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Case-study - The transition of Belgium towards a low carbon society: A macroeconomic analysis fed by a participative approach

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ABSTRACT

We describe a new approach for analyzing the socio-economic impacts of a low carbon transition. It consists in feeding a traditional macroeconomic model of a national economy, namely Belgium, with the results of a participative modelling exercise based on a prospective energy accounting model, the so-called Calculator. While contributing to overcoming important economic modelling barriers, this approach fosters stakeholders engagement and allows for extending the scope of the energy transition impact analysis.

1. Introduction

Under the Paris Agreement, Parties decided to hold the global temperature rise this century well below 2 °C above pre-industrial levels and to pursue efforts to limit this temperature increase to 1.5 °C. This means that worldwide greenhouse gas (GHG) net emissions need to come close to zero or even become negative during the second half of the century. To achieve this objective, the European Union and its member states have committed to largely decarbonise their economies by 2050.

In this context, many countries have engaged in a process to define and implement low carbon strategies. The Federal State of Belgium has launched an initiative to investigate the challenges of the transition with the aim of contributing to the definition of such a strategy at the national level. A first step has been the construction of various energy transition scenarios. This has traditionally been a key step towards the adoption of a strategy. Indeed, debating issues such as the role of technologies and of demand side measures, the extent of the electrification of the demand sectors or the management of power production intermittency is essential to determine key energy-related indicators featuring the strategy, such as the share of renewable energies, the level of energy efficiency, the GHG emissions reductions per sector or the backup and storage requirements for instance.

From these energy transition scenarios, a quantification of the direct energy system costs can be performed and expressed in terms of investments, operating expenses and fuel costs. Such assessments usually show that the energy transition requires additional investments, which may be partly or fully offset by a reduction of the energy bill. However, analyses of the macroeconomic impacts of these additional investments on growth, employment and sector competitiveness, on the resulting price effects and the impact on public finances and the fiscal system are often either disconnected from the energy transition scenarios or simply not performed. Yet, these macroeconomic impacts represent critical dimensions of the problem faced by policy makers in particular for what concerns the financing, the distributive and the employment impacts of the transition.

This paper describes the innovative methodology adopted in Belgium to analyze the macroeconomic impacts of the transition. It consists in feeding a traditional macroeconomic model of the national economy with the results of a participative energy modelling exercise. The paper is organized as follows. The next section highlights the motivation for developing such an innovative approach. The participative construction of energy transition scenarios is described in section 3. Section 4 then shows how its results are fed into the macroeconomic model and describes the resulting macroeconomic impacts. Finally, section 5 concludes.

2. Motivations for developing a new approach

The methodology chosen for analyzing the transition impacts pursues two related objectives. The first one is to foster the engagement of

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actors and thereby their commitment to the transition. The second one is to increase the policy-relevance of the socio-economic impacts analysis by overcoming several limits of a traditional economic modelling.

2.1. Fostering stakeholder engagement

The methodology has been elaborated in the spirit of the transition theory (see e.g. Rotmans *et al.* [14]; Geels et al. [8]). This theory formalizes the critical role of actors at different levels. The transition is presented as a long and gradual process which requires support and action of different societal actors in interaction with the governmental authorities. Indeed, long term overarching strategies such as low carbon development strategies will be adopted and effectively implemented only once they are supported by the various key stakeholders and actors.

The associated concept of *transition management* refers to the way the transition is steered and oriented by these key actors, including public authorities (Loorbach [9]). The methodology is elaborated in such a way that the Belgian federal public authority creates a platform (a so-called *arena* in the transition management literature) in order to fuel reflections, promote exchanges between key actors, build low carbon visions and scenarios, and finally debate on their impacts.

Among these impacts, the macroeconomic aspects are often less easily accessible, or perceived as obscure and disconnected from energy visions by some actors. The methodology aims at connecting as much as possible the macroeconomic impacts analysis with the co-constructed energy scenarios. We elaborate on this aspect in the next section.

2.2. Increasing policy relevance

The second objective is to increase the policy relevance of the economic analysis by overcoming two important limits of traditional computable economic models.[1]

The first limit deals with the non-marginal effects of the low carbon transition. Indeed, reaching important emission reductions requires profound, radical, transformative changes (Stern [16]). Traditional economic models are usually more appropriate for the analysis of marginal changes. In particular, the estimation of price and revenue elasticities used in computable economic models is based on past energy prices, in the context of an energy system largely relying on fossil fuels. Building and analyzing long term scenarios on the basis of such observations from the past does not allow to capture possibly new and different behavioral responses to changes in energy prices (DeCanio [6]). Moreover, preferences of economic agents are usually assumed to be constant over time while social sciences show that norms and lifestyles are likely to evolve with the energy transition and the increasing consciousness about environmental (and more broadly, sustainable development) challenges (Bellis [3]). For these reasons, economic models tend to underestimate drastically the potential of strong behavioral responses.

The second limit of computable economic models has to do with their scope. Such a formalized approach usually limits the scope of the analysis to the energy system and its direct impact on economic activities. Computable economic models are not designed to deal with non-market impacts nor to integrate the multiple unpriced potential benefits of the transition, such as reduced congestion, health benefits, increased energy security, etc. (Stern [16]).

These important limitations, amongst other, call for developing new approaches to economic modelling and for using complementary approaches in the context of the low carbon transition (Ackerman and Daniel [1]; Farmer et al. [7]; Miller *et al.* [11]; Stern [17]). We describe below how feeding a traditional macroeconomic model of the Belgian economy with a participative scenarios building approach constitutes such a new approach and contributes to meeting this twofold objective.

3. Participative construction of low carbon scenarios

The prospective energy accounting model initially developed by MacKay [10], the Calculator, has been adapted to the Belgian context. It constitutes the focal tool, a common language to build and organize the debate around low carbon scenarios in Belgium.

3.1. Participative process

The whole process has been initiated by the public authorities. A pool of more than one hundred experts and actors from the civil society, universities and public administrations at different levels have been identified with the purpose of covering the wider spectrum of various knowledge and views on the transition. These actors participated actively to one or several of the numerous sectoral workshops. The purpose of each of these workshops was to define, among a limited but representative set of participants, the possible levers for the reduction of GHG, as well as to parametrize those levers, i.e., to associate different ambition levels to each of these levers. In total, about sixty levers were defined, with four different ambition levels for each of them (see Cornet *et al.* [5]). These levers constitute the backbone of the Belgian calculator. Some of them are of a technological nature, for example the penetration of electric vehicles or the renewable energy for electricity production. Others relate to behavioral, lifestyle changes such as changes in mobility demand, in housing habits or in diets. We come back to these levers in the next subsection.

A high-level committee was appointed to help define low carbon scenarios by making choices on the level of ambition for each of the sixty levers. The purpose of this step was to co-construct different technical storylines, contrasting alternative pathways towards a reduction of Belgian GHG emissions of at least 80% by 2050 with respect to 1990.

3.2. Scenarios characterized by non-marginal, behavioral changes

The participative process described above has shown that several, potentially different pathways could lead to drastic GHG emission reductions. In contrast with techno-economic modelling exercises, pathways relying heavily on strong behavioral and lifestyle changes have also been identified. Participative modelling thus broadens the scope of the policy analysis which, in economic modelling, is most often limited to, or oriented towards, technological choices (Miller et al. [11]), due to the limits of such an approach. This is best illustrated with a few examples that relate to the major GHG emitting sectors in Belgium.

In the transport sector, the reduction of passengers mobility demand has been identified as one of the behavioral levers for reducing GHG emissions. For the lowest level of ambition of the lever, stakeholders have proposed an increase of passengers transport demand per person in Belgium of 20% over the period 2015–2050. This corresponds to the business-as-usual (BAU) official projections on transport activity. Debates among the participants at the highest, still realistic, level of ambition of this lever have led to the selection of a decreasing transport demand per person of 20% over the same period. This corresponds to a reduction of about 40% points with respect to the BAU situation. While intermediate levels have also been defined, reaching such a change in mobility demand entails particularly strong behavioral and lifestyle changes, going beyond marginal changes. Clearly, when setting that (perceived as highest possible) ambition level, participants accounted for the fact that current mobility patterns face a series of challenges that go beyond reducing GHG and that include congestion, air pollution and accidents. They also accounted, to some extent, for technological developments that affect mobility demand, such as those related to teleworking or online shopping for instance.

A low carbon scenario considered as balanced between the

[1] For the main criticisms of economic modelling in the context of the energy/low carbon transition, see for instance DeCanio [6], Pindyck [13], Stern [15–17], as well as NCE [12].

behavioral and the technological options,[2] was built with the high-level group of stakeholders. In this scenario, the transport passenger demand lever was set at an intermediate, but still relatively high, level of ambition with a demand reduction of 10% over the period 2015–2050, which represents a reduction of about 30% points with respect to the BAU situation. In the same scenario, choices on other levers such as modal shift towards public transport or the occupancy rate of vehicles complement and reinforce the impact of the mobility demand lever on suggested changes in mobility patterns.

There are similar examples in the other GHG emitting sectors. In the buildings sector for instance, stakeholders decided that a balanced scenario should not rely prominently on technological options, such as the insulation of the envelope and the installation of environmentally-friendly heating systems, but also on the degree of compactness of houses, typically measured by the share of flats versus houses in the new built, or on the choice of indoor temperatures. Again, many considerations going beyond energy and climate challenges were included, such as spatial planning choices and visions on social cohesion. In the agriculture sector, choices on diets, and more specifically on meat consumption, were identified as having an important impact on GHG emissions. The balanced scenario integrates strong changes on the basis of considerations that include sanitary impacts for instance. Hence, even in a balanced scenario, the participative approach supports deep behavioral changes that rarely characterize scenarios stemming from traditional techno-economic modelling.

These changes then strongly impact the energy system and the related costs. Going back to the transport example, beyond a switch from internal combustion engine cars towards electric and other low carbon technologies cars, the number of cars in the balanced scenario is drastically reduced due to the strong behavioral changes: from 6.2 billion cars in the BAU scenario to 3.4 billion cars by 2050 in the low carbon scenario. The important reduction in the number of cars then entails a large reduction in the total amount of investments required at the sector level as well as for energy production[3] and the related energy demand reduction drastically reduces energy expenditures. This has a positive financial impact for consumers, while it encourages industrial players to think of higher value-added services instead of continuing with a pure product-driven (consumption-oriented) approach. Similar conclusions can be drawn from the impact of the other behavioral levers: they lead to large energy savings, with capital requirements that are much lower than any equivalent technological option. This will have sectoral and macroeconomic implications, as we shall see in the next section.

4. Feeding a macro-econometric model of the national economy with the co-constructed scenarios

A central element of the methodology we adopt is the introduction of each lever characterizing the low carbon scenario into a mainstream macroeconomic model of the Belgian economy[4] and the simulation of their macroeconomic impacts with respect to a BAU scenario. By doing so, the macroeconomic analysis is fully consistent with the micro-level scenario analysis built under the participative approach. This departs from traditional modelling, which usually consists in simulating only the impact policies (such as a carbon tax or a subsidy to renewable energy for instance) through the energy system module of the macroeconomic model.

4.1. Adapting the model and its inputs

The sixty levers characterizing the balanced low carbon scenario provide a series of annual CAPEX, OPEX and energy savings. For the period 2016–2030, which corresponds to the time horizon of the macro model, this data is adapted to fit the agents (households and firms) and economic sector categories of the macro model. The changes are introduced exogenously into the model. Some CAPEX is introduced as changes in expenditures (e.g. electric cars), while others are introduced as capital formation (e.g. dwellings). Energy savings translate into reduced expenditures on energy.

Total investments and operating costs over the period are 7% higher in the low carbon scenario than under the BAU scenario. Levers in the buildings sector are responsible for the largest increase in investments, followed by the levers from the power and the industry sectors. Transport levers lead to a decrease of total investments. In terms of economic sectors, households show the largest rise in investments through the renovation of their dwellings, followed by the market services and the manufacturing industry sectors.

Energy expenditures are 17% lower in the low carbon scenario over the period. Transport levers are responsible for the largest decrease with noticeable impacts in almost all economic sectors, especially households, market services and transport and communication. Investments in households and market services dwellings also lead to significant reductions in energy expenditures. These large energy savings together with increased investments are driving the macroeconomic results.

4.2. Main results

Three key messages emerge from the macroeconomic simulations (see Berger et al. [4], for further details). They relate to the impact on economic activity, on employment and on competitiveness.

First, our modelling results indicate that emission reduction measures and other actions leading to a low carbon pathway do not substantially reduce the GDP growth level in Belgium. As illustrated in Fig. 1, the model even predicts an extra GDP rise of around 2% in 2030 with respect to the reference level. The main operating mechanisms may be explained follows. The low carbon nature of investments makes it possible to reduce the different actors' fuel expenses. Subsequently, the increased private and public investment level contributes to the revival of economic activity in the different sectors. Finally, given the openness of the Belgian economy, the stimulating effect on activity is enhanced by the adoption of low carbon policies by other countries, at both the European and international level. All this leads to an improvement of the companies' operating surplus and to an enhancement of the households' purchasing power.

Second, compared to a BAU scenario, our results show that the transition can lead to a net employment growth in Belgium, amounting to approximately 80 000 jobs in 2030.[5] As the structure of the investments in a low carbon energy system is different to that of an unchanged policy scenario, the various economic sectors are impacted in different ways. Although the largest number of direct new jobs is expected in the construction sector, a significant number of jobs would be created in industry as well, including in the intermediate goods sector. However, the transport sector would be affected in an asymmetric way: job losses related to decreased demand for private vehicle maintenance would be mitigated by the positive effects of the economic activity in the sector, for example in the deployment of services related to collective transport. Finally, half of the employment creation would be indirect,

[2] We refer here to the CORE scenario in Cornet et al. [5].

[3] The capital expenditures drop related to car purchases largely outweigh the rise of capital expenditures in public transport.

[4] The HERMES model which is traditionally used for the Belgian official economic and budgetary forecasts. See Bassilière et al. [2] for a detailed description of the model.

[5] The macroeconomic simulation includes, on top of the micro levers introduced, a carbon price in the form of a uniform carbon tax. Several options for recycling the revenues of the tax are tested, including a reduction of labour taxes. In Berger et al. [4] it is shown that the carbon price policy has a positive, although not decisive impact on employment.

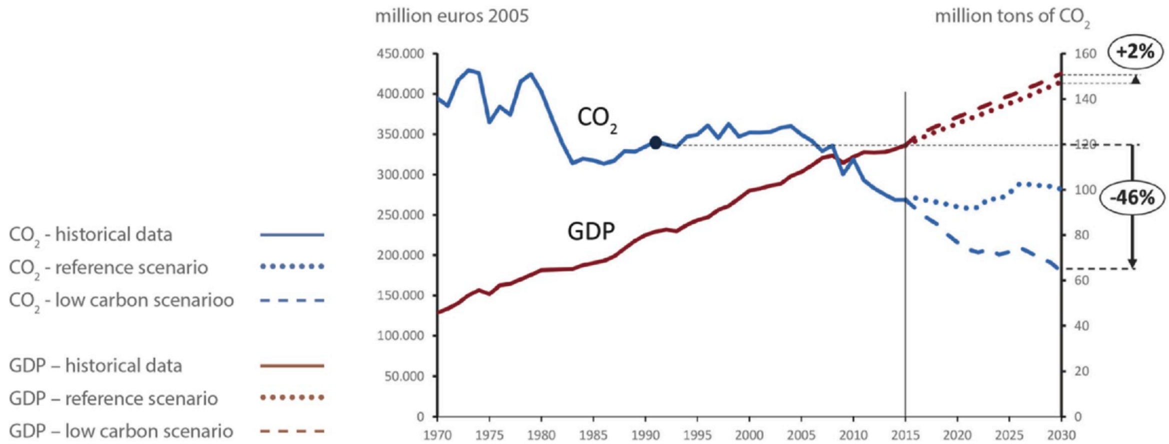

Fig. 1. Evolution of the GDP and CO_2 emissions in Belgium: historical perspective and impact of the low carbon scenario.

showing a significant rise in the services sector.

Third, the increase of energy prices has a moderate effect on production costs at the macroeconomic level due to the increase in energy efficiency. In 2030, it will be possible to halve the energy balance deficit in Belgium, which corresponds to a gain of about 2 GDP percentage points. This constitutes an advantage for European industries compared to their international competitors. Moreover, the revival of economic activity stimulates international trade.

These three – rather encouraging – results are partly driven by the approach we adopted. As we explained, some emission reduction measures and actions lead to the adoption of different lifestyles in the field of individual mobility, habitat, food and consumption habits. These important behavioral changes participate to the economic stimulus as they lead to a high energy savings-investments ratio. The growth content of a low carbon economy is thus potentially significantly different from the growth content of an economy that doesn't undergo such a transition.

5. Conclusions

Transparent energy accounting models such as the Calculator offer a twin opportunity for governments to feed their energy and low carbon transition strategies. First, their content can be co-constructed together with civil society, in the spirit of transition management. The Belgian experience shows that such an approach fosters the engagement of key actors who tend to use and spread the results of the process, thereby facilitating the future adoption and realisation of the strategy. Providing transparent bottom-up energy foundations to the macroeconomic impact analyses enhances such an engagement.

Second, these kind of tools allow broadening the scope of the policy analysis which, in economic modelling, is most often limited to technological choices. In particular, the Belgian case-study shows that co-constructed low carbon scenarios tend to put a significant weight on behavioral and lifestyle changes. Any macroeconomic analysis that can be performed directly on the basis of these scenarios is influenced by these changes as they typically entail strong energy savings. In the present case-study, these tend to stimulate significant economic activity and employment.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.esr.2020.100463.

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