Scenarios for a climate neutral Belgium by 2050

Summary

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Summary

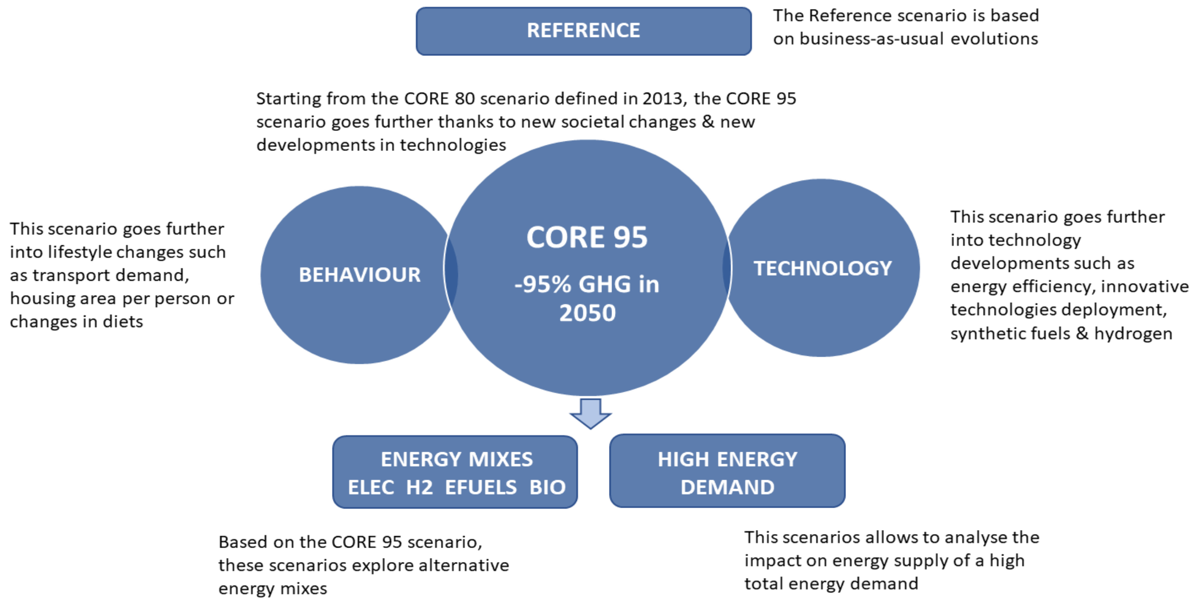
Climate neutrality is the new policy context in which any societal prospective analysis needs to be framed since the adoption of the Paris Agreement and the recent developments at the European level. This work provides new insights on pathways and actions to be deployed for reaching climate neutrality by 2050 in Belgium. As such, the analysis contributes to underpin the development of a broad, quantitative vision on the transition in Belgium, while identifying the necessary transformations. Therefore, it allows us to take more informed strategic decisions.

An innovative methodology

A set of five main scenarios are built on the basis of the Belgian “2050 Pathways Explorer”, which is an energy accounting model extended to materials, products, land and food systems. The model is based on a series of levers that allow for potentially strong technological developments as well as radical changes in societal organisation and behavioural patterns. A key feature of the model consists in outlining all potential decarbonisation options, thereby offering a broad view on the challenges of the transition, in particular on a series of trade-offs between sectors and fields of activity. Given this broad view offered by the model, certain specific aspects of the transition nevertheless need to be explored more thoroughly by complementary, sector-specific modeling analyses.

Besides a “REFERENCE”, business-as-usual scenario, two scenarios shed light on the technological versus behavioural dimensions underpinning climate-neutral scenarios: the “BEHAVIOUR” scenario emphasises transformational changes in mobility, housing and dietary patterns, while the “TECHNOLOGY” scenario relies more heavily on technological developments. A “CORE-95” scenario is defined based on a balanced approach between these two dimensions. A fourth scenario, the “HIGH DEMAND” scenario, is set to explore the implications of a pathway characterized by a significantly higher level of energy demand than in the other climate neutral scenarios and by constant industrial production volumes in 2050 when compared to 2015. Finally, a set of sensitivity analyses are performed on the basis of the CORE-95 scenario in order to analyse impacts from energy mixes focusing either on electrification (“ELEC”), hydrogen (“H_2”), e-fuels (“E-FUELS”) or biomass (“BIO”).

Figure 1: Illustrative scenarios

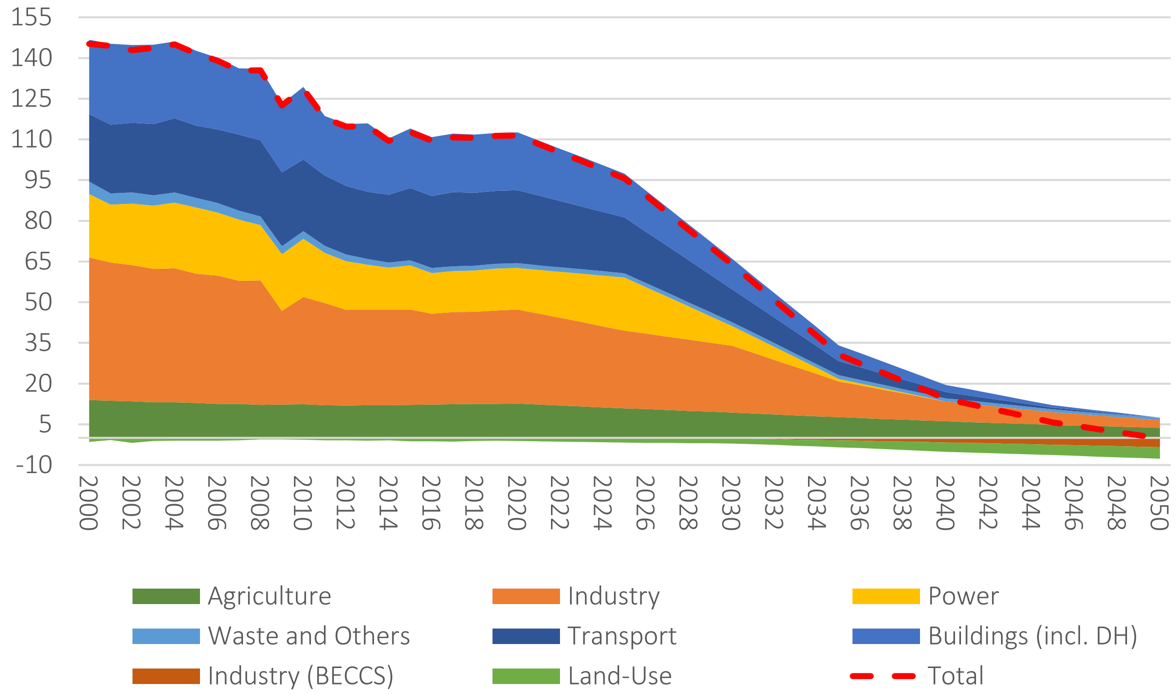


The different pathways described here are not prescriptive in nature. They should be considered as a set of narratives that allow a concrete understanding of possible implications of the transition in Belgium, while inviting everyone to reflect on them and to build their own transition scenario.

Transversal results

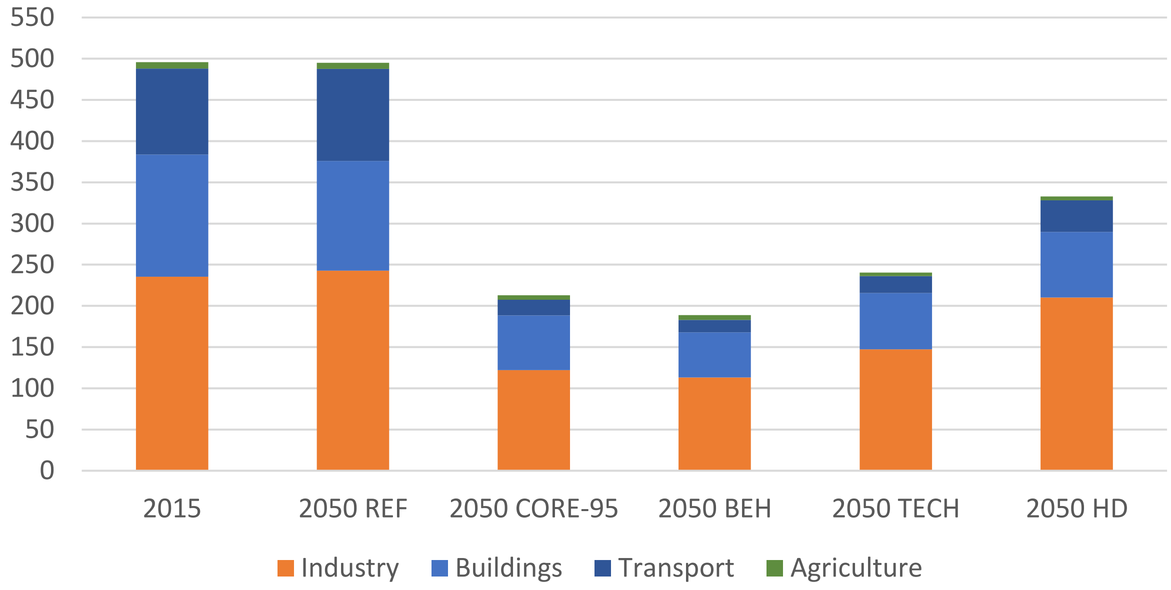
Reaching climate neutrality in Belgium by 2050 is technically feasible, even though it is particularly challenging and requires systemic changes. New technologies such as hydrogen, e-fuels, direct air capture or bioenergy with carbon capture (BECCS), as well as new consumption and production patterns are needed in all scenarios. Furthermore, while greenhouse gas (GHG) emissions can be reduced to zero in the buildings, transport and energy production sectors, some hard-to-abate emissions in the industrial and agricultural sectors will remain and will need to be offset by negative emissions through land use, direct air capture and storage or BECCS. In 2050, these negative emissions will need to amount to between 7 and 11 $MtCO_2e$ (8 $MtCO_2e$ in the CORE-95 scenario, of which 4 $MtCO_2e$ in the LULUCF sector – see Figure 2).

Figure 2. GHG emissions – historical and CORE-95 scenario (2000-2050, $MtCO_2e$)



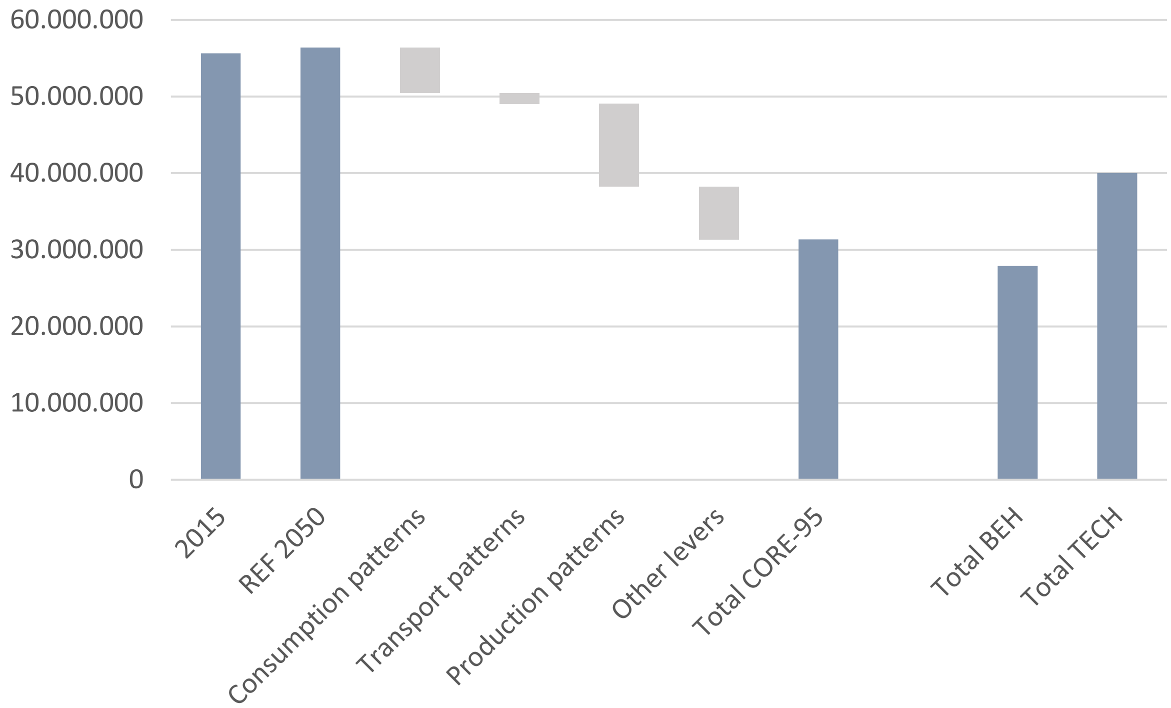
In all scenarios, energy demand decreases significantly and fossil fuels are gradually phased out through electrification and the use of carbon neutral fuels. The decrease in final energy demand amounts to as much as 57% in 2050 in the CORE-95 scenario w.r.t. the REFERENCE scenario (with 62% in the BEHAVIOUR scenario and 33% in the HIGH DEMAND scenario – see Figure 3). Electrification of the demand sectors, combined with a power production system based entirely or almost entirely on renewable energy sources, is the main avenue to gradually phase out the use of fossil fuels. Since electrification is not possible for all energy end-uses, it needs to be complemented with the deployment of climate-neutral fuels. Biomass will be used to some extent but its potential, although significant, remains limited and is strongly linked to land use choices. Hydrogen and e-fuels will be required to close the gap, especially for use as industrial feedstocks. Finally, the small amount of fossil fuels remaining in the industry need to be combined with CCUS.

Figure 3. Final energy demand per sector and in total
(in TWh, incl. industrial feedstocks)



Material demand is much lower than current levels in all climate neutral scenarios. When expressed in terms of tons of materials, the demand decrease ranges from more than 50% in the BEHAVIOUR scenario to less than 30% in the HIGH DEMAND scenario, with 44% in the CORE-95 scenario (w.r.t. the REFERENCE scenario – see Figure 4). This is driven by drastic changes in consumption patterns that are characterized by a strong reliance on the sharing economy and the economy of functionality, as well as behavioural changes with respect to mobility (reduced travel demand, modal shift, …), housing (smaller living spaces), diets and waste. These changes are much more pronounced in the BEHAVIOUR scenario. Changes in production patterns also impact material demand significantly, especially material efficiency (by improving product design, using more efficient materials or reducing material losses) and material switch. Changes in diets also lead to profound changes in the agricultural sector, which in turn has a strong impact on land use through freed up land that can be used to stimulate carbon absorption and, potentially, biodiversity depending on how the freed up land is used.

Figure 4. Impact of selected groups of circular economy-related levers on materials demand in 2050 (in t)



Additional investments in infrastructure are required but can be limited, depending on the extent to which behaviour changes and the circular economy develops. In all decarbonisation scenarios, additional capital expenditures in climate friendly infrastructure are required in all sectors. Total capital expenditures are nevertheless significantly reduced when demand for energy-consuming activities, products or services decreases as a result of behavioural changes and the transition to a more circular economy. In the BEHAVIOUR scenario, these additional investments are about 12% higher than in the REFERENCE scenario, while this increase amounts to about 26% in the TECHNOLOGY scenario. Fuel cost reductions tend to compensate capital expenditure increases. Although electricity expenditure increases in all sectors, fossil fuel expenditure reaches almost zero in the long run. The price and consumption levels of hydrogen and e-fuels, including for use as feedstock, therefore become a determinant element of total fuel expenditures in the future.

Sectoral results

Buildings

In the buildings sector, the renovation rate and depth need to drastically and quickly increase. The renovation rate needs to move from 1% per year to about 2.5 to 3% per year and the depth of such renovations also needs to evolve from shallow to mainly deep renovations. These renovations go along with an increased need for materials, about 3 times higher than in the REFERENCE scenario. For new constructions, however, the demand for materials can be drastically reduced by limiting the surface in both residential and non-residential buildings, as it is the case in the BEHAVIOUR and the CORE-95 scenarios where material demand for new buildings is divided by around 3, as opposed to a reduction of only about 20-25% in the TECHNOLOGY and HIGH DEMAND scenarios.

Fossil fuels are completely phased out in the buildings sector and electricity becomes the most important energy vector, representing more than 80% of the final energy demand in the CORE-95 scenario. Biomass and H_2/e-fuels complement the energy mix, mainly where electrification is too difficult or costly to implement. Finally, behavioural changes, such as for instance keeping the demand for cooling needs under control, are key in order to keep final energy demand in 2050 at much lower than current levels, i.e. decreases between 46% and 63% in the HIGH DEMAND and BEHAVIOUR scenarios, respectively.

Transport

In the transport sector, total energy demand can be strongly reduced through a set of behavioural levers, such as a lower transport demand per capita, a higher degree of vehicles' occupancy, a higher load factor of trucks, and a strong modal shift towards public transport and active modes (passengers) and towards rail and inland waterways (freight). These behavioural levers together lead to a reduction of more than 50% of final energy demand in the CORE-95 scenario w.r.t. the REFERENCE scenario (from 64% in the BEHAVIOUR scenario to 1% in the HIGH DEMAND scenario). Together with the development of the sharing economy that increases the utilisation rate of vehicles, the total number of registered cars and trucks falls drastically in all decarbonisation scenarios, and especially in the BEHAVIOUR scenario.

Technological switches, in particular electrification, also have a major impact on energy demand and greenhouse gas emissions. Decarbonised electricity and fuels allow to reach a complete decarbonisation of the sector. Even though different energy mixes can be considered for this sector, electrification (batteries) always reaches very high levels in passenger transport, while hydrogen, e-fuels and potentially biofuels will likely need to play a larger role in freight transport.

Industry

Industry is a hard-to-abate sector where remaining energy efficiency gains are lower than in the other sectors, while electrification cannot be pushed to the same extent. Carbon neutral fuels (hydrogen, e-fuels and biomass) will need to be deployed where electrification is not possible, and as industrial feedstocks. Furthermore, end of pipe CCUS will need to be deployed, in combination with BECCS, by an amount ranging from 7 $MtCO_2e$ in the BEHAVIOUR scenario in 2050 to 17 $MtCO_2e$ in the HIGH DEMAND scenario.

New consumption and production patterns based on a circular economy have the potential to considerably reduce energy demand and use of resources, and thereby greenhouse gas emissions. As stated above, changing consumption patterns, such as reducing packaging, food waste, and adopting more sustainable consumption patterns, as well as changing transport patterns such as sharing cars, extending their lifetime and better organizing travel demand and improving logistics, have a strong impact on material demand. If such changes are implemented on a broad scale, they will likely impact the volumes of domestic production of goods and materials. Furthermore, changing production patterns such as material efficiency through better product design, using more efficient materials, reducing material losses and switching towards less GHG intensive materials, are also reducing resources and energy use, and thereby GHG emissions. While production volumes decrease in most illustrative scenarios, the total value of this production does not necessarily decrease.

Power

Total electricity demand will be significantly higher than current levels, with an increase by about 25% in the BEHAVIOUR scenario to 90% in the HIGH DEMAND scenario (38% - reaching 121 TWh in the CORE-95 scenario) by 2050, assuming that about 20% of the domestic hydrogen and e-fuels demand is produced domestically. Raising this share of domestic production increases total electricity demand considerably.

Producing 100% renewable electricity is achievable, even in high electricity demand scenarios, provided that intermittency is adequately managed. We assume a level of electricity imports between 20 and 30% by 2050 in our main scenarios, acknowledging that higher or lower levels could be set. Under this assumption, the renewable energy potential is sufficient to fully cover the electricity demand in all scenarios, mainly through an installed capacity in solar PV of between 30 and 46 GW, an onshore capacity up to between 8 to 9 GW (11 GW in the HIGH DEMAND scenario) and an offshore capacity up to 6 GW in Belgian waters, to be increased by up to 2 to 6 additional GW elsewhere in the North Sea.

Agriculture

In the agricultural sector, gradual but transformative changes of consumption patterns and agricultural practices are required to reach climate neutrality by 2050. On the demand side, a series of levers need to be deployed to reduce GHG emissions such as strong changes in total calories consumption (-34% and -15% w.r.t. current levels in the BEHAVIOUR and TECHNOLOGY scenarios, respectively), the type of diets and food waste. On the supply side, some trade-offs need to be made regarding changes in agricultural practices (towards a lower use or no use of synthetic fertilisers and (chemical) pesticides), climate-smart livestock and land management in order to further reduce emissions.

Remaining emissions can be compensated by increased natural absorption. The transformation of agricultural practices and consumption patterns, and the related reduction of livestock allow to free up a significant part of land that can be converted in natural prairies, forests or non-food cropland. Such a gradual reallocation of land leads to an absorption of between 3.7 $MtCO_2e$ (BEHAVIOUR scenario) and 4.9 $MtCO_2e$ (TECHNOLOGY scenario) in 2050, thereby contributing to reaching climate neutrality in this time horizon.