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Mésange Vert, a New Model to Assess the Impact of Economic Shocks on France's Carbon Emissions

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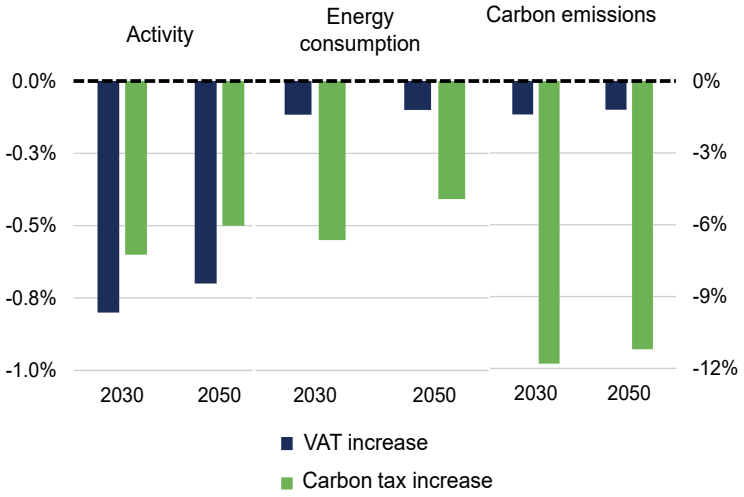
- Mésange Vert extends the scope of the macroeconomic model Mésange (*Modèle économétrique de simulation et d'analyse générale de l'économie*) used by the French Treasury (*DG Trésor*). The new module quantifies the impact of economic shocks and policy reforms on France's carbon emissions in the medium and long terms. Besides measuring the climate impact of standard shocks, it is also a useful addition to the toolkit for assessing economic and climate policies.

- Mésange Vert is structured in two parts: energy and climate. The energy component gives a stylised view of the country's final energy consumption and how it breaks down between gas, electricity and other sources, while the climate component calculates the carbon emissions associated with this energy profile.

- The module is designed to be extremely flexible to use: the default settings include several energy sources (electricity, coal, oil and gas) and two economic agents (households and firms). Other features, such as the method for calculating energy demand and calibrating the model can all be easily adjusted as needed to fit modelling requirements.

- Mésange Vert can be used, for example, to analyse and compare the economic and climate effects of a permanent increase in VAT and the carbon tax to generate extra revenue equivalent to one percentage point of ex ante GDP in each case, without recycling the revenue generated. Compared to a VAT increase, putting up the carbon tax would have a slightly lower negative impact on the economy. And, by specifically targeting energy use, the carbon tax option would lead to a far greater reduction in energy consumption than a VAT increase. In addition, the carbon tax would encourage households and firms to switch from fossil fuels to electricity, making the reduction in emissions proportionally greater than the drop in energy consumption.

Comparison of the effects of a VAT and carbon tax increase equivalent to 1% of ex ante GDP on economic activity, energy consumption and carbon emissions (In % deviation from a baseline scenario)



Source: Mésange and Mésange Vert; DG Trésor calculations.

Note: shocks are first simulated in the model Mésange to estimate their impact on the main economic aggregates and then fed into Mésange Vert. The left axis shows the impact on activity and the right axis the effect on energy consumption and carbon emissions.

1. Effective green transition policies call for an array of analysis tools[1]

Any assessment of green transition and broader economic policies must estimate how effective they are in achieving their economic and climate objectives. Ultimately, the aim is to compare the outcomes of the measures and minimise their costs. Policy assessments can be classed in two main categories:

- Microeconomic analysis identifies the impact of a given measure on specific economic agents (such as households or firms) and use econometric techniques, modelling and more qualitative studies.
- Macroeconomic analyses are typically conducted before policy measure are introduced to assess their potential impact on key macroeconomic aggregates. Using macro models that also incorporate energy and climate factors, they give a concise view of the main economic relationships between national institutional agents (households, firms and government) and with the rest of the world.

Microeconomic and macroeconomic analyses complement each other and are sometimes combined in an iterative process. For example, the results of microeconomic modelling can be used to calibrate macroeconomic models and the output from the macro models can then be fed back into the microeconomic model in a sequence of iterations until convergent and consistent results are obtained.

Mésange[2] modelling at the Directorate General of the Treasury has mainly fallen into the second – macroeconomic – class, but focused exclusively on the effects of economic policies and shocks on the main French macroeconomic aggregates. The new green module, Mésange Vert, expands this analysis capability to bring in energy and climate issues.

2. Mésange Vert: a module to calculate carbon emissions from national energy consumption

Traditionally, the Mésange macroeconometric model has measured the impact of shocks on major economic indicators, such as employment or GDP and its components (consumption, investment, imports and exports). It also examines the effects on energy prices and energy consumption by households and firms, but only on aggregate – the model is calibrated to consider energy as a single generic good. But, if we aim to assess the climate effect of a shock together with the macroeconomic impact, the energy component of the model needs to be calibrated in finer detail, since CO_2 emissions differ by energy source. This is what Mésange Vert seeks to achieve.

Specifically, Mésange Vert details the impact of shocks on France's energy mix and carbon emissions in two stages:

- The energy component of the module gives a stylised model of energy consumption by households and firms broken down into electricity, coal, oil and gas, to show changes in the energy mix. Demand for each energy source modelled depends on three factors: i) aggregate energy demand; ii) price; and iii) the preferences and technical constraints that prompt decisions to switch energy source, quantified by the elasticity of substitution.[3] The energy component also converts the total energy consumption value calculated by the Mésange model and expressed in national accounting volume (i.e. in euros at the prior year's chain-linked prices) into its physical equivalent (ton of oil equivalent, toe).
- The climate component of the module calculates carbon emissions from energy consumption. For each energy source, the model uses "technical" coefficients to convert consumption metrics to emissions and determine the average carbon emissions for each physical unit consumed. These

(1) Overview of Mésange Vert (in French only), by Boullot M., Girard P. L. and Tokay N. (2024), Présentation du module Mésange vert, *DG Trésor, Working Paper* No. 2024-4.

(2) Bardaji J., Campagne B., Khder M.-B., Lafféter Q. and Simon O. (Insee), Dufernez A.-S., Elezaar C., Leblanc P., Masson E. and Partouche H. (2017), "Le modèle macroéconométrique Mésange : ré-estimation et nouveautés ", *DG Trésor Working Paper*, No. 2017-04 (in French only).

(3) An elasticity of substitution greater than 1 indicates that it is easy to substitute one energy source for another. In other words, a percent change in the relative prices of the two energy sources would result in a proportionally greater percent change in the relative quantities consumed. Conversely, a near-zero elasticity of substitution means the two energy sources are complementary and not easily substitutable: a change in price leads to little or no change in relative consumption. The elasticity of substitution values is based on the estimates given in the literature.

coefficients are calculated in one of two ways: (i) directly from the emissions generated by using these energy source (for coal and oil); or (ii) as the weighted sum of the emissions generated to produce the energy for electricity (generated from both fossil and low-carbon sources) and for gas (substituting biogas for natural gas), assuming these are passed on to the end user. According to the model, emissions from coal stood at 3.3 $MtCO_2$ per toe, compared with 0.5 $MtCO_2$ per toe for electricity in France in 2020. Mésange Vert only models carbon emissions linked to final energy consumption in France. It leaves out other sources of emissions (from agriculture, for instance), other greenhouse gases and imported emissions (according to the definition of carbon footprint).[4]

Just like the Mésange model, this new Mésange Vert module is built around a baseline scenario. By comparing the results to this baseline, the impact of shocks can be assessed independently of the historical context. This is known as a "variational" approach where only the change induced by the shock is studied. In Mésange Vert, the baseline scenario is based on the revised French National Low Carbon Strategy (SNBC-2) – the country's roadmap for decarbonising the economy. The baseline scenario will be adjusted in line with the third update to the strategy which is currently under way.

3. Examples of Mésange Vert uses

Five analytic shocks were modelled to study the impact on energy and emissions between 2030 and 2050:

(i) Permanently increasing aggregate public investment (i.e. not specifically targeting decarbonisation) would help boost the economy and increase prices (as the means of production could not immediately respond to the resulting surplus demand). As a result, energy prices would go up and consumption by households and firms would increase. The price of each energy source would rise in the same proportions and would have no effect on the energy mix. In this scenario, emissions would depend solely on energy consumption, which would increase in line with activity.

(ii) Generating higher tax revenue by increasing VAT would only marginally affect relative energy prices when the VAT increase is applied across all sectors of the economy in the Mésange model. There would be little change in energy consumption by households and firms, and emissions would only fall as economic activity weakens. Compared to a general reduction of the same magnitude in public investment in fiscal terms, a VAT increase would have a greater and longer lasting impact on activity and therefore on reducing CO_2 emissions.

(iii) Higher labour productivity would see economic activity gradually expand and aggregate prices fall as production costs are reduced. This shock would affect the whole economy, but would not affect use of different energy sources. With no change in relative energy prices, CO_2 emissions would rise as the economy expands.

(iv) A permanent $10 per barrel increase in oil prices would bring down the relative price of electricity. In this scenario, households and firms would substitute electricity for oil – leading to lower carbon emissions – and reduce their total energy use as energy prices overall go up. As a result, emissions would fall 8% by 2030 and 12% by 2050 relative to the central account baseline.

(v) Increasing the carbon tax on households and firms consumption of coal, oil and gas to generate extra revenue equivalent to one percentage point of ex ante GDP would cause both to reduce fossil energy consumption. But households and firms consumption of electricity, which is not directly affected by the tax hike, would increase. All in all, total energy consumption would decrease and emissions would be cut by 12% by 2030: made of up a 12.5% cut in fossil energy emissions and a 0.5% increase in emissions from electricity.

(4) France's emissions encompass those induced by household consumption and domestic economic activities, whereas its carbon footprint is also made up of emissions outside the country associated with imports, minus the country's emissions associated with exports to the rest of the world.

In contrast to how the effect of the shocks described above are analysed, Mésange Vert generally requires combining several analytical shocks (for example an increase or decrease in tax together with a similar change in the same direction in expenditure items) to assess the impact of specific green transition policy measures, like the Mésange model. It is also possible to evaluate the effects starting from an energy price shock that alters the energy mix, or by directly acting on the energy mix to determine how energy prices respond.

There are several options for developing Mésange Vert in the future. For one, non-energy national emissions by industry and agriculture could be included, and indexed against additional economic variables taken from Mésange. As things stand, the module design prioritises analysing changes in the energy mix and carbon emissions in the medium to long term. However, a short-term component could be configured to give a more granular focus on what happens when the shocks are ramped up. Lastly, the French Treasury may seek to model other household consumption items (such as housing or travel) and other sectors of the economy for firms (industry, transport, commercial goods and services).

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