MINISTÈRE
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Macroeconomic and Fiscal Implications of Carbon Neutrality

AUGUST 2022

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EXECUTIVE SUMMARY

In **France**, macroeconomic assessments of the second National Low-Carbon Strategy, published in 2020, concluded that it would yield a **"double dividend" in the long term**: achieving carbon neutrality by 2050 would also increase GDP (by 3.5%) and add net jobs (between 700,000 and 880,000), compared to a scenario where current climate measures are maintained. In its most recent report, the **Intergovernmental Panel on Climate Change (IPCC)** estimates that, on the basis of the international literature, **carbon reduction measures will not significantly affect global GDP**, either positively or negatively, in the long term.

But **this outlook** of moderate GDP effects or macroeconomic gains associated with reducing greenhouse gas (GHG) emissions **is not a given**. It depends on the **economic context** in which climate measures are implemented. If financing conditions were tightened, for example, it would reduce France's anticipated GDP growth due to mitigation policies. Similarly, the **short- and medium-term effects on employment** of a measure banning the sale of new internal combustion vehicles in 2035 would depend on the price differential (positive or negative) between conventional and electric cars for households.

Moreover, even if the impacts of carbon neutrality on GDP are inconsequential, there are still **tangible risks for public finances**. Replicating the assessment method used by the UK's Office for Budget Responsibility, the report illustrates the possibility of such risks for France, primarily stemming from a loss of fossil-fuel-related tax revenue and some additional public investment spending.

Under these circumstances, **there is a clear need for macroeconomic and fiscal management of low-carbon policies**. This stronger macroeconomic and fiscal management is needed in the immediate term, particularly for the preparation of France's energy and climate strategy and its next National Low-Carbon Strategy to be launched in 2024, and in support of the new Secretariat General for Environmental Planning.

While there is room for improvement, **France already has tools** that could be used to strengthen its management, especially regarding **macroeconomic assessment**. In this respect, France is **better positioned than other governments and institutions**, namely the United Kingdom, Germany, Denmark and the European Commission, whose practices have been studied for this report.

That said, there are limitations to France's current macro-fiscal management of climate mitigation policies, namely **the relatively small part played by the Ministry for the Economy and Finance** and, in view of the uncertainty surrounding most of the effects of the low-carbon transition faced by most of the European and international governments that were surveyed, **the limited use of stylised assessment tools**.

This report has put forward **five operational proposals** to strengthen macroeconomic and fiscal management of mitigation policies in France in the short term. These proposals could be implemented **as early as autumn 2022**, ideally as part of preparations for the Energy and Climate Planning Act.

PROPOSALS

Proposal 1: Take greater account of macroeconomic assessment in the preparation of the Energy and Climate Planning Act, NLCS3 and bills and decrees implementing NLCS3.

Proposal 2: Formalise a joint initiative between government and climate macroeconomics research institutions in order to continue improving models for assessing low-carbon policies and implement an interministerial roadmap for priority improvements to these models.

Proposal 3: Within the Ministry for the Economy and Finance, establish in-house capacity for macroeconomic assessment of carbon neutrality policies by adopting and adapting existing macroeconomic climate models rather than building new ones.

Proposal 4: Despite the uncertainty surrounding the macroeconomic effects of carbon neutrality policies, encourage assessment of such policies by means of stylised assessment tools.

Proposal 5: Strengthen management of the multi-year fiscal effects of the mitigation policies set out in the Energy and Climate Planning Act and NLCS3.

CONTENTS

INTRODUCTION

On 22 April 2022, the Minister for the Economy, Finance and the Recovery and the Minister Delegate reporting to the Minister for the Economy, Finance and the Recovery with responsibility for Public Accounts wrote to the General Inspectorate of Finance to task it with developing macroeconomic and fiscal management tools in relation to climate targets.

To give context to this assignment, which focused solely on climate policies designed to achieve the target of net zero GHG emissions by 2050[1] ("mitigation" policies), there are two background issues to highlight. Firstly, the European Union's initiative to increase the target for reducing net GHG emissions by 2030 to at least 55% below 1990 levels ("Fit for 55") must be incorporated into preparations for France's upcoming Energy and Climate Planning Act, to be adopted no later than July 2023[2]. This act will establish the framework for the next National Low-Carbon Strategy (NLCS). Secondly, there have been questions about the ability of climate macroeconomics to analyse the consequences of achieving carbon neutrality[3]. In April 2022, *France Stratégie,* an independent institution reporting to the Prime Minister that contributes to public action through its analyses and proposals, formed forward-looking working groups to identify ways to improve and make better use of macroeconomic models by 2023. We participated in these working groups to ensure the report is aligned with efforts already underway.

The proposals, which relate to both macroeconomic and fiscal management tools for low-carbon policies, have been formulated from an operational perspective and could be implemented as early as autumn 2022. There are three components to the investigation methodology behind these recommendations:

- Macroeconomic simulations were kindly provided by three French modelling teams, whom we wish to thank for their contributions. The objective was to gauge the need for macroeconomic management of low-carbon policies in France and the ability of existing tools to fulfil this need in the immediate term.
- We conducted a benchmarking exercise among European governments and institutions (United Kingdom, Denmark, Germany and the European Union), which involved making four trips, arranged with the support of the Regional Economic Departments of France's Directorate General of the Treasury. We also interviewed representatives from several international organisations.
- In France, we had in-depth discussions with departments of the Ministry for the Economy and Finance as well as the Ministry for Ecology and its agencies in order to identify interministerial tools. We also took into account policy management needs expressed by civil society (management and labour representatives, think tanks).

This report does not express a position on whether it is advisable or possible to achieve carbon neutrality in view of the economic consequences. Rather, its aim is to determine how the government can ensure that this objective, which has been enacted in positive law, is achieved as effectively as possible.

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[1] France's Energy Code, Article L.100-4.

[2] France's Energy Code, Article L.100-1 A.

[3] Cf. for example: Pisani-Ferry, "Climate Policy is Macroeconomic Policy, and the Implications Will Be Significant", Policy Brief 21-20, Peterson Institute for International Economics, August 2021.

1. The prospect of a "double dividend" of reduced GHG emissions and increased economic activity has obscured the need for macroeconomic and fiscal management of climate policies

1.1. Macroeconomic assessments of the second National Low-Carbon Strategy (NLCS2) have concluded that there is a long-term double dividend, consistent with the international literature

1.1.1. Ex ante assessments of NLCS2 reveal a double dividend associated with low-carbon policies and suggest a lack of risk for public finances

The NLCS is the primary tool for climate mitigation policy planning in France.

Adopted by decree, the NLCS defines the process for steering GHG mitigation policy[4]. It establishes limits for GHG emissions, expressed in millions of tonnes of CO_2 equivalent, which are not to be exceeded at national level over five-year periods, and sets public policy strategies for carrying out the low-carbon transition.

The current strategy, NLCS2, was published in March 2020 and sets carbon budgets[5] through to 2033[6]. NLCS3 will be published within one year of the Energy and Climate Planning Act, which is to be adopted by July 2023[7]. NLCS3 will allow GHG emissions reduction targets to be established for three five-year periods. The Multiannual Energy Plan[8] will also be updated along the same timeline and is expected to align with NLCS3[9]. Together with the National Climate Change Adaptation Plan[10], the Energy and Climate Planning Act, the NLCS and the Multiannual Energy Plan form France's energy and climate strategy.

According to the macroeconomic assessment of NLCS2 (cf. Box 1), achieving net zero by 2050 would be a source of growth and jobs ("double dividend") as compared to a baseline scenario where no additional climate measures are taken.

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[4] France's Environment Code, Article L.222-1 B.

[5] Based on Article L.122-1 A of France's Environment Code, a national GHG emissions limit ("carbon budget") is established by decree for each five-year period.

[6] Revised strategy for the second carbon budget (2019–2023), the third carbon budget (2024–2028) and the fourth carbon budget (2029–2033).

[7] France's Energy Code, Article L.100-1 A.

[8] The Multiannual Energy Plan, established by decree, defines public policy for the management of all types of energy in mainland France for the purpose of achieving the targets set by Articles L.100-1, L.100-2 and L.100-4 of the Energy Code and by the act set out in Article L.100-1 A (Energy and Climate Planning Act) (Article L.141-1 of the Energy Code). It establishes quantitative planning targets and sets a maximum indicative budget for the public funds to be spent by the government and its government-funded institutions to achieve these targets. This budget is determined in terms of commitments and actions. It may be allocated by target and by industry (Article L.141-3 of the Energy Code).

[9] France's Energy Code, Articles L.141-1 and L.141-4.

[10] Plan provided for in Article 42 of Planning Act No. 2009-967 of 3 August 2009 on the implementation of the *Grenelle* Environment Round Table.

The assessment conducted using the ThreeME model indicates a gradual positive effect on GDP, which would rise 2.5% by 2030 and **3.4%** by 2050. Some 541,000 net jobs would be created by 2030 and **878,000** by 2050. The additional growth would increase public revenue and improve the general government balance by 1.3 percentage points of GDP by 2030 and 3.8 points by 2050. Assuming stable public consumption as a percentage of GDP, implementation of NLCS2 would lower the debt ratio by **52.5 percentage points of GDP** by 2050[11].

As simulated by the IMACLIM model[12], the transition to carbon neutrality would lead to an additional 0.7% of GDP by 2030 and **3.7%** by 2050. It projects net job creation of 300,000 by 2030 and **700,000** by 2050. Increased economic growth would in turn increase public revenue, which would allow the public deficit to be contained over the long term (an additional 0.2 percentage points of GDP)[13].

In both assessments, the positive shock from the investments needed to make the transition creates a virtuous circle giving rise to macroeconomic gains. In the assessment using ThreeME, the investment multiplier (which is the ratio between additional GDP and additional direct investment for the transition) is 1.4 for 2030[14]. In the IMACLIM model assessment, this GDP gain to investment ratio is 1.2 for 2030 and 4.2 for 2050[15].

Box 1 : Principles for the macroeconomic assessment of mitigation policies

For the **ex ante** macroeconomic assessment of low-carbon transition scenarios, we defined a scenario where **additional measures** are taken ("AM" scenario), which reflects the impact of new measures introduced in the future in order to stay on the trajectory defined in the transition scenario being assessed and achieve the net zero target by 2050. **Ex post** assessment differs from ex ante assessment in that it uses econometric analysis of historical data.

This AM scenario is compared to a benchmark scenario, for instance one where only **current measures** are taken ("CM" scenario), capturing the effects of policies and measures that have already been adopted. In the specific case of NLCS2, the AM scenario is one in which France stays on the emissions-reduction trajectory set by NLCS2. It is compared to a CM scenario in which no additional measures are introduced after 1 July 2017[16].

Modelling for the measures being assessed is based on an **explicit price** of carbon (carbon tax, price per tonne of carbon in an emissions trading system) or an **implicit** or **shadow price**. This is introduced into the equation for trade-offs made by economic agents in order to reproduce behaviour (energy use, investment, etc.) observed outside the macroeconomic model.

The **ad hoc shadow price** technique used for the macroeconomic assessment of NLCS2 is a means of "forcing" the attainment of GHG emissions reduction targets without the price being tied to a public policy climate mitigation measure.

*Sources: French Environment and Energy Management Agency (ADEME), "*Évaluation d'un scénario SNBC 2 sans hausse de taxe carbone et sans prix fictifs ad hoc*", June 2020; the authors.*

[11] Ministry for the Ecological Transition, "*Évaluation macroéconomique de la NLCS 2 avec le modèle ThreeME*", February 2022.

[12] The IMACLIM-S France model was used to assess NLCS2.

[13] Ministry for the Ecological and Inclusive Transition, "*Rapport d'accompagnement de la stratégie nationale bas-carbone*", March 2020, p. 16.

[14] Ministry for the Ecological Transition, ibid., pp. 48–49. Based on a combined reading of Figures 2 and 3 in Part III, additional direct investment of 1.75% of GDP in 2030 would lead to a 2.5% rise in GDP.

[15] Ministry for the Ecological Transition, March 2020, ibid., p. 16.

[16] Ministry for the Ecological and Inclusive Transition, February 2022, ibid., p. 3.

1.1.2. The double dividend associated with NLCS2 is consistent with the results of the international literature, including ex post studies

The international literature suggests that low-carbon policies would have moderate effects on global GDP.

In the most recent report from the Intergovernmental Panel on Climate Change (IPCC), it is estimated, with a high level of confidence, that the aggregate long-term effects of mitigation policies on global GDP will be small, based on modelled scenarios that assess low-carbon policies but that do not account for damages from climate change or adaptation costs[17].

For instance, the International Monetary Fund (IMF) recently assessed the macroeconomic consequences of gradual carbon price increases, combined with green investment and low-carbon production subsidies, in order to reduce worldwide gross GHG emissions by 80% in 2050. In the first 15 years after these measures are implemented worldwide, through additional "green" public expenditure, output would rise on average by about 0.7% of GDP compared to a baseline "current measures" scenario. The initial growth in aggregate demand, which would progressively lead to productivity gains in low-carbon sectors, is the driver of this macroeconomic gain. Subsequently, however, the costs of the transition would exceed the gains due to the continued rise of carbon prices, resulting in losses of about 1% of global GDP by 2050[18].

Ex post impact studies also indicate that mitigation policies have a minimal impact on GDP.

An econometric assessment was conducted on the effects of the carbon tax introduced in 31 European countries. According to the assessment, the carbon tax had positive ex post effects on GDP growth and employment, although they were often statistically non-significant[19].

In France, a study by the Organisation for Economic Co-operation and Development (OECD) of 8,000 firms representative of the French manufacturing sector over the 2001–2016 period showed that a 10% increase in the cost of energy has negligible effects on net employment at industry level due to reallocations between energy-intensive and energy-efficient firms, and also results in a 6% reduction in energy use at firm level and CO_2 emission reductions of 7%[20].

1.2. In this context, and given the European Union's decision to set more ambitious 2030 targets, France has focused its strategy on the risks of failing to achieve emissions reduction targets

The method used to draft NLCSs is heavily focused on technical and sectoral issues, with the aim of identifying GHG emissions reduction targets for each sector and additional measures to help achieve these targets.

[17] IPCC, Working Group III Contribution to the IPCC Sixth Assessment Report, "Summary for Policymakers", p. 49, paragraph C.12.2.

[18] IMF, World Economic Outlook, "Mitigating Climate Change – Growth and Distribution-Friendly Strategies", October 2020; Jaumotte, Liu and McKibbin, "Mitigating Climate Change: Growth-Friendly Policies to Achieve Net Zero Emissions by 2050", IMF Working Paper, July 2021.

[19] Metcalf and Stock, "Measuring the Macroeconomic Impact of Carbon Taxes", American Economic Review Papers and Proceedings, 2020.

[20] Dussaux, "The Joint Effects of Energy Prices and Carbon Taxes on Environmental and Economic Performance: Evidence from the French Manufacturing Sector", OECD Environment Working Paper, 2020.

NLCSs are developed based on sectoral work[21] which aims to propose trajectories for reducing energy use and GHG emissions and, where possible, additional measures that can be used to adhere to these trajectories. Sectoral targets for energy use and emissions are established using sector-specific[22] analytical tools[23] which help set trajectories for energy use and emissions based on physical assumptions[24], usage assumptions[25] and/or cost assumptions[26]. Physical, technical, usage and cost assumptions for technologies are therefore integral to defining the NLCS.

Sectoral working groups, which bring together stakeholders[27], are presented with the assumptions used to develop the trajectories, analyse the modelling results and propose the necessary measures and policies. During the sectoral working group process, there is no assessment of the impacts of the proposed trajectories on the main macroeconomic variables.

Multiple runs[28] of the sectoral trajectories are conducted, overseen by the Directorate General for Energy and Climate (DGEC) of the Ministry for Ecology. The aim is to ensure that the overall emissions target is achieved and that biomass and energy use is sustainable. These runs each last two to three months (cf. Figure 1).

Although the NLCS3 drafting method takes better account of cross-cutting issues, sectoral and technical issues still dominate the timetable.

The drafting of NLCS3, which will take place as part of the development of France's overall energy and climate strategy, has a bigger focus on cross-cutting issues than NLCS2. In addition to sectoral working groups, it will also involve a greater number of cross-cutting working groups. NLCS3 will include working groups dedicated to the economy, to local and regional authorities, to social dynamics and lifestyles and to carbon footprint, none of which were part of the NLCS2 process (cf. Box 2).

Still, the timetable is heavily skewed towards sectoral and technical considerations, in the context of preparations for the Energy and Climate Planning Act and Europe's more ambitious emissions reduction targets for 2030.

[21] For NLCS3: agriculture; transportation; construction; industry, waste and energy; forests and soils. Source: Directorate General for Energy and Climate (DGEC).

[22] For NLCS3: MoSUT (agriculture), forest/woodland calculator (forestry), land take, MENFIS (residential heating), energy aggregator (other residential uses), tertiary model (GCSD), MICO (air conditioning), MODEV (traffic flows), fleet/stock models, aviation model, enerMED (industry and energy), waste (ADEME tools), F-gaz. Source: DGEC.

[23] Technical or technical/economic models or calculators.

[24] For example: building stock assumption from the MICO model (air conditioning).

[25] For example: usage and behaviour assumptions from the MICO model (air conditioning).

[26] For example: assumptions for energy prices and system/renovation costs from the tertiary model.

[27] Firms, non-governmental organisations, unions, consumer groups, members of parliament, local and regional authorities, scientific experts.

[28] Two for NLCS2 and three for NLCS3.

On one hand, the NLCS3 drafting timetable (whose main milestones are shown in Figure 1) is dictated by the preparations for the planning act: a first version of the NLCS3 scenario[29] must be made available before the planning act is tabled. In the planning act, only the overall reduction targets for the next three five-year periods will be set, but developing a first version of the NLCS3 scenario will help get closer to the possible trajectory for energy use and emissions reductions for each sector as well as identify a preliminary list of associated additional measures. This means adding one more run compared to NLCS2. Two runs are planned as part of developing the first version of the NLCS3 scenario, before the Energy and Climate Planning Act is adopted. A third run is planned as part of developing the second version of the NLCS3 scenario, after the planning act is adopted, the "Fit for 55" package is adopted and the macroeconomic framework is updated, if needed.

On the other hand, by setting bolder targets for 2030, the "Fit for 55"[30] package has further reinforced the need for technical and sectoral management in preparing NLCS3. The European Union has set itself a binding target of achieving climate neutrality by 2050 and has increased its 2030 climate objectives by committing to reduce emissions by at least 55% compared to 1990 levels[31]. This new European target means a correspondingly more ambitious target compared to what was used to develop NLCS2, requiring each sector to find even more ways to reduce emissions from a physical and technical standpoint. NLCS2 was developed based on the target of reducing GHG emissions by 40% between 1990 and 2030[32]. In parallel to the NLCS3 drafting process, legislative texts are currently being revised at European level to introduce the measures needed to achieve the new targets[33].

In 2021, to secure the implementation of NLCS2 and contribute to the next NLCS, a low-carbon sectoral roadmap exercise was launched; these roadmaps also have a heavy focus on sectoral and operational issues[34]. The purpose of these roadmaps is to help industry stakeholders understand the NLCS targets[35], identify measures and initiatives to implement and remove any barriers identified by industry stakeholders. The first three roadmaps (steel, chemicals and cement) were drafted by strategic industry committees led by France's Directorate General for Enterprise (DGE). In 2022, work began on seven more roadmaps, overseen by the General Commission for Sustainable Development (GCSS) and the DGEC[36].

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[29] Additional measures (AM) scenario (cf. Box 1).

[30] The decision to raise the emissions target to a net reduction of 55% by 2030 compared to 1990 levels, along with proposals to revise and update EU legislation and introduce new initiatives to implement these new targets.

[31] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ("European Climate Law").

[32] Targets mentioned in Article L.100-4 of France's Energy Code (introduced by Act No. 2015-992 of 17 August 2015 on the energy transition for green growth and amended by Act No. 2019-1147 of 8 November 2019 on energy and climate). The outcome in the NLCS2 scenario is a 43% reduction by 2030, which is slightly more than the legislated target.

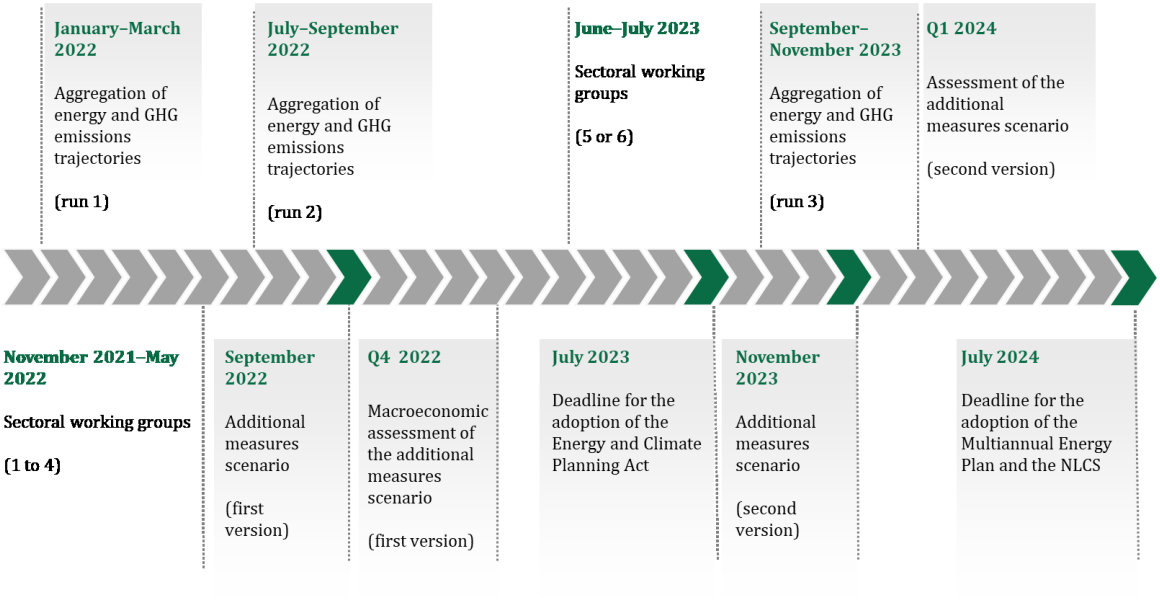
[33] In June 2022, the Council of the European Union adopted its general approaches on the legislative proposals in the "Fit for 55" package, which will enable the European Union to reduce its net GHG emissions by at least 55% by 2030 compared to 1990 levels and to achieve climate neutrality in 2050.

[34] These roadmaps are provided for in Article 301 of Act No. 2021-1104 of 22 August 2021 on combating climate change and strengthening resilience to its effects (known as the Climate and Resilience Act).

[35] In achieving the sector-specific targets to be set out in NLCS3, the low-carbon roadmap exercise launched in 2022 is being based on NLCS2 targets that have been uniformly raised in consideration of the EU's new "Fit for 55" targets.

[36] Automotive, heavy vehicle, airline, construction, spatial planning, maritime transport and waste. The exercise is managed by a project manager reporting to the GCSS and the DGEC and two DGEC representatives each contributing 0.5 full time equivalents (FTEs) with support from an external firm. Source: The project directorate responsible for low-carbon roadmaps at France's Ministry for Ecology.

Figure 1 : Main NLCS3 milestones as part of the Energy and Climate Planning Act process



Source: The authors, based on information provided by the DGEC.

Box 2 : Committees behind France's energy and climate strategy

The development of France's energy and climate strategy involves a substantial committee process, which includes committees, working groups, workshops and inter-administration meetings overseen by the DGEC:

- **"SFEC" committees,** composed of members of the National Ecological Transition Council and the Economic, Social and Environmental Council (one meeting at the time of writing, four in total scheduled between now and the end of 2023).
- **Sectoral working groups** (agriculture; transportation; construction; industry, waste and energy; forests and soils), the goal of which is to provide a forum for technical work, to combine different areas of expertise to pool available knowledge, and to discuss policies and measures, the assumptions and outcomes of sector-specific scenarios and the NLCS strategies for the sector (five or six meetings per sectoral working group between November 2021 and July 2024).
- An **inter-administration meeting** involving all relevant government departments, in advance of each cycle of sectoral working group meetings, in order to prepare for the work with stakeholders (one meeting at the time of writing).
- **Cross-cutting working groups**, each with its own specific objectives and meeting schedule: a **local and regional authorities** group, which discusses policies and measures to assess their level of ambition in light of the experiences of local and regional authorities (meetings in March 2022 and June 2022); a **social dynamics and lifestyles** group, which aims to develop a more complete narrative of how society and lifestyles will evolve in the NLCS scenario, i.e. a more exploratory focus (meetings in November 2021 and July 2022); an **economics** group, which is a forum for discussing economic modelling and challenges relating to the review of the NLCS (meetings in November 2021 and July 2022); a **carbon footprint** group, which aims to develop a more complete narrative of the emissions created by lifestyles and production methods, improve the assessment of the impact of national consumption and imports in terms of emissions and material resources, and establish indicative carbon footprint budgets in addition to existing sectoral budgets (meeting in July 2022); and the **overseas France** group, which is a technical forum for discussing trajectories for the territories covered by the NLCS (two meetings in February 2022 and one meeting in March 2022).
- Technical Multiannual Energy Plan **workshops.**
- **Working groups** on the national Climate Change Adaptation Plan.

There are also several consultation initiatives planned: a first voluntary public consultation (2021) a second voluntary consultation on energy mix and consumption (2022), a preliminary Multiannual Energy Plan and NLCS consultation (2023), mandatory consultations (2024) and an online public consultation (2024).

Source: The authors, based on information provided by the DGEC.

1.3. However, there are several risks connected with how the low-carbon transition is carried out that could shrink or even cancel out the double dividend, highlighting the need for macroeconomic management of transition policies

1.3.1. In the event of a delayed transition, the macroeconomic cost incurred by transition risks could be as high as the cost of physical risks of climate change in 2050

The mission looked at three low-carbon transition scenarios assessed by the Network for Greening the Financial System (NGFS)[37].

In the "net zero 2050" scenario, climate policies are introduced as from 2020 to progressively reduce GHG emissions. Global warming is limited to 1.5 °C by 2100.

In the "disorderly and delayed transition" scenario, there is no reduction in CO_2 emissions until 2030, meaning strong measures are then needed to limit warming to 2 °C by 2100.

In the "current policies" scenario, existing measures are maintained but no new ones are introduced to limit GHG emissions. Global warming exceeds 3 °C in 2100.

These simulations suggest that in the event of a disorderly and delayed low-carbon transition, France would see equally negative macroeconomic effects (1.3% decline in GDP) for both physical risks and transition risks in 2050.

The NGFS assessments use a macroeconomic and sectoral model that combines the use of sector-specific integrated assessment models (cf. Box 4) and the NiGEM macro-econometric model, which enables physical climate risks and transition risks to be analysed in the same framework[38]. The quantification of climate change-related damage is taken from an external study using temperatures specific to each scenario[39].

According to these simulations (cf. Chart 1), a "net zero 2050" scenario would result in a double dividend in the medium term (2030) and long term (2050) if the transition were orderly and gradual, with carbon tax revenue recycled into public investment and a reduction of the public debt.

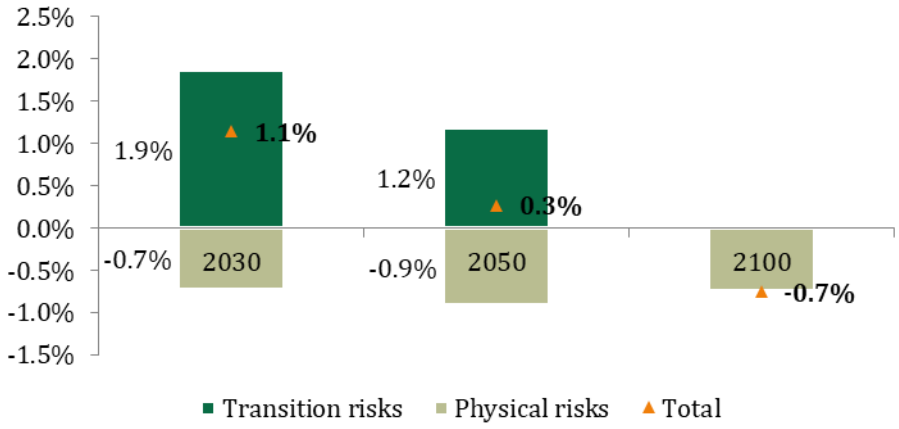
[37] A global network launched in 2017 after the One Planet Summit bringing together 114 central banks and financial regulators to coordinate on scaling up green finance and reinforcing the role of central banks in combating climate change. There are a total of six scenarios in the NGFS database. See: "NGFS Climate Scenario Database", Technical Documentation (v2.2), June 2021. To our knowledge, this study is the only one to analyse physical risks and transition risks in the same framework with results for France. There is open access to the simulation results: NGFS Scenario Explorer (iiasa.ac.at).

[38] Physical risks, which represent the vulnerability of natural or human systems to climate-related hazards, arise from the gradual warming of the planet or more frequent extreme weather events. Transition risks arise from the transition to a low-carbon economy. See: Sandra Batten, "Climate Change and the Macroeconomy: A Critical Review", Bank of England Staff Working Paper, 2018.

[39] Kalkuhl and Wenz, "The Impact of Climate Conditions on Economic Production. Evidence from a Global Panel of Regions", Journal of Environmental Economics and Management, 2020.

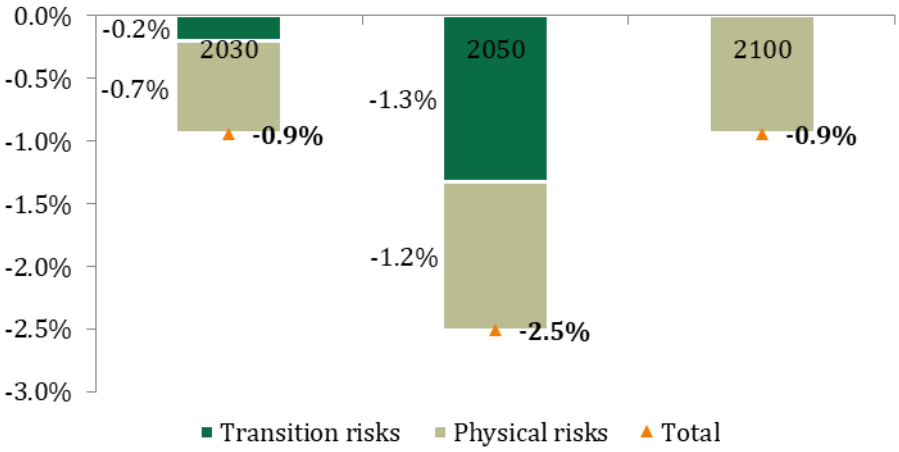
However, in the case of a disorderly and delayed transition (cf. Chart 2), low-carbon policies would have potentially negative effects on GDP, to a similar degree as the effects of physical risks by 2050 (1.3% decline in GDP).

Chart 1: Effects on France's GDP of transition risks and physical risks related to climate change (as a % of trend GDP[40]) – Net zero 2050



Sources: NGFS version 2.2, simulations from the REMIND integrated assessment model[41]; authors' own calculations.

Chart 2: Effects on France's GDP of transition risks and physical risks related to climate change (as a% of trend GDP) – Disorderly and delayed transition



Sources: NGFS version 2.2, simulations from the REMIND integrated assessment model, authors' own calculations.

1.3.2. There are different macroeconomic consequences depending on the instrument chosen for low-carbon transition policies

Different measures presenting the same emissions reduction potential can have substantially different economic effects.

[40] Defined as the extension of the rate of GDP growth from its historical average, without any physical climate risks.

[41] These results are robust to the choice of the integrated assessment model.

For example, the assessment of the European target to reduce GHG emissions by 55% in 2030 suggests that the resulting macroeconomic effects would be worse if this target were achieved using regulatory measures as opposed to carbon pricing measures[42].

For its macroeconomic assessment of the target to reduce GHG emissions by 55% in 2030, the European Commission conducted an impact study involving scenarios wherein different tools are used to achieve the emissions reduction target, including:

- The CPRICE scenario, where the 55% emissions reduction target is achieved by strengthening and further expanding carbon pricing instruments to the transport and buildings sectors, for instance by introducing an emissions trading system in these sectors.
- The REG scenario, which assumes an intensification of energy efficiency goals, renewables and transport policies, allowing the emissions reduction target to be achieved without making any changes to carbon pricing, including keeping the scope of the EU's emissions trading system unchanged.

By increasing revenue from carbon pricing/taxation, the CPRICE scenario recycles this revenue to reduce labour taxation and labour market imperfections, generating a smaller unfavourable impact on real GDP in achieving the 55% emissions reduction target than in the REG scenario[43].

1.3.3. As illustrated by the ad hoc variants provided by three modelling teams, less favourable macroeconomic assumptions weaken the perspective of a double dividend

Assessments of NLCS2 already suggest there are limitations that could affect the macroeconomic gains associated with reducing GHG emissions.

Adverse assumptions relating to the international environment were tested. For instance, if France were the only country to combat climate change, it would see a lower rise in GDP (by 0.5 percentage points) as a result of low-carbon policies compared to a situation where the rest of the world instituted energy transition policies to achieve carbon neutrality[44].

More broadly speaking, in these assessments, energy transition investments do not crowd out other economic investments, and pressures on production capacity are deemed negligible[45].

The intentionally adverse simulations that were solicited for this report (cf. Box 3) illustrate the contingent nature of the double dividend and the need for macroeconomic management of low-carbon policies.

The variants examine several potential macroeconomic risks, one at a time, without assessing any cumulative consequences.

[42] European Commission, Staff Working Document No. SWD(2020) 176, September 2020.

[43] European Commission, September 2020, ibid., p. 77. The assessment was conducted using the JRC-GEM-E3 model of the European Commission's Joint Research Centre (cf. Box 4). In the CPRICE scenario, the impact on real GDP in 2030 compared to the baseline scenario was −0.24%, and in the REG scenario it was −0.30%.

[44] Ministry for the Ecological and Inclusive Transition, March 2020, ibid., p. 22.

[45] Ministry for the Ecological and Inclusive Transition, March 2020, ibid., p. 13.

These simulations reveal the need for management. **The size of the double dividend – and whether it will materialise at all – depends on the economic context** in which carbon neutrality policies are implemented. For example:

- A modest tightening of real interest rates (up 0.2 percentage points) in 2021 would likely reduce – by half in 2030 (down from 0.2 to 0.1 %) and by one-third in 2050 (down from 0.9 to 0.6 %) – the GDP gain associated with reducing GHG emissions by raising the carbon tax (which is partially recycled)[46] to €751 per tonne of CO_2 over the period[47].
- Reducing the elasticity of substitution between capital and energy by half in the sectors (excluding electricity sector output) compared to the baseline scenario could cause real GDP to fall 0.2 % in 2050, mainly due to a drop in investment of 0.6 % of GDP[48].

Furthermore, the simulations show that **in addition to the double dividend (higher GDP and lower emissions), the effects of a low-carbon transition on employment** must also be managed:

- The manner in which the carbon tax is recycled, if the tax is increased to achieve carbon neutrality, makes a difference. For instance, a 25% carbon tax increase as from 2021, resulting in a roughly 25% decrease in emissions between 2021 and 2030, could trigger a 0.6 percentage point increase in the unemployment rate over the same period if carbon tax revenue is not recycled[49].
- Similarly, in the event of an unfavourable trajectory of the price differential between electric and conventional vehicles (if the differential remains at €8,000 and France increases its imports of electric vehicles), the ban on sales of internal combustion vehicles in 2035 could lead to a loss of 189,000 jobs in 2040. At the same time, CO_2 emissions would fall 36% between 2021 and 2050[50].

Box 3 : Adverse variants requested from ADEME, CIRED and SEURECO

At our request, the French Ecological Transition Agency (ADEME) conducted simulations using the ThreeME model (version V2), with the current-trend scenario of the "Transition(s) 2050" forecasting exercise[51], as a baseline, to assess the macroeconomic effects of:

- A carbon tax increase combined with (i) tightened financing conditions, (ii) a lack of carbon tax revenue recycling and (iii) a lack of price movement in renewable energies.
- A ban on sales of internal combustion vehicles in a less favourable macroeconomic context.
- The accelerated depreciation of "brown" (non-green) assets.

[46] In the variant simulation, only the portion collected from households is returned to them in the form of a flat tax credit.

[47] Simulation conducted by ADEME (ThreeME model).

[48] Simulation conducted by SEURECO (NEMESIS model).

[49] Simulation conducted by CIRED (IMACLIM-R France model). In this model, a lack of recycling of carbon tax revenue leads to increased savings and therefore investment via feedback. This stimulus effect drives the construction sector, whereas the lack of recycling to households negatively affects composite goods consumption, which in the model includes manufacturing and services. Since there is higher employment intensity in the composite sector than the construction sector, this results in a job deficit.

[50] Simulation conducted by ADEME (ThreeME model).

[51] As part of this exercise, ADEME built four scenarios presenting technical and economic options for achieving carbon neutrality by 2050. See: Scenarios – The French Agency for Ecological Transition (ademe.fr). These scenarios were assessed compared to a current-trend scenario where no new measures are introduced. The existing energy transition measures in the current-trend scenario are as follows: residential energy retrofitting subsidies, mandatory renovations in the tertiary sector, the bonus/malus system for car purchases and purchase incentives for electric vehicles, and the carbon credit price increase in the European emissions trading system. In the current-trend scenario, fossil fuel prices fluctuate according to European Commission assumptions and long-term productivity gains follow NLCS2 assumptions.

The International Centre for Research on Environment and Development (CIRED) conducted two series of variant scenarios using the IMACLIM model (IMACLIM-R France) compared to an NGFS scenario where carbon neutrality is achieved:

- The first series assesses the consequences of an upward carbon tax trajectory, whether or not combined with a lack of recycling of carbon tax revenue.
- The second series analyses the effects of a ban on the sale of internal combustion vehicles in a context where the supply of electric vehicles declines or where there is subdued demand for them in the short term.

Economic modelling firm SEURECO used the NEMESIS model (version 5.1) to simulate two variant scenarios compared to the same baseline scenario used by CIRED:

- One where carbon tax revenue is not recycled.
- Another where the elasticity of substitution between capital and energy is cut in half, while carbon tax revenue is fully recycled.

Source : The authors.

1.4. Even if the consequences of carbon neutrality on GDP are small, they could lead to a deterioration of public finances

In the United Kingdom, the Office for Budget Responsibility[52] has estimated that even if the low-carbon transition does not have a significant impact on GDP, it could have an effect on the public debt, as the result of direct effects on revenue.

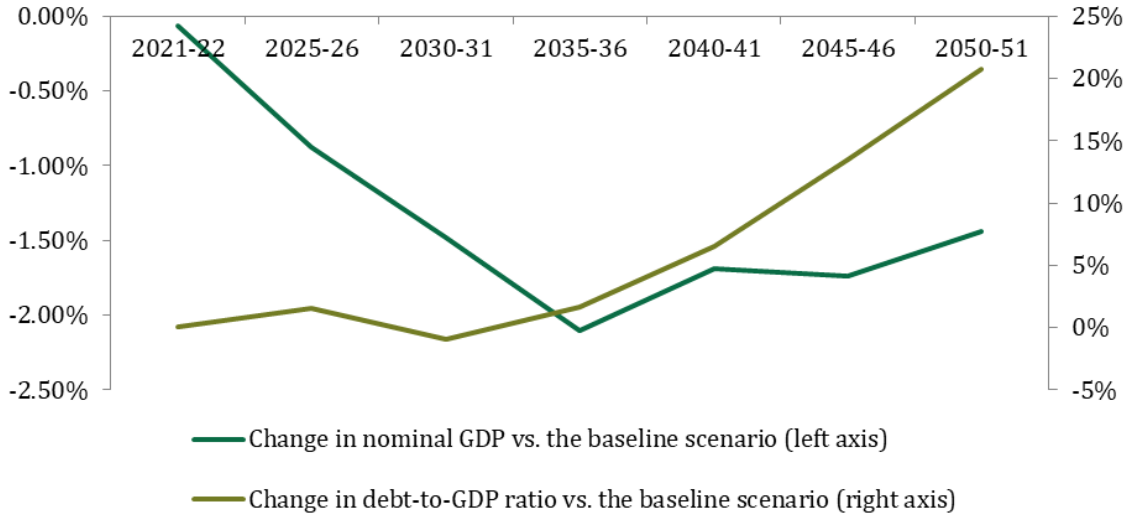
In its July 2021 Fiscal Risks Report, the Office for Budget Responsibility assessed the fiscal risks associated with the low-carbon transition using a stylised model[53]. According to the assessment, in an NGFS scenario of an orderly transition where net zero is achieved by 2050 (cf. Section 1.3.1), a moderate decline in GDP could be accompanied by a notable deterioration of public finances.

For example, by 2040–2041, nominal GDP could fall by 1.7 percentage points of GDP and the public debt could increase by 6.5 percentage points of GDP compared to the current-trend scenario where existing policies are maintained as is (cf. Chart 3). According to the Office for Budget Responsibility, this worsening debt-to-GDP ratio is attributable chiefly to a loss of revenue caused by the low-carbon transition, with the negative effect on public finances outweighing the effect of the investment shock.

[52] The Office for Budget Responsibility was established in 2010 in the United Kingdom to examine and report on the sustainability of public finances.

[53] See: Fiscal Risks Report – July 2021 – Office for Budget Responsibility (obr.uk).

Chart 3 : Change in nominal GDP and debt-to-GDP ratio in an "orderly transition" scenario compared to a "current policies" baseline scenario (in the United Kingdom)



Source: The authors, based on data from the UK Office for Budget Responsibility[54].

Applying the Office for Budget Responsibility's methodology to France, we also found risks for public finances that would warrant fiscal management.

Chart 4 shows the potential effects of carbon neutrality policies on the public debt and how these effects break down between 2020 and 2050.

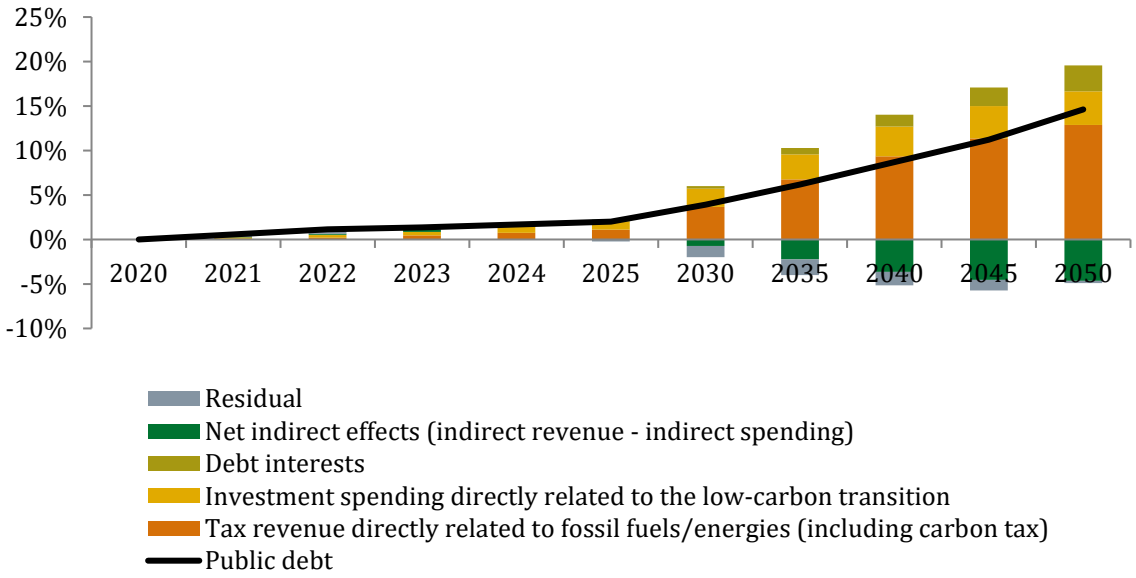
In our central simulated scenario[55], the public debt would increase by approximately 15 points of GDP in 2050 compared to the baseline scenario. The investment shock from spending directly related to the transition contributes 4 points of GDP to the upward trajectory of the public debt. Just as in the assessment conducted in the UK, the most significant risk would be the loss of tax revenue directly related to fossil fuels and energies (around 13 % of GDP).

Along the same lines as the work of the Office for Budget Responsibility, we used a stylised tool to generate an overall assessment of the effects of a low-carbon transition on public finances. Although these preliminary results could be refined and rely on assumptions from the simulated scenario, they can be considered to be sufficient to illustrate the need for fiscal management of climate mitigation policies.

[54] There is open access to the data we used: https://obr.uk/download/july-2021-fiscal-risks-report-supplementary-tables/.

[55] Orderly low-carbon transition, additional investment spending taken from the work of the Institute for Climate Economics (I4CE), 25% of additional investment spending assumed by the government, trajectory of energy revenue taken from the work of the Tax Policy Directorate, and elasticities in relation GDP of other revenue and expenditure items of 1 and 0.5, respectively.

Chart 4 : Breakdown of the change in debt-to-GDP ratio in an "orderly transition" scenario compared to a "current policies" scenario (in France)



Sources: The authors, using data from the NGFS (GDP figures taken from transition scenarios in France), the Institute for Climate Economics (I4CE, additional investment spending required for the transition), the Tax Policy Directorate (projected tax revenue directly related to energy) and France's 2022 budget bill.

*How to read this chart: **(i)** Indirect revenue and spending are those not related to the low-carbon transition. Following the methodology used by the Office for Budget Responsibility, we assumed elasticities of 1 and 0.5 relative to GDP, respectively; **(ii)** The residual is a breakdown of the difference in the debt-to-GDP ratios between the variant scenario ("net zero 2050") and the baseline scenario ("current policies") taken from the work of the NGFS.*

2. The divide between macroeconomic/fiscal policies and climate mitigation policies must be bridged

2.1. The macroeconomic consequences of transition policies are not adequately taken into account in design of the NLCS although France has more macroeconomic assessment tools than its European neighbours

2.1.1. In France, as in most of the countries considered in this report, macroeconomic assessment of low-carbon policies does not feed back into their content

Ex post macroeconomic assessment of NLCS2 has had no impact on the trajectory.

The macroeconomic impacts of NLCS2 have been assessing using the ThreeME and IMACLIM models (cf. Section 1.1.1). The results have been published in aggregate form, although there is some sector-specific information[56]. Most importantly, the assessment took place after the underlying low-carbon transition scenario had been finalised. This macroeconomic assessment contains no economic risk analysis, whether for an NLCS2 trajectory in less favourable economic conditions or for alternative emissions reduction trajectories, for example delayed and faster.

This macroeconomic assessment met the requirement for an economic assessment of the NLCS enshrined in France's Environment Code[57] but did not affect determination of the overall emissions reduction target or the breakdown of reduction targets by year and sector, or even the choice of measures recommended by the NLCS to reach these targets.

The limited effect of feedback from macroeconomic assessment on the content of low-carbon strategies is not specific to France.

In **Germany**, the federal government has approved a climate action plan for 2050. The 2019 Federal Climate Change Act (*Bundes-Klimaschutzgesetz*) sets sector-specific annual carbon budgets subject to regular monitoring by the Federal Environment Agency and the Council of Experts on Climate Change. In 2021, following an amendment to the act, the reduction target for GHG emissions was raised to 65% below 1990 levels by 2030. A macroeconomic assessment of this target, which was confirmed by the coalition agreement of November 2021, is in progress and includes its consequences for the energy system[58].

[56] Breakdown of results for change in GDP and absolute employment change in 5 sectors for IMACLIM; net job gains and losses detailed for 27 sectors in ThreeME. Source: Ministry for the Ecological and Inclusive Transition, ibid., pp. 17-19.

[57] France's Environment Code, Article L.222-1 D, paragraph II.2.

[58] Source: Federal Ministry for Economic Affairs and Climate Action (*Bundesministerium für Wirtschaft und Klimaschutz*, BMWK), Germany.

In **Denmark** the 2020 Climate Act sets a target of reducing GHG emissions to below 70% of 1990 levels by 2030. The act further provides that mitigation targets must be met cost-effectively without weakening public finances[59]. An ex post assessment of the economic impacts of this target was carried out by Denmark's Economic Councils once the target had been set[60]. The government also publishes an economic assessment of each annual climate programme (cost to households, business and government) using guidelines laid down by the Ministry of Finance for all ministries[61]. Nevertheless, the Danish government's low-carbon strategy has not yet been subject to a macroeconomic assessment feeding back into its content. The GreenREFORM project (cf. Section 2.1.2.2) currently under development is intended specifically to provide a structure for such assessment.

In the **United Kingdom**, carbon budgets are proposed by the Climate Change Committee[62], which ensures the overall sustainability of reduction targets: the United Kingdom's nationally determined contribution entails reducing emissions by at least 68% by 2030 compared to 1990[63]. For the Sixth Carbon Budget, the Climate Change Committee used transition cost analysis with no macroeconomic feedback: in relation to GDP, transition costs were deemed acceptable, which supported the Climate Change Committee's recommendations on emissions targets[64]. In addition, an outside macroeconomic assessment of the consequences of the Sixth Carbon Budget was commissioned using the Cambridge Econometrics' E3ME model[65]. Since it was carried out after the sector-specific trajectories had been determined, the assessment did not feed back into the content of carbon budgets.

[59] OECD, Integrating Climate into Macroeconomic Modelling: Drawing on the Danish Experience, February 2021.

[60] Economic Councils, Economy and Environment, 2020, 2020 (Reports | De Økonomiske Råd (dors.dk). The Economic Councils, which are independent bodies responsible for providing the Danish government with guidance and analysis on economic and fiscal matters, comprise the Economic Council established in 1962 and the Environmental Economic Council set up in 2007.

[61] Source: Ministry of Finance (*Finansministeriet*), Denmark.

[62] The Climate Change Committee, an independent body established under the 2008 Climate Change Act, is responsible for advising the government on emissions targets and reporting to Parliament on progress made in reducing emissions and adapting to the impacts of climate change.

[63] Climate Change Committee, Sixth Carbon Budget Report (December 2020) and Impact Assessment for the Sixth Carbon Budget (April 2021).

[64] The analysis method sought to calculate the additional annual cost of producing low-carbon goods and services. The additional costs of low-carbon capital investment (such as purchase of an electric rather than an internal combustion vehicle) were estimated and then annualised. The analysis suggests that the cost of reducing GHG emissions to the target of net zero would rise to 0.6% of GDP in the 2030s and 2040s before falling to approximately 0.5% of GDP in 2050. The scenarios demonstrate the potential for slightly higher or lower costs, all around 1% of GDP or less. Source: Climate Change Committee, The Sixth Carbon Budget – The UK's Path to Net Zero, December 2020 (Part 2, Chapter 5.3).

[65] Cambridge Econometrics, Economic Impact of the Sixth Carbon Budget, December 2020.

In our benchmarking exercise, the macroeconomic assessment that seems to have had the greatest impact is that carried out by the **European Commission** in preparation for the EU's "Fit for 55" package[66], even though the assessment is not fully comparable to that for the NLCS, since its purpose was to assess the impacts of the overall target for emissions reductions by 2030 rather than an implementation strategy for this target. The assessment was carried out using three different models[67], and its results were taken into account when assessing the overall sustainability of a 55% reduction target by 2030[68] in comparison with a possible 50% reduction target. These two targets were assessed with the three models and common variants[69].

Macroeconomic assessment work has been anticipated and better managed for NLCS3, but the planning process does not guarantee that macroeconomic assessment will be properly taken into account in future decisions.

Two macroeconomic assessments with the ThreeME and IMACLIM models are planned for NLCS3, one after the second run in autumn 2022 and the other, of the last version of the scenario, in late 2023 or early 2024 (cf. Figure 1), whereas NLCS2 had only one macroeconomic assessment ex post. Governance has also been improved with the establishment of an economics working group[70] (cf. Box 2) and introduction by the DGEC of coordination between the different modellers and government departments involved in this field[71].

Nevertheless, all the conditions are not yet in place for such feedback to be organised properly.

Firstly, there has been no macroeconomic assessment of the first run, although the results have been available since June 2022 and have been supplied to the modelling teams through the NLCS3 economics working group and the *France Stratégie* working groups on macroeconomic climate models (cf. Section 2.1.2.3).

Secondly, the second-run assessment results might not be fully exploitable for decision-making because, in the context of the economics working group, the DGEC has planned assessment of only one scenario – in addition to the "with existing measures" scenario – with macroeconomic modelling[72].

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[66] European Commission, September 2020, ibid. (EUR-Lex - 52020SC0176 - EN - EUR-Lex (europa.eu)).

[67] The GEM-E3 model of the European Commission's Joint Research Centre, the E3ME model of Cambridge Econometrics and the E-QUEST model of the Directorate-General for Economic and Financial Affairs (ECFIN).

[68] The analysis of the impact of raising the target to 55% also covered the following aspects: impact on objectives for energy efficiency and share of renewables in the energy mix, sectoral impacts (including impacts on the energy system, other GHG emissions, soils, the environment, air pollution and health, biomass and land use), social impacts (employment and households) and administrative impacts.

[69] Variants covered five aspects: climate policy objectives for non-EU countries, mix of instruments to be used (extent of carbon or similar taxes), carbon revenue redistribution mechanisms, labour market imperfections and behaviour of energy-intensive industries in the EU ETS.

[70] This working group is meant to be a forum for discussing economic issues relating to the review of the NLCS. It has a number of goals: gathering views on guidelines for carbon and energy price trajectories in modelling, considering cross-sector trade-offs and determining investment trajectories, and carrying out macroeconomic assessment of the scenario (especially variants illustrating the weight of certain parameters, and sharing of assumptions for the second run) and social impact assessment of the transition (energy poverty and impact on household bills). Source: DGEC.

[71] ADEME, GCSD, Directorate General of the Treasury, I4CE. Source: DGEC.

[72] Variants for sensitivity tests are nevertheless discussed in the economics working group, without full feedback at the preparatory stage of the Energy and Climate Planning Act. These variants cover energy prices, a high-emissions climate change scenario, behavioural changes, the role of gas and the degree of reindustrialisation. Source: DGEC, NLCS economics working group.

However, the possibility of simulating a much larger number of variants and the goal of taking greater account of macroeconomic assessments when building scenarios call for enhanced management of modellers by government at a time when the economics working group has so far met only in November 2021 and July 2022 and the DGEC is managing a large number of committees in connection with France's energy and climate strategy (cf. Box 2)[73].

Proposal 1: Take greater account of macroeconomic assessment in the preparation of the Energy and Climate Planning Act, NLCS3 and bills and decrees implementing NLCS3.

2.1.2. France is well positioned for macroeconomic tools, but government departments, and the Ministry for the Economy and Finance in particular, still make insufficient use of them

2.1.2.1. In France, four macroeconomic models, mostly developed outside government, are suitable for use in the immediate future to assess climate mitigation policies

Box 4 shows the standard types of macroeconomic models used for assessments of green transition policies.

The **ThreeME model**, a multi-sectoral computable general equilibrium (CGE) model, has been developed jointly by the French Economic Observatory (OFCE) and ADEME. It provides detailed modelling of the French economy[74]. Development of the first version began in 2008 and lasted for two years. Between 4.8 and 6.4 full-time equivalents (FTEs), mostly permanent staff members, have worked on the ThreeME model at the OFCE every year since 2019[75]. Used to assess public policies, including the NLCS (ex ante), the model is able to run simulations up to 2050 on an annual basis. A microsimulation module, particularly useful for analysing the redistributive effects of low-carbon policies, and a module incorporating climate damage functions are in the pipeline.

The **IMACLIM France model**[76] – a CGE model developed by CIRED – also models the French economy in detail. The first version, a static model, began development in 1997 and led to a paper three years later[77]. At CIRED, between 13.0 and 15.5 FTEs have worked on all IMACLIM models (global, country and France) every year since 2019[78]. These models are used to assess low-carbon policies in France, including the NLCS[79]. A microsimulation module is also in use.

[73] All this management work is handled by three members of staff in the DGEC. Source: DGEC.

[74] The ThreeME model covers 24 production sectors. Source: ThreeME model | threeme

[75] Representing between €0.44m and €0.55m in wage costs and related overheads. Permanent staff accounted for 4.1 FTEs in 2019, 4.3 FTEs in 2020, 4.6 FTEs in 2021 and 4.7 FTEs in 2022. Source: OFCE

[76] There are two IMACLIM models for France: a static model (IMACLIM-S France) and a recursive dynamic model (IMACLIM-R France). CIRED has also developed a recursive dynamic model for the global economy (IMACLIM-R Monde) and for individual countries.

[77] See Hourcade et al., *"Le rôle du changement technique dans le double dividende d'écotaxes"*, *Économie et Prévision*, pp. 143-144, 2020.

[78] Representing between €1.02m and €1.17m in wage costs and related overheads. Permanent staff accounted for between 4 and 5 FTEs depending on the year. Of 14.0 FTEs in 2019 and 2020, 1.5 worked on the France models, the corresponding figures for 2021 being 2.7 out of 13.0 FTEs and for 2022 3.7 out of 15.5 FTEs (permanent and non-permanent staff, IMACLIM-R France and IMACLIM-S France). Source: CIRED.

[79] Using the IMACLIM-S France model. A dynamic version for France (IMACLIM-R) is being updated. Source: CIRED.

The **NEMESIS model**, a macro-econometric dynamic model used by SEURECO, covers not only France but also all the other EU countries. It has a degree of sector disaggregation, with a particularly developed energy module. The first version of this model was designed between 1999 and 2002 as part of the EU's NEMESIS research project. The NEMESIS model has been developed mainly in an EU framework with EU funding. The team assigned to the model consists of 4.5 FTEs[80].

From late 2022 France will also have the **Vulcain** model, a stylised general equilibrium model developed in-house by the GCSD. In 2022 the GCSD also began exploring the **CGE-Box** model[81], developed by the University of Bonn, with the aim of using it for assessment of low-carbon transition scenarios and measures in 2023.

Box 4 : Description of model types used for macroeconomic assessment of low-carbon transition policies

1. Computable general equilibrium (CGE) models

These models, which are often large-scale (tens of thousands of equations), have considerable sectoral granularity. They are calibrated using results from the literature and accounting relationships (input/output tables[82]) or to replicate ex post results. They do not incorporate intertemporal optimisation. Most of these models are resolved statically, while some can include a recursive dynamic[83].

CGE models are the type of model most commonly used to assess climate policies. The category includes **ThreeME** (ADEME/OFCE), **IMACLIM** (CIRED), **GEM-E3** (European Commission's Joint Research Centre), **ENV-Linkages** (OECD), **CGE-Box,** and **GreenREFORM**, a model currently being built in Denmark.

2. Macro-econometric models

Their long-term behaviour is very similar to that of CGE models. For the short term they are often based on a neo-Keynesian approach entailing temporary imbalances. They do not include intertemporal optimisation, and expectations are usually adaptive.

Among the macro-econometric models used for assessing climate policies are **E3ME** (Cambridge Econometrics, used to assess the "Fit for 55" package), **NiGEM** (National Institute of Economic and Social Research, used by the *Banque de France*) and **NEMESIS** (SEURECO).

3. Integrated assessment models (IAMs)

These models, offering a wealth of information about the energy sector but not so much about non-energy sectors, are fully calibrated. They are often used in a normative approach, for example to determine the optimal rise in carbon price to maximise people's welfare in a given environmental framework (a downwards emissions trajectory, for example), rather than for public policy assessment. They follow on from William Nordhaus's DICE model for calculating the best carbon emissions abatement strategy.

Combined with the NiGEM macro-econometric model, these models are used by the **NGFS** to assess its low-carbon transition scenarios (cf. Section 1.3.1).

[80] Covering all functions (finding European partners, replying to calls for proposals, establishing databases, dealing with new developments, maintaining the model, running simulations, and writing papers and reports) relating to development work and research for France and other countries. Time spent on work relating to France is estimated to be 0.5 FTEs. Source: SEURECO.

[81] A CGE model without market imbalances (no unemployment) covering multiple sectors (57) and multiple countries (use of GTAP global database with 140 countries). Source: GCSD.

[82] These tables analyse each of the nomenclature products by origin (domestic output or imports) and intended use (final consumption, export, investment).

[83] The transition from one period to the next is made by updating the parameters (such as carbon tax) or through accumulation equations (for capital, for example).

4. Dynamic stochastic general equilibrium (DSGE) models

These models explicitly take account of anticipatory behaviour in rational agents, who maximise utility, in the case of households, and profit, in the case of businesses, on an intertemporal basis under resource constraints. They include frictions in labour and goods markets and allow for a temporary deviation from long-term equilibrium, making short-term assessment more realistic. Strong and restrictive modelling assumptions tend to cramp the use of these models[84].

These tools are used to assess climate policies by introducing different substitutable technologies – brown or green – or constructing an energy sector with different energy sources (fossil, renewable).

The European Commission's Directorate-General for Economic and Financial Affairs (ECFIN) employs a DSGE model, **E-QUEST**, which remains crude in its disaggregation of other sectors of the economy[85]. E-QUEST has been used to assess the "Fit for 55" package in particular.

*Sources : The authors; Directorate General of the Treasury; Frédéric Ghersi et al., "*Les modèles intégrés économie-climat : quels usages pour quelles décisions ?*", 2021.*

2.1.2.2. The foreign institutions and government departments considered here are on the whole less well-positioned for macroeconomic tools than France

Two of the foreign government departments consulted do not yet use a dedicated model to undertake macroeconomic assessment of their low-carbon policies.

Denmark has no macroeconomic climate models at present. However, the GreenREFORM project[86] aims to develop a tool allowing concurrent assessment of the economic effects of climate policies and the climate effects of economic policies. The project consists in design of a CGE model (cf. Box 4) that is hybrid (cf. Section 2.1.2.3) and multi-sectoral, and it is to be developed by the Danish Research Institute for Economic Analysis and Modelling (DREAM)[87]. The model should be operational by the end of 2022.

At the time of writing, the Federal Ministry for Economic Affairs and Climate Action in **Germany** is not using a macroeconomic climate model to assess mitigation policies. On the other hand, the ministry commissioned outside research in January 2022 on the effects of climate change and of climate mitigation and adaptation measures on overall economic development and on potential output in the short (1 to 3 years), medium (4 to 8 years) and long term (2045 and beyond). The research aims at describing transmission channels first qualitatively, and then empirically and quantitatively[88].

Another government department and an institution have commissioned internal or external assessments using macroeconomic models, but there seem to be less tools available than in France.

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[84] For example, the values assigned to certain parameters are constrained by the model in order to ensure an equilibrium path.

[85] Sectors are grouped into seven categories: two energy-providing categories, three capital-producing categories (sectors manufacturing goods that for their subsequent use will require fossil fuels, electricity or no energy), an emission-intensive category and a category covering the rest of the sectors. See Varga, Roeger and in 't Veld, "E-QUEST: A Multi-Region Sectoral Dynamic General Equilibrium Model with Energy", Discussion Paper 145, European Commission, September 2021.

[86] See https://dreamgroup.dk/greenreform/

[87] The DREAM group is an independent government institution that conducts a variety of statistical and descriptive analyses of the Danish economy. It provides economic models, demographic projections and quantitative analyses, and users include ministries, NGOs and think tanks. Source: DREAM | About us (dreamgroup.dk)

[88] Source: Federal Ministry for Economic Affairs and Climate Action (BMWK), Germany.

In the **United Kingdom**, Treasury investment in macroeconomic climate models is recent[89]. The Treasury currently uses two models: the NiGEM macro-econometric model (climate extension) and a CGE model (cf. Box 4) that the Treasury has built on the basis of existing models[90].

In our benchmarking exercise, the **European Commission** was the best positioned of the institutions considered. Macroeconomic assessment of the "Fit for 55" package was carried out with three different models: the Joint Research Centre's GEM-E3, the E3ME model of Cambridge Econometrics and the E-QUEST model of the Directorate-General for Economic and Financial Affairs (ECFIN).

2.1.2.3. All macroeconomic models used to assess low-carbon policies in France and abroad have the same features and limitations

At least two features of macroeconomic climate models set them apart from traditional macroeconomic assessment tools.

The **sectoral disaggregation** specific to these models – especially CGE and macro-econometric models – presents technical challenges. Calibration or estimation of parameters must attain a degree of precision that cannot always be satisfied by the available data[91]. In the case of a multi-country model, consistency must be ensured between national accounts and international trade data at a sectoral level that is more granular than in traditional macroeconomic models, while these databases must also include environmental extensions.

A **hybrid approach** consists in combining a macroeconomic structure with technical and economic modules in order to incorporate technical constraints reflecting physical and climatic realities documented by engineers. In the technical and economic modules, for example, energy consumption is not automatically linked to household income as in conventional macroeconomic models but is linked instead to housing or capital stock (vehicles, for example) or to the energy intensity of goods in the consumption basket. Utilisation of an item of capital may increase with disposable income or reach a saturation level owing to physical criteria. The hybrid approach thus increases model complexity by introducing non-linearities and threshold effects that disrupt solving algorithms.

From a government standpoint, these technical features create a "black box" effect that may limit the scope of climate policy assessment.

Firstly, the models' highly technical nature – especially in the case of CGE models – and use[92] makes it difficult to understand transmission channels and interpret results informing public policy choices, especially if macroeconomic assessment is outsourced.

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[89] The Treasury did not have any macroeconomic climate models when the Sixth Carbon Budget was being proposed by the Climate Change Committee in December 2020. The impact assessment published by the government in April 2021 was carried out on the basis of abatement costs. The Net Zero Review published in October 2021 drew on outside models for its macroeconomic assessments. Source: HM Treasury, United Kingdom; Impact Assessment of the Sixth Carbon Budget, pages 50 and 51, paragraphs 187 and 188; Net Zero Review, Chapter 1, pp. 11-13.

[90] GTAP and CGE-Box. Source: HM Treasury, United Kingdom.

[91] For example, disaggregating electricity production by different energy sources requires definition of an equal number of production functions with specified quantities of labour and capital.

[92] For example, there are 14,000 equations and 70,000 parameters in the ThreeME model (source: Directorate General of the Treasury), and one to two hours of computing would be necessary to calibrate the GreenREFORM model and simulate a shock (source: Danish Research Institute for Economic Analysis and Modelling).

Secondly, a number of frictions are not adequately captured by existing models, such as labour market imbalances or capital crowding-out effects (in the ThreeME model used to assess NLCS2 (cf. Section 1.3.3) or the GreenREFORM model in Denmark, for example[93]). The sensitivity of macroeconomic variables to these imbalances when climate mitigation polices are implemented is thus not properly understood. Consequently, in April 2022 *France Stratégie* set up working groups associating modellers and government departments in order to improve macroeconomic models to assess the effects of climate transition.

Proposal 2: Formalise a joint initiative between government and climate macroeconomics research institutions in order to continue improving models for assessing low-carbon policies and implement an interministerial roadmap for priority improvements to these models.

2.1.2.4. In France, government departments have taken different approaches to the models available for assessing the macroeconomic effects of low-carbon policies although these models are open-source and relatively well documented

ADEME is the main user of these models, particularly ThreeME, among French government departments. Two modellers in the agency's teams have expert knowledge of the ThreeME model and carry out assessments of the NLCS[94]. ADEME has entered into an annual research agreement with the OFCE, which is the principal source of funding for development of the ThreeME model[95]. The agency has also been the leading commissioner of research in France using the IMACLIM model between 2019 and 2022[96] and the second leading commissioner for NEMESIS over the same period[97].

The **GCSD** has published with ADEME a joint assessment of NLCS2 using the ThreeME model[98]. For this, it audited and adopted the model. The GCSD, which has 1.5 modeller FTEs for macroeconomic tools to assess climate policies[99], is now focusing on exploration and development of other models[100] to supplement ThreeME.

[93] The model under development has a fixed nominal interest rate at this stage, given the characteristics of the Danish economy (small open economy with currency pegged to the euro). Source: Danish Research Institute for Economic Analysis and Modelling (DREAM).

[94] Source: ADEME.

[95] €263,000 per year on average between 2019 and 2022. Source: OFCE.

[96] Over this period, ADEME commissioned three studies amounting to a total of €210,000. The other contracts came from the Ministry for the Ecological Transition, totalling €110,000, and the French Development Agency for capacity transfers, totalling €784,000. Source: CIRED.

[97] *France Stratégie* commissioned two studies relating to forward planning for jobs and skills, and ADEME one study for the LIFE programme. Source: SEURECO.

[98] Ministry for the Ecological and Inclusive Transition, February 2022.

[99] Two researchers each devoting 0.75 FTEs to modelling work. Source: GCSD.

[100] The Vulcain model and tailoring CGE-Box to France for the macroeconomic models. Source: GCSD.

The **Directorate General of the Treasury** has not commissioned any of the studies by OFCE, CIRED or SEURECO since 2019. The directorate has not signed any research agreements with these bodies. On the other hand, it has assigned 1.15 modeller FTEs for the adoption of two models: ThreeME and Oxford Economics. This investment is recent[101] but significant[102]. The teams of the Directorate General of the Treasury have had no recent training in use of ThreeME[103] and have not so far communicated with CIRED teams regarding their exploratory work on the models.

However, most of these macroeconomic models are available and relatively well documented (cf. Table 1).

The CIRED and OFCE research teams have chosen open-source models that can thus be used by different government departments. The third version of the ThreeME model is open-source, with full documentation and access to the code and data providing the calibration. The fourth version of ThreeME will be made available in free format during 2023. The code for the IMACLIM-S France model is open-source, and documentation for the country model is available[104].

As for the NEMESIS model, the documentation is freely accessible but not, at present, the code. Continuing development of the model in a European framework will result in greater access to the model's code in coming years. It is thus expected to become open-access when the building of its global version begins in December 2022. The code should thus be published as open-source by 2026[105].

Table 1 : Accessibility of different versions of ThreeME and IMACLIM models

Model and version	Availability of data (Y/N)	Accessibility of code (Y/N)	Availability of technical documentation [*data,estimation and calibration*] (Y/N)	Availability of technical documentation [*scenario simulation*] (Y/N)
ThreeME				
Version 1	N	N	N	N
Version 2	Y	Y	Y	Y
Version 3	Y	Y	Y	Y
IMACLIM				
IMACLIM-S France	Y	Y	Y	N
IMACLIM-R Monde	N	N	Y	Y
IMACLIM-R France	N	N	Y	Y

Sources: OFCE, CIRED.

[101] Preliminary exploration of ThreeME started in 2020. Work on the models proper began early in 2021 with adoption of ThreeME and was stepped up from September 2021. Source: Directorate General of the Treasury.

[102] The Macroeconomic Policy France Office of the Macroeconomic Policy Sub-directorate has 4 modellers for macroeconomic models. Source: Directorate General of the Treasury.

[103] Five people were trained for Version 1 of ThreeME, 12 for Version 2 and 11 for Version 3. These people are in the OFCE, GCSD and ADEME. Source: OFCE.

[104] For IMACLIM, an open-access Python code designed to cover all country models is in the pipeline. It should also be possible to recode the technical modules of the IMACLIM-R France model on the Python platform (in six months' time at an estimate). Source: CIRED.

[105] Source: SEURECO.

2.1.3. The Ministry for the Economy and Finance must become more involved in macroeconomic management of low-carbon policies, which must include use of stylised tools and targeted studies, as in other European countries

The purpose of our benchmarking exercise was not to compare the organisation of the Ministry for the Economy and Finance in France with government departments abroad. However, the exercise has made it possible to **gather some pointers** to the human and financial resources enlisted for macroeconomic management of low-carbon policies.

Among our European neighbours, more involvement by the Ministry for the Economy and Finance is reflected in more human and financial resources and use of stylised assessment tools.

Thus 15 to 20 people – to whom may be added the officials dealing with climate policy in other teams – make up the climate coordination team in the **United Kingdom Treasury** and are responsible for producing the Net Zero Review, an analytical report exploring the key issues of decarbonising the UK economy. In **Denmark**, 25 people[106] were involved in the setting-up of the Centre for Climate, Green Economy and the EU within the Ministry of Finance, which is playing a lead role in the GreenREFORM project (cf. Section 2.1.2.2)[107].

As for modelling resources, three modellers have adopted and adapted the CGE-Box model in the **United Kingdom**[108]. In the Directorate-General for Economic and Financial Affairs (ECFIN) of the **European Commission**, 1 to 2 FTEs are responsible for climate macroeconomics. They have developed the E-QUEST model, which is used to assess the macroeconomic consequences of mitigation policies[109].

Regarding financial resources, in 2019 the Ministry of Finance in **Denmark** joined the GreenREFORM project by funding the establishment of a dedicated model group with four economists and four research assistants in the Danish Research Institute for Economic Analysis and Modelling (DREAM). The project's grant from the Ministry of Finance totals some €2m over the period from October 2019 to the end of 2022[110]. In **Germany** the Federal Ministry for Economic Affairs and Climate Action has approximately €11m annually to commission external research from economists[111]. This money has been used, for example, to initiate a study in January 2022 on the effects of climate change and of climate mitigation and adaptation measures (cf. Section 2.1.2.2).

Lastly, in the **United Kingdom** and **Germany**, for example, these human and financial resources are also enlisted to manage economic assessments of climate policy that are not based on dedicated macroeconomic models (cf. Box 5).

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[106] Redeployment and new posts. Source: Ministry of Finance, Denmark.

[107] Development of GreenREFORM is officially divided into a research project funding a research group comprising researchers from the University of Copenhagen and Aarhus University and a project supported by a grant from the Ministry of Finance in 2019, which funds a full-time model group. Source: Project description (dreamgroup.dk).

[108] Source: HM Treasury, United Kingdom.

[109] Source: European Commission, ECFIN.

[110] Source: Danish Research Institute for Economic Analysis and Modelling (DREAM).

[111] Source: Federal Ministry for Economic Affairs and Climate Action (BMWK), Germany.

Box 5 : Stylised tools for macroeconomic assessment of low-carbon policies

1. United Kingdom: the Treasury's Net Zero Review[112]

In the United Kingdom, the Treasury announced in 2019 that it would publish an analytical report, the Net Zero Review, using existing data to analyse the key issues and trade-offs as the United Kingdom has decarbonised, against a backdrop of significant uncertainty regarding technologies and costs as well as changes to the economy over the next thirty years.

The first Net Zero Review was published in October 2021. It covered the following issues: the overall impact on the economy of the transition to net zero, the impact on competitiveness and analysis of carbon leakage, the impact on households and factors affecting the degree of household exposure to the transition, the public policy levers that could support the transition, especially in the field of carbon pricing, and the fiscal implications of transition policies.

The Net Zero Review is not based on a macroeconomic model in the narrow sense. It brings together qualitative and quantitative analyses, both internal and external, which sometimes apply to other countries and different types of tools and data. The Net Zero Review further draws on the results of available macroeconomic assessments[113]. It also makes use of data from simplified models such as that of the Office for Budget Responsibility (cf. Section 1.4) and databases (from the OECD, for example) to determine the relative exposure of certain sectors or household categories. The study has also used other ministries' sectoral models.

The Net Zero Review assumes a degree of uncertainty. It is the result of an iterative process, with a first interim report published in autumn 2020 and a final report in October 2021. Two of the six chapters of the final report, concerning households' exposure to the transition and developments relating to electricity bills, explicitly takes on board the implications of this degree of uncertainty in the assessment.

2. Germany: a study of potential output published in connection with the spring 2022 forecasting report

In Germany, the Leibniz Institute for Economic Research (RWI) has examined the possible impact of transition policies on potential output through two transmission channels: changes in the energy mix and the quickening pace of capital depreciation. The RWI has studied these two channels separately and without macroeconomic feedback.

To assess the impact of lower energy consumption and changes in the energy mix, the study changed the production function usually used by the institute in order to estimate Germany's potential output in keeping with EU guidelines[114]. Thus a production function with constant elasticity of substitution, and an energy subaggregate, has been modelled[115]. On this basis the RWI has made various assumptions for energy-saving technological progress in order to put figures on the technological advances needed to achieve the potential output that has been forecast, with the original model, by the leading research institutes.

The RWI has also assessed the impact of stranded assets by varying the asset depreciation rate, for the major asset categories, with a constant investment rate.

Sources: HM Treasury, "Net Zero Review: Analysis exploring the key issues", 2021; BMWK, "Gemeinschaftsdiagnose" (forecast by Germany's leading economic institutes), spring 2022.

[112] Net Zero Review Final Report - GOV.UK (www.gov.uk).

[113] Such as those of Cambridge Econometrics or the European Commission. Source: Net Zero Review, October 2021.

[114] European Commission, "The Production Function Methodology for Calculating Potential Growth Rates and Output Gaps", Economic Papers 535, November 2014.

[115] On the work behind the RWI's method, see in particular: Directed Technical Change as a Response to Natural-Resource Scarcity (su.se)).

In France, fewer resources seem to be allocated by the Ministry for the Economy and Finance to macroeconomic management of climate neutrality policies than elsewhere.

The aim of the mission was to examine how the macroeconomic and fiscal implications of the transition have been taken into account. It was not to consider how climate issues are addressed in the work of the Directorate General of the Treasury as a whole. When it comes to coordination, the Directorate General of the Treasury can count on a high-level expert with responsibility for climate and environmental issues. The directorate has also recently made an investment in macroeconomic climate models (1.15 FTEs in the Macroeconomic Policy France Office[116], cf. Section 2.1.2.4). The ensuing resources nevertheless seem scantier than in the United Kingdom, Denmark or the European Commission regarding the practices covered by our benchmarking exercise.

Furthermore, the Directorate General of the Treasury has no budget for commissioning research or participating in further development of models from outside research organisations to assess mitigation policies, and this is now reflected in the directorate's absence from model governance (cf. Section 2.1.2.4).

Proposal 3: Within the Ministry for the Economy and Finance, establish in-house capacity for macroeconomic assessment of carbon neutrality policies by adopting and adapting existing macroeconomic climate models rather than building new ones.

To be operational in the short term, this in-house assessment capacity, which would be in the Directorate General of the Treasury, must be based on **adopting models that are free, accessible and already known** to government departments (the OFCE's ThreeME model and one of CIRED's IMACLIM models) rather than building new ones.

If the Ministry for the Economy and Finance is to play a larger part in macroeconomic assessment of climate policies, **adoption of models must be comprehensive** (audit of model and independent ability to run simulations – assessment of the NLCS, for example) and include, where necessary, modifying the model to create an in-house version.

Proposal 4: Despite the uncertainty surrounding the macroeconomic effects of carbon neutrality policies, encourage assessment of such policies by means of stylised assessment tools.

Straight away, the macroeconomic consequences of low-carbon policies on **potential output** could be analysed further using models without macroeconomic feedback, following the example of what was found in Germany.

Drawing on the model of the UK Treasury's **Net Zero Review**, the Directorate General of the Treasury could lead an assessment of the economic effects connected with the transition to a low-carbon economy without relying solely on macroeconomic modelling tools and also accepting that such an exercise would presuppose, at present, some degree of uncertainty. This review, which would be published in the shape of a specialist or general report, would cover:

- Assessment methods for the macroeconomic and fiscal impact of GHG emissions reduction policies.
- Recognition of such assessments in macroeconomic and medium-term fiscal projections.
- Principal fiscal risks associated with implementation of these policies.

The review might be formalised within one year of the adoption of the next NLCS.

[116] These staff are assigned to identifying and analysing existing models, adopting them and participating in work led by *France Stratégie* (cf. Section 2.1.2.3) and the NLCS economics working group (cf. Box 2).

2.2. NLCS3, which will derive from the Energy and Climate Planning Act, will be difficult to align with the next Public Finance Planning Act

2.2.1. NLCS2 did not lend itself easily to fiscal assessment, while at this stage the impact of NLCS3 – now in preparation – on public finances has not been costed

The fiscal cost of the measures needed to implement NLCS2 was not calculated when the strategy was being designed.

This lack of costing was due to absence of information on all the measures needed to achieve the targets. This failure to clarify the strategy also adversely affected the macroeconomic assessments. In NLCS2 a significant proportion of the measures needed to reach the targets were as yet unidentified, entailing a prospective overshoot of the 2050 emissions target by some 17 million tonnes of CO_2[117].

Nor were the measures already identified in NLCS2 costed on a consolidated basis by the DGEC or Budget Directorate. The accuracy of such costing would have depended on the measures, since NLCS2 did not always specify the details of implementation (schedule and/or scope, for example) required for costing[118]. This costing would have needed a cross-sector approach, as the NLCS covers all sectors of the economy, unlike the Multiannual Energy Plan, which specifically focuses on renewable energy development trajectories and the associated budgets.

The Energy and Climate Planning Act does not include a component concerning the resources needed to fund it, and the working groups led by the DGEC have not made any consolidated assessments of this aspect, despite the very first version of the low-carbon transition scenarios having been produced in June 2022.

The purpose of the Energy and Climate Planning Act is to determine the goals of energy policy and of mitigation policies[119]. For one of these goals, energy retrofitting, the fiscal impact is spelt out in law[120], but the law is not expected to lay down the corresponding trajectory or financial incentives[121]. The relevant public resources are instead supposed to be set out in the Multiannual Energy Plan.

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[117] Source: ADEME, "*Évaluation d'un scénario NLCS 2 sans hausse de taxe carbone et sans prix fictifs ad hoc*", June 2020. Getting rid of ad hoc shadow prices (cf. Box 1) on the assumption of the energy mix originally forecast in NLCS2 results in excess emissions of some 17 million tonnes of CO_2.

[118] For example, NLCS2 recommends making it easier to charge vehicles at home and at the workplace by supporting, amongst other things, provision of charging infrastructure for multi-family housing through regulatory and legislative measures and financial aid. It also recommends providing more financial support for all households for retrofitting, speeding up investment in building renovation, and making public buildings a model of energy efficiency, with the target of a 15% reduction over 5 years. Source: National Low-Carbon Strategy, March 2020.

[119] France's Energy Code, Article L.100-1 A.

[120] France's Energy Code, Article L.100-1 A, I.5: "Attainment of these goals [for energy retrofitting in the construction sector] shall be based on greater financial incentives for efficient and comprehensive energy retrofitting […] through introduction of a stable system of fiscal support, government tax incentives […]".

[121] By contrast, the Energy and Climate Planning Act is to determine the pace of retrofitting on the basis of Article L.100-1 A of the Energy Code.

However, whether or not financial resources are included in the Energy and Climate Planning Act, it ought to be possible to show that the act is compatible with multiannual fiscal planning, as is the case for all other planning acts[122]. The constitutional bylaw of 28 December 2021 provides that the government shall refer provisions of planning bills with a fiscal impact to the High Council of Public Finance[123]. Yet at this stage, the mission has not found any consolidated assessments of the costs of the initial measures identified by the sectoral working groups or any information on their relative efficiency.

Costing of the measures nevertheless seems possible given the first run for NLCS3 (cf. Figure 1) submitted in early June 2022 by the DGEC in the context of the working groups on France's energy and climate strategy. It contains draft measures that could be costed and assessed: some already have been costed[124], and others continue or bolster measures that already have a record of expenditure[125]. For other measures, costing could be done on the basis of the assumptions used in the first run and knowledge of current arrangements[126].

Proposal 5: Strengthen management of the multi-year fiscal effects of the mitigation policies set out in the Energy and Climate Planning Act and NLCS3.

A dual approach to assessment might be taken here:

- Produce assessments with the emphasis on **costing and efficiency**, taking particular account of abatement cost curves, if available, or expected effectiveness according to sectoral work on the NLCS. Work relating to efficiency of measures could draw on assessments carried out by the working group managing macroeconomic assessments (cf. **Proposal 1**).
- Employ **stylised tools** making it possible, in the course of NLCS3 runs and implementation, to carry out a consolidated assessment, for revenue and expenditure, of the potential fiscal impacts of NLCS3 (cf. Section 1.4).

2.2.2. Potential growth assumptions, used to develop the next Public Finance Planning Act, could take greater account of the effects of mitigation policies

The assumptions about potential growth made by the Ministry for the Economy and Finance in France do not expressly include the consequences of mitigation policies.

The macroeconomic simulations that were gathered (cf. Section 1.3.3), together with the fiscal assessments surveyed abroad (cf. Section 1.4), suggest that transition policies may have adverse effects on the economy in the short and medium term that are not taken into account at present.

The mission has therefore tried to identify climate entry points[127] in construction processes for short- and medium-term fiscal forecasts, together with assumptions underlying potential growth.

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[122] In view of the opinion from the Conseil d'État of 17 December 2020 on the planning bill for solidarity-based development and combating global inequalities, it would seem possible to consider the Energy and Climate Planning Act a programming (planning) act within the meaning of Article 34 of the French Constitution because its content covers quantified goals for government in the field of energy. Source: Budget Directorate.

[123] Constitutional Bylaw 2021-1836 of 28 December 2021 on modernising the management of public finances, section 30.

[124] Forests and soils, for example: €500m for forestry consolidation (France 2030 investment plan).

[125] Such as, for industry, extension of the recovery plan's call for projects (including France 2030), and, for buildings, doubling of the heat fund by 2025 and support until 2050.

[126] For example, for buildings, retrofitting of all poorly insulated homes by 2028 (to Category B/C/D).

[127] To ensure that existing public financial management procedures provide effective support for adaptation and mitigation policies, the IMF has identified various entry points within the budget cycle for taking account of climate

The estimate of potential growth made by the Directorate General of the Treasury is based on a modelling of total factor productivity, labour input and capital input[128] that does not expressly take account of low-carbon transition policies.

Thus the next Public Finance Planning Act for 2022-2028 will be based on potential growth assumptions that fail to reflect the possible effects of low-carbon policies.

Our benchmarking exercise nevertheless suggests that implementation of mitigation policies is likely to affect potential output as well as macroeconomic and fiscal central projections.

In **Germany**, government forecasts, guided by the projections of five independent economic research institutes[129], have not, to date, expressly factored in low-carbon transition policies.

However, an analysis has been published in connection with the spring 2022 forecast (cf. Box 5)[130] that sets out to assess the consequences of decarbonisation on potential output by examining two vectors:

- By 2030 the capital stock could decline by 1.5% to 3% because of accelerated depreciation of certain assets, and, as a consequence, potential output would fall by 0.5% to 1.1% in relation to the "current policies" baseline scenario.
- If Germany is to reach the same level of output by 2030 as that hitherto projected by the five institutes in their joint forecast whilst reducing energy consumption to cut GHG emissions by 65% by 2030 in comparison with 1990, a leap in technical progress will be necessary to make energy efficiency gains. The energy efficiency growth rate would have to reach 5.6% on average for the 2020-2030 period, as against 2.7% for the period from 1973 to 2019, a similar increase to that recorded after the first oil shock.

Lastly, in the **United Kingdom**, in its most recent fiscal risks report dated July 2022[131], the Office for Budget Responsibility has included two fiscal impacts of the low-carbon transition in its long-term central projections[132]:

- Loss of revenue from motoring and fossil-fuel taxes.
- A modest reduction in productivity growth (of around 0.1% of GDP a year up to 2050) that might be attributable to the low-carbon transition.

goals (strategic planning and fiscal framework, budget preparation, budget execution and accounting, control and audit). For the strategic planning stage, the IMF suggests that macro-fiscal forecasting and modelling that incorporate climate and environmental impacts can inform the preparation of fiscal strategy. According to the IMF, climate change, like other important structural changes (such as population ageing), should be factored into long-term fiscal sustainability analysis, at least qualitatively. Source: IMF, Climate-Sensitive Management of Public Finances, IMF Staff Climate Notes, August 2021.

[128] Directorate General of the Treasury, *Lettre Trésor-Éco*, No. 206, September 2016.

[129] Deutsches Institut für Wirtschaftsforschung (DIW) Berlin, ifo Institut, Kiel Institut für Weltwirtschaft (IfW Kiel), Leibniz-Institut für Wirtschaftsforschung Halle (IWH) and RWI.

[130] Source: *Gemeinschaftsdiagnose 2022*, spring 2022 report, chapter on effects of decarbonisation on potential output (p. 79) and background paper on energy-saving technical progress.

[131] See Fiscal risks and sustainability – July 2022 - Office for Budget Responsibility (obr.uk)

[132] Direct impacts on public spending have not been considered, since the UK government has announced that green investment will be included in the scheduled increase in public investment. Nor has the Office for Budget Responsibility included in its central scenario any assumption of new direct revenue from carbon tax, since the government has made no announcements concerning the carbon tax trajectory and the potentially protracted increase in energy prices poses a risk to such revenue.

Paris, 16 August 2022

Charles Murciano, Inspector of Finance

Thomas Brand, Inspector of Finance

Aude Costa de Beauregard, Inspector of Finance

Selma Mahfouz, General Inspector of Finance

APPENDIX 1

Glossary

Appendix 1

AM Scenario	Additional Measures Scenario
ADEME*	Ecological Transition Agency
CGE	Computable general equilibrium
CIRED*	International Centre for Research on Environment and Development
CM Scenario	Constant Measures Scenario
DGE	Directorate General for Enterprise
DGEC	Directorate General for Energy and Climate
DREAM	Danish Research Institute for Economic Analysis and Modelling
ECFIN	Directorate-General for Economic and Financial Affairs
EU	European Union
FTE	Full-Time Equivalent
GCSD[1]	General Commission for Sustainable Development
GDP	Gross Domestic Product
GHG	Greenhouse Gas
I4CE	Institute for Climate Economics
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
NGFS	Network for Greening the Financial System
NLCS[2]	National Low-Carbone Strategy
OECD	Organisation for Economic Co-operation and Development
OFCE	French Economic Observatory
RWI	Leibniz Institute for Economic Research

* French acronym.

[1] *Commissariat général au développement durable* (CGDD).

[2] *Stratégie nationale bas-carbone* (SNBC).

APPENDIX 2

Statement letter

GOUVERNEMENT
Liberté
Égalité
Fraternité

April 22, 2022

Subject: Building capabilities and tools to better incorporate climate change mitigation targets into macroeconomic and fiscal policymaking (and monitoring)

France has committed in the 2019 Energy and Climate Law to reduce greenhouse gas emissions that France so as to achieve carbon neutrality by 2050. Meeting this commitment will require that all economic agents significant change their behaviors in the coming years. The resulting sectoral, regulatory and economic policy changes could represent a macroeconomic shock of an unprecedented nature in the years to come.

In this context, evaluating the macroeconomic and fiscal impacts of the climate transition, which are still poorly documented, is a priority. A first step is to identify and quantify the economic impact of the shocks induced by the transition to net zero. Combined with the assessment of the environmental effects of public policies, it should aim at enhancing the coherence and effectiveness of all the policies implemented to achieve the objective of carbon neutrality, and thus improve their management. These evaluations also respond to a growing demand for transparency on the environmental, economic and social effects of climate policies and the capacity of public policies to achieve climate objectives.

Such evaluations should be strengthened, both institutionally and methodologically. The French High Council for the Climate (HCC) regularly formulates advices along these lines, recommending in particular that government departments strengthen their ability to evaluate qualitatively and, if possible, quantitatively new measures. The preparatory work for the "Environmental" component of "France Relance", the French investment package launched in September 2020 to recover from the sanitary and economic crisis, or the Climate and Resilience Law, have recently shown the limits of the tools and methodological frameworks available to administrations in order to evaluate the macroeconomic effects of various sectoral and cross-cutting measures necessary to achieve our climate objectives. This need is widely shared by experts, both nationally and internationally.

At a time when academics and institutions are reflecting on how to renew the macroeconomic analysis of the climate transition, it seems necessary to identify the objectives and priorities, from the point of view of public action, in order to strengthen the analytical capacities and the tools for assessing the impact of shocks and measures implemented to achieve carbon neutrality. More specifically, the tools will need to assess the expected macroeconomic and fiscal impacts of the climate transition.

1/ The "*Inspection générale des Finances*"[1] is tasked by the Minister of Economy and Finance to identify existing tools for assessing the macroeconomic and fiscal effects of the climate transition and make recommendations to improve the analytical framework available, building on ongoing work.

The administrations lack appropriate tools to estimate the specific macroeconomic and fiscal effects of the climate transition within a unified framework. On the one hand, simulation models integrating energy, either stylized or more detailed from a sectoral point of view, have been developed, as well as technical-economic models, which provide optimal trajectories under emission constraints in particular. On the other hand, the administrations and services of the French Ministry of Economy and Finance rely on tools, notably macroeconomic models, to carry out macroeconomic evaluations and forecasts. As it stands, these models do not take into account sectoral specificities. In addition, they do not include emission trajectories, which means that public policy scenarios compatible with the transition to a lower carbon economy must be calibrated outside the model.

In parallel with the preparation of the third French transition plan to lower carbon emissions ("*SNBC3*"), the team will draw up an overview of the main economic transmission mechanisms at play in the transition and the existing tools that will allow us to better identify both the macroeconomic and fiscal consequences of the public policies implemented to achieve our climate objectives. To do this, the team will analyze the tools and methods that already exist within the administration and the academic world, drawing on the work launched at the national level by *France Stratégie* and at the international level, in particular by the network of central banks for greening the financial system (NGFS) in the context of the G7 Finance. More broadly, the team will consider the use of these tools to (i) calibrate public policy scenarios consistent with emission reduction objectives and (ii) assess the macroeconomic and fiscal effects of the transition, depending on the tools used for its implementation.

Based on this overview, the team will propose recommendations on the tools that could be developed and then operationalized or used in the short and medium term to support better policy making. These tools will have to provide assessments on (i) the impacts of the transition on GDP and its composition (investment/consumption) in order to achieve the targeted reduction in emissions, depending on the levers mobilized, (ii) the implications in terms of employment and (iii) their implications for public finances.

[1] General auditing and consulting service under the authority of the French Minister of the Economy and the Minister of the Budget.

2/ The IGF team will also have to identify the ways in which these tools could be developed and implemented.

Several options may be considered: inter-administration work, delegation to a specific public entity or a new or existing independent authority. In particular, the mission could provide technical orientations for the work being launched on the subject by *France Stratégie*. In addition, the team could assess the additional human resources required to operate these new tools for assessing emissions reductions efforts and the economic and fiscal impact of the associated measures. The recommendations could draw inspiration from similar practices in other countries. The team will pay particular attention to the agility, reliability and transparency induced by the different organizational options. The recommendations that have a link with fiscal policy making will have to be articulated with the French budgetary procedure.

The IGF team will be able to rely on the expertise of the French Treasury, Budget Department and the National Institute of Statistics and Economic Studies. It could also rely on the services of *France Stratégie* and consult more widely with qualified persons (especially economists), institutes with expertise in public policy evaluation or European and international institutions.

Finally, it is expected to draw on practices and models developed abroad, for example in the United Kingdom and Denmark.

The conclusions are expected by the end of July 2022.