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The Imaclim-R model and French Low-Carbon Scenarios

For the scenarios for France, the partners in the ENCI-LowCarb project used the IMACLIM-R France model developed at CIRED. It is a dynamic model with 15 sectors. This hybrid model simulates the economic impact of energy policy measures and other changes that influence the energy sector. It calculates both impacts at the macroeconomic level (change in welfare, gains, or losses of competitiveness) and changes at the microeconomic level (weight of energy in the structure of production costs or in household expenditures).

Like any conventional general equilibrium model, IMACLIM-R provides a consistent macroeconomic framework to assess the energy-economy relationship. It is based on a description of the economy both in monetary terms and in physical quantities, linked by a price vector. This dual vision of the economy guarantees that the projected economy is supported by a realistic technical background and, conversely, that any projected technical system corresponds to realistic economic flows and consistent sets of relative prices.

The model allows the incorporation of technological information coming from bottom-up models and experts' judgement. It can handle a number of different proposals for policy measures.

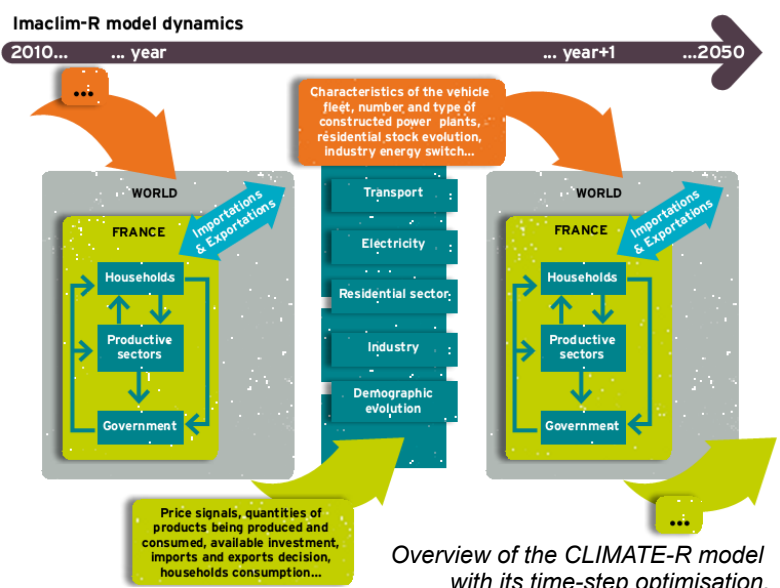
The model relies on a recursive architecture (see figure) with exchange of information between a macroeconomic module and several dynamic modules:

- For each year, the macroeconomic module in the model establishes an equilibrium of the French economy and energy flows. In this equilibrium, the markets have fixed equipment stocks and fixed intensity of labour, energy and other intermediary inputs, but have flexible utilisation rates. For each region, the market equilibrium gives information on the levels of production, consumption, international exchanges, investments, relative prices, and profitability

rates of sectors. It gives a snapshot of the economy, year by year, in monetary terms (in currency) and in physical quantities for energy (here: in Mtoe)

- The dynamic modules describe demography, capital dynamics, and sectors with bottom-up technical descriptions. The sector modules take into account the economic values of the previous static equilibrium, assess the reaction of the technical systems and send back this information to the macroeconomic module in the form of revised descriptions of the sectors (new input-output coefficients). Each year, technical choices are flexible, but they modify only at the margin the input-output coefficients and labour productivity of the next year. This gives a "clay-putty" description of the world, where parameters gradually develop over time.

The model includes a number of constraints, with the capacity-restriction of production as probably the most important. Investments in capacity can only increase production capacity in the given sector in the following year. An example of another constraint is a travel-time budget that limits the personal travel time, based on empirical findings.



ENCI-LowCarb Project Partners

RAC-France (Coordinator) Climate Action Network – France, att. Meike Fink, www.rac-f.org
 Germanwatch, att. Jan Burck, www.germanwatch.org INFORSE-Europe, att. Gunnar Olesen www.inforse.org/europe
 CIRED - Centre International de Recherche sur l'Environnement et le Développement, att. Sandrine Mathy www.centre-cired.fr
 PIK - Potsdam Institute for Climate Impact Research, att. Brigitte Knopf, www.pik-potsdam.de

The French Low-Carbon Scenarios

The Imaclim-R France model was used to develop a low-carbon scenario for France, where inputs were defined by French stakeholders during a series of debates. The modelling team received these results and then incorporated into the model those measures that were supported by a majority of stakeholders. This led to an “acceptable” scenario reducing CO₂ emissions from energy by 68% over the 1990 – 2050 period. The scenario has a number of positive effects for the society over the period 2010-2050, including higher GDP, lower energy imports, and lower household energy expenditures, the latter even including the costs of energy-related renovations. The positive effects on GDP only start in 2015 and household budgets only become lower from around 2025. Until then, there is an “investment period” lowering GDP up to 0.3% in one year. Unfortunately, the CO₂ reductions attained are below the objective of a “Factor Four” reduction of emissions between 1990 and 2050 (75%).

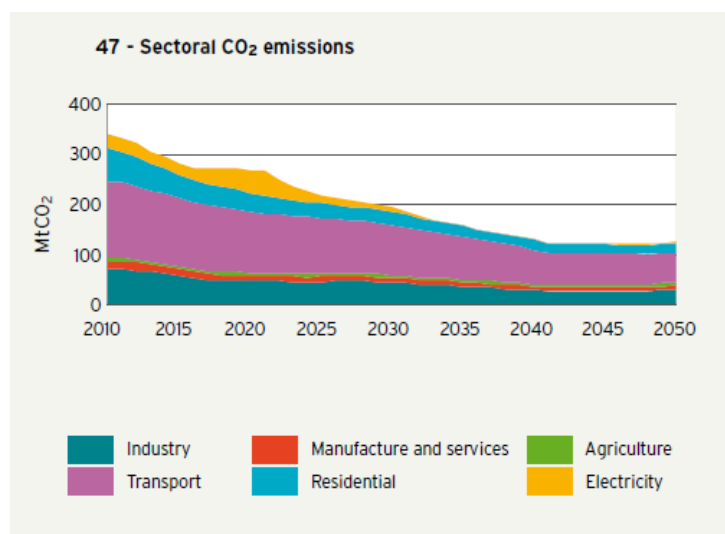
Because the reductions did not meet the reduction objective, the modelling team designed a scenario with renovation obligations for buildings and with an energy/CO₂ tax instead of an CO₂ tax only. These measures were not supported by a majority of stakeholders. This alternative scenario led to 73% emission reductions instead of 68%.

The stakeholders asked for sensitivity analyses. The modelling team carried out sensitivity analyses of fossil fuel price changes, of a less materialistic lifestyle, and of “re-shoring” (consumption implies more domestically-produced goods). This yielded the following resulting emission reductions from 1990 to 2050:

- 68% reduction with standard assumptions
- 74% reduction with 30% higher oil price
- About 70% reduction with 30% lower materials demands and higher service-sector demand instead
- About 66% reduction with “re-shoring” of production

The results were based on three sectoral dialogues with stakeholders:

1) The residential sector, in which stakeholders agreed to a series of measures including tax credits



Emissions in the “acceptable” scenario.

and zero-interest loans for energy renovations, and a carbon tax. These measures led to the renovation of most buildings up to a level “C” (annual heat consumption 91-150 kWh), while new buildings would have heat consumption below 50 kWh/year.

2) In the transport sector, stakeholders agreed to a series of measures including eco-taxes, urban planning, promotion of teleworking, a rail investment program – measures that, together, lead to a smaller shift from road to rail but a large-scale introduction of hybrid-electric vehicles. The resulting scenarios showed that hybrid-electric vehicles will represent 50% of the car fleet by 2040, with most of the rest being fuel-driven cars with a mileage better than 3 litre/100 km.

3) The electricity sector, in which stakeholders agreed to ban shale gas, and to keep nuclear and CCS. Agreed policy measures included progressive tariffs (higher tariffs for consumption above a given level), feed-in tariffs, and taxes. The resulting scenario showed a gradual increase in renewable electricity, gradual decrease in nuclear power production, and some fossil fuel use to meet remaining demands.

Source and more information: The materials of the ENCI-LowCarb Project are available from the website www.lowcarbon-societies.eu. The reports and articles from the German and French scenario development processes are available on the website www.enci-lowcarb.eu

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