by at least 40% by 2030 as compared with 1990 levels, and achieve carbon neutrality by 2050 to contribute to the objectives set out in the Paris Agreement. This is a demanding target that requires ambitious policies to reduce greenhouse gas emissions and accelerate research and innovation, with a view to promoting renewable energy sources. That will contribute to reducing France's emissions.

In 2021, Following a reorganization of the French State budget in 2021, support to renewable energy in France have been included in the eligible expenditures to green OATs. Thanks to this integration, a **significant increase of the total eligible expenditures occurred in 2021 compared to 2020 (€15 vs €8 billion).Support to renewable energy thus accounted for 32% of the eligible expenditures in 2021**.

This report focuses on the environmental impact of subsidized renewable energies, both in mainland France and in non-interconnected zones (Corsica and Overseas Territories). The aim is to **provide an overview of the impacts of subsidized renewable production systems**. Following the classification of the French support to renewable generation, the renewables studied in this report are:

- In mainland France: onshore and offshore wind, photovoltaic, small hydropower and biomethane.
- In non-interconnected zones (NIZs), all renewables for electricity production are subsidized (except bagasse when co-fired with coal).

[1] Members of the Green OATs Evaluation Council: Manuel Pulgar-Vidal, WWF (chair); Mats Andersson, Global Challenges Foundation, PDC; Nathalie Girouard, OECD; Mike Holland, independent consultant; Karin Kemper, World Bank; Rana Roy, independent consultant; Thomas Sterner, University of Gothenburg; Eric Usher, UNEP-FI; Sean Kidney, Climate Bond Initiative (observer); Nicolas Pfaff, International Capital Market Association (observer).

2. Main results of the evaluation provided to the Council

The **objective of this study is to provide qualitative and quantitative indicators on the key environmental impacts of expenditures allocated to supporting renewable energies in France**.
As the primary impact of renewable energies is the reduction of greenhouse gas emissions, this subject forms the core of this study. Other types of impacts included in the analysis are: the reduction of air pollutant emissions and associated avoided costs, water and soil pollution, the use of raw materials and recycling, land use, preservation of biodiversity and naturel areas, and climate change adaptation.

The study follows a mixed quantitative and qualitative approach. The major impacts (especially greenhouse gases emissions, but also air pollutant emissions, raw materials use and land-use) have been quantified based on a dedicated methodology comparing a reference and a counterfactual scenario. This quantitative analysis is completed by qualitative elements from a literature review covering all environmental impacts of renewable generation (biodiversity, water and soil pollution, climate change adaptation, etc.).

The quantitative assessment is based on a comparison of reference scenarios with counterfactual scenarios, both for the historical period of the support to renewable (from 2000 to 2021), and for the decades to come, using prospective scenarios (up to 2040). This prospective approach makes it possible to analyze the potential impacts that the renewable capacities currently installed and subsidized will have in the future. The "reference scenarios" assume a renewable energy development identical to historical data and in line with the considered prospective scenarios[2] for the future. The "counterfactual scenarios" are similar in all respects to the reference scenarios, except they do not include additional renewables compared to the start of the period. In order to simulate the inclusion of renewables within the power grid in mainland France, also considering interconnections with neighbouring countries, the European electricity system of the different scenarios have been simulated using Artelys Crystal Super Grid[3].

This methodology allows to estimate both which type of power source generation is replaced by power renewable generation, and where it is replaced (in France or elsewhere in Europe).

It was possible to find that the renewable energies under scrutiny have an effect on:

- **Climate change mitigation.**

In recent years, **renewable electricity in mainland France has almost exclusively replaced thermal generation, most of it in neighboring countries** (between 75% and 86%) as a consequence of electrical energy exports. In the considered prospective scenarios, additional renewable electricity is found to replace mostly gas-fired generation, and to enable a higher hydrogen generation by electrolysis (therefore replacing a fossil fuel-based hydrogen production via steam methane reforming).

In Non-interconnected areas, renewable electricity subsidized and financed by Green OATs was found to replace thermal generation only, and more specifically oil, except in "La Réunion" and "Guadeloupe" where the remaining coal capacities are phased-out as well. Some limitation could nonetheless appear in the future with a rising share of renewables, which would require additional means of flexibility (*e.g.* storage) to cope with the variability of renewable generation.

[2] Two scenarios were used from ADEME Transition(s) 2050 scenarios: S2 and S3Nuc. These are two reference and contrasted scenarios built by the French ecological transition agency.

[3] This software **optimizes the production of the European power system at an hourly level, taking into account various constraints such as climate variability of renewable, exchanges between different European countries and the optimization of storage facilities**.

In 2021, on a life cycle analysis basis, the following **avoided greenhouse gases emissions** are estimated:

- 24.3 $MtCO_2eq$ (with annualization) for subsidized renewable electricity production in mainland France (49.8 TWh production), with 85% of these emissions being avoided in neighboring countries
- 0.7 $MtCO_2eq$ for subsidized biomethane production in mainland France (4.3 TWh)
- 2.7 $MtCO_2eq$ for renewable electricity production in the non-interconnected zones (3 TWh)

The avoided emissions for all subsidized renewables represent around 4,5% of the total carbon footprint of France in 2019 (605 $MtCO_2eq$). It should be emphasized that the quantification of avoided emissions only concerns the power system itself. Taking into account the reduction of indirect emissions thanks to increased production enabling the electrification of emitting end-uses (heating, industry, transport) would increase the benefits.

In average, 180€ of public subsidies for renewable electricity in mainland France were spent for each ton of CO_2eq avoided annually since 2014. There is a significant disparity between solar energy on the one hand, and wind and hydropower on the other hand, due to the high 2008-2011 feed-in tariffs for solar rooftop panels (€546/MWh in 2010). From the moratorium on photovoltaics at the end of 2010 (to allow the government and industry players to discuss subsidy levels), feed-in tariffs decreased leading to a lower difference between solar PV and other technologies.

- **Air, water and soil pollution reduction**.

Air pollutant emissions (PM2.5, SO_2, NOx, NMVOC) avoided by renewable generation have the same order of magnitude than the current emissions from the whole power sector in France[4]. The sum of these avoided emissions represents a small fraction of the total emissions in France (lower than 1% for all pollutant considered), but taking into account indirect reduction in emissions thanks to electrification would also increase the benefits.
With a direct impact on health, and more marginally on crops, forests and building materials, the impact of local pollutants can be converted in equivalent damage costs to these sectors. Depending on the methodology used to assess these costs, **avoided damage costs of air pollution could range between €0.9 to €7.6 billion (in both France and Europe) for the 2000-2021 period, which can be compared to total subsidies to renewables amounting to €39 billion over the same period**.
For water and soil pollution, most of the benefits are directly correlated to the replacement of fossil fuels that generate pollution hazards throughout the value chain, from production to use. Renewables can also have negative impacts on local pollution, mainly linked to the extraction of raw materials to build the different components of solar panels and wind turbines, but also at the installation stage.

- **Raw materials use and recycling**

The development of renewables will significantly increase the consumption of raw materials for the power generation, since material intensity is significantly higher for wind and solar than other low-carbon production technologies (hydroelectric, nuclear) or fossil fuels. By 2050, raw material consumption for the energy transition will be particularly high, especially for electric vehicles, power grids and renewable generation systems. Renewables will account for about 10% of current French aluminium production and about 5% of copper consumption and steel production. Batteries for electric vehicles, whose storage capacities will be useful in the future to facilitate the integration of increasing share of variable renewables in the energy mix, will need significant quantities of lithium, nickel and cobalt, but less so on rare earth elements.

Metals used in renewable energy systems could be reused or recycled to meet the needs of other industries. For **solar energy, approximately 95% of the mass of resources can be recycled**, but there is still room for progress to improve the separation of glass and semiconductor films, according to the EEA. **For wind energy, approximately 90% of the materials can be recycled or reused**, but recycling the composite materials used

[4] Keeping in mind that most of the reduction are located in neighboring countries, and not in France.

in wind turbine blades remains a challenge that requires additional research. Raw material needs could be reduced through energy sufficiency and improved energy efficiency.

- **Preservation of biodiversity and natural areas**

Climate change and biodiversity loss are interconnected challenges, and climate change is one of the five direct drivers of biodiversity and ecosystem change, according to the IPBES. **Renewable power generation, by contributing to climate change mitigation, also proves important for biodiversity conservation.**

On the other hand, land use change due to renewables is one of the main drivers of biodiversity loss associated to renewables. **In the considered prospective scenarios in 2050, the surface area co-used by renewables for power generation would represent around 2-3% of France's total area, and renewables would account for about 0,6% of French artificialized surfaces.** In addition to the mobilization of brownfields, different solutions can help to mitigate this impact of renewables, such as agrivoltaics, a greater development of rooftop solar panels (even if they are associated to a higher cost), or installing floating panels on artificial lakes.
In their operation phase, renewable energies are associated to negative impacts for biodiversity, especially **wind turbines regarding the increased mortality of birds and chiropters. This impact is in average relatively limited compared to other threats to birds**. Impact assessments are conducted for every project to mitigate its environmental impacts, protect locally endangered species and limit the disturbance on the vicinity of the wind farms.

- **Climate change adaptation**

Solar and wind renewable generation in France will not be significantly affected in the future due to climate change. Hydroelectric power generation will be slightly more impacted, with a variation in hydrological cycles, but the average annual precipitation volume is not expected to change significantly, according to RTE.
Renewable energies can also, to a limited extend, contribute directly to the adaptation to climate change, thanks to possible synergies with photovoltaic production, through agrivoltaics and solar installations on water bodies to limit evaporation.

3. Quality of the evaluation

It is the Council's opinion that **the study meets the objectives** defined by the terms of reference providing quantitative and qualitative evidence on the impact of renewable energies on climate change mitigation and others environmental impacts. In particular, the Council welcomes the analysis regarding the EU Taxonomy. The Council wishes to highlight the **innovative nature of the study, as it contributes to the development of impact reporting methodologies.** The Council welcomes the qualitative impact analysis on others objectives, as biodiversity protection.

4. Conclusion and next steps

The Evaluation Council welcomes the results of the renewable energies impact, as it provides a robust and transparent methodology on climate change mitigation, as well as a thorough literature review on other environmental objectives.

The Council wishes to underscore the soundness of the evaluation process. The study meets current academic standards and developed robust methodology.

The Council is confident that this fifth impact evaluation will be useful to other green bond issuers and contribute to the advancement of evaluation best practices on the market. In particular, this study could be useful for sovereign issuers focusing on climate change mitigation. Indeed, such impact studies and transparency are essential factors to foster the development of green finance.

The publication of this study confirms the important role of the Evaluation Council in ensuring the credibility and transparency of the Green OATs.