FABI

EDITION 2019

BELGIUM ENERGY OUTLOOK 2050

« Rien ne sert de courir, il faut partir à point »
Jean de La Fontaine

FABI is the Federation of Belgian Associations of Civil Engineers, Agricultural Engineers and Bioengineers. It has some 7.000 engineers who are members of their school association. The FABI is the spokesman for the profession and the defense of the title of engineer, with the academic authorities, the economic policies and the regional policies that federal and international.
FABI has highlighted all the questions relating to the status of the engineer and the recognition of his diploma. It strives to promote the engineering profession and to respect its ethical and deontological rules.

« Energy Transition Platform » was set up in line with statutes relating to the development of information and training activities highlighting the influence of engineers and benefiting the Belgian economic activity.

The FABI Board of Directors has stated that it is important to do so. This topic has been subject to an important topic with the purpose of each one of them. leading to sustainable energy visions.

FABI will collect its members opinions via its website www.fabi.be

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Introduction

The first half of the 21st century will be shaped by two major challenges: the digital revolution and the energy transition. « Major », because they may lead to a radical re-evaluation of our habits and behaviours, and « challenges », because they are complex to manage.

The growth-based society has established itself on an almost permanent basis in Europe since the last world war. However, since it is mainly «nourished» by fossil fuels, it is also responsible for a significant portion of the greenhouse gas emissions (GHG) released into the atmosphere.

Belgium has ratified the Paris Agreements. In a European context, it has committed to reducing its emissions by 55% by 2030 and by 95% by 2050, by increasing the share of renewable energy in electricity generation to 100% (IRE[1] + biomass + hydroelectricity). It also wants to phase out nuclear power rapidly, which today, accounts for around 50% of its electricity generation.

[1] IRE stands for Intermittent Renewable Energy (mainly solar + wind power)

However, like the Paris Agreements, the draft federal climate law has a « reverse agenda » insofar as it is based on general objectives without considering either the technical and financial means to be implemented or the social consequences that it could entail. One fundamental question, in particular, is to consider whether such a drastic reduction in emissions will remain compatible with a society based on even low growth.

FABI has taken the opposite approach, viewing a reduction in emissions not as a prerequisite but as the necessary result of assumed technological, behavioural, and economic changes.

Starting from a « baseline » constructed from the history of energy consumption over the last 15 years, three robust scenarios have been developed up to 2050.

They are based on relatively strong hypotheses. They are intended to not only displace fossil fuels and nuclear energy in favour of renewable energy but to also optimise energy consumption through a significant improvement in energy efficiency within a less energy-demanding society.

The scenarios are based partly on technologies currently considered mature enough to be easily implemented in the various usage sectors (transport, housing, industry and electricity generation) and partly on reasonable changes to techniques, structural organisation and processes.

They take into account Belgium's low population growth. While they do consider certain behavioural changes, the three scenarios assume continued economic growth in Belgium.

The decision to focus the scenarios exclusively on Belgian territory explains, in particular, why air (no domestic flights in Belgium) and maritime transport were excluded from the scope. As the scenarios are limited to the issue of energy consumption, certain emissions, such as those related to agriculture and deforestation, were not considered.

Engineers have a vital role in influencing the future of our society through their essential contributions to technological development and applied research.

The global situation

In 2017, humanity consumed 157 PWh[2] of primary energy from all sources, 85% of which was from fossil fuels. The combustion of these fuels emitted 33 Gt_{CO2}. 62% was from non-OECD countries, the excess emissions of which are mainly due to coal.

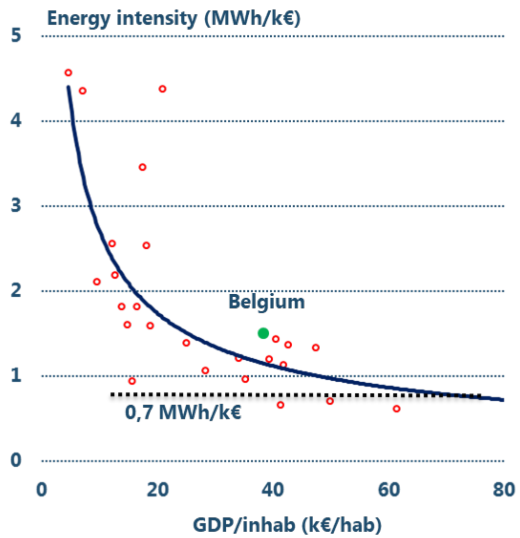
Région	Energy intensity	Carbon content	Emissions per in habitant	Energy sobriety
	MWh/k€	kg_{CO_2}/MWh	t_{CO_2}/inhab	MWh/inhab
World	2,2	213	4,4	20,9
OCDE	1,5	191	9,6	50,1
Non-OCDE	3,3	228	3,4	15,0
China	3,4	253	6,7	26,3
US	1,5	196	15,6	79,8
Europe	1,3	180	6,9	38,3

World Energy Indicators
Source : BP Statistical Review 2018 and World Bank

[2] One petawatt hour (PWh) is equal to one billion megawatt hours (MWh)

The main energy indicators[3] (energy intensity, carbon content, per capita emissions and energy sobriety index) of non-OECD countries are, unsurprisingly, well above the global average, whereas OECD countries are, on the contrary, systematically below it.

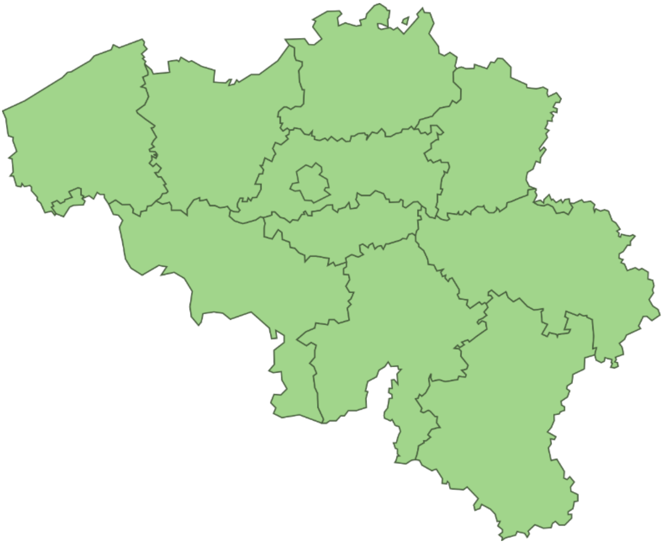
Europe appears to be the best performer, well below the global average but also that of OECD countries and, in particular, the United States. An American citizen for example consumes twice as much energy and emits two-and-a-half times as much CO_2 as a European citizen.



Energy intensity by GDP/population
Source : BP Statistical Review 2018 and World Bank

European data also show that energy intensity decreases rapidly with an increase in per capita GDP and converges towards an asymptotic value of 0.7 MWh/€k.

[3] See the definitions in the appendix



The baseline

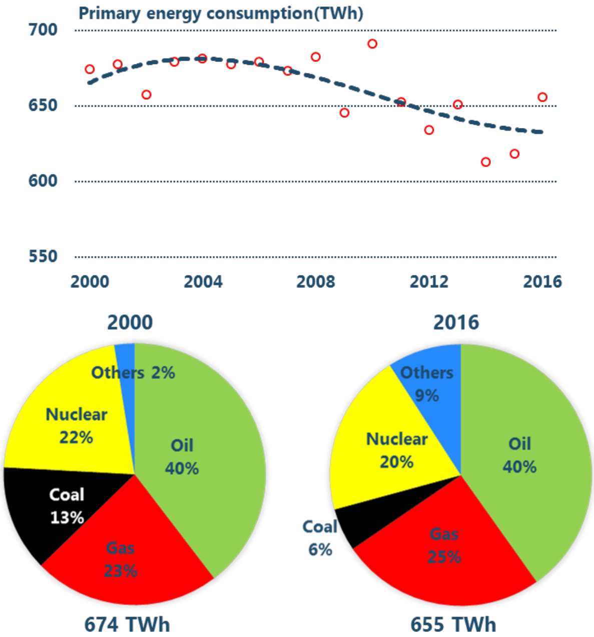
Primary energy

In 2016, Belgium consumed 655 TWh[4] of primary energy, 70% of which was from fossil fuels.

Since the turn of the century, its energy mix has changed only slightly. Its emissions fell from 121 Mt_{CO2} in 1990 to 100 Mt_{CO2} in 2016. This downward trend is mainly linked to the reduction in the share of coal as well as a moderate contraction in industry.

However, Belgium has seen a positive change in its energy indicators: over the 2000-2016 period, energy intensity declined by 40%, carbon content by 18% and its per capita emissions by 30%.

[4] One terawatt hour is equal to one million megawatt hours



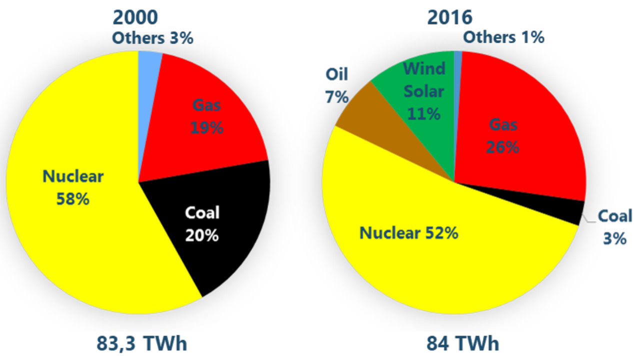
Evolution of the Belgian primary mix since 2000
Data source : STATBEL

However, compared to its European peers, Belgium lags behind except for the carbon content of its MWh. It is one of the least carbon-intensive countries in Europe due to its generation of nuclear power. More than its emissions, Belgium's main problem is the lack of energy sobriety.

Electrical power generation

In 2016, Belgium consumed 84 TWh of electricity. Since the beginning of the century, the share of nuclear power (52%) has slightly decreased in favour of gas (26%), renewables (11%) and biomass (7%).

Nuclear has a load factor[5] of almost 90% compared to just over 10% for solar and 28% for wind. This value, which is higher than the European average, is due to the significant contribution of offshore wind power.



Electricity generation by sources 2000 and 2016
Data source : STATBEL

Usages

In 2016, transport accounted for 21% of final energy consumption. In this sector, oil reigns supreme. It accounts for 93% of consumption.

In 2016, housing accounted for 29% of final energy consumption. It is dominated by natural gas (42%), electricity (27%) and oil in the form of fuel oil (25%). Biomass accounts for 5% while coal has almost completely disappeared.

In 2016, Belgium had 5.35 million homes, 31% of which were in Wallonia, 58% in Flanders and 11% in the Brussels region. Belgian housing stock is very antiquated. Half of its homes date from earlier than the 1960s and a quarter from before the 1920s.

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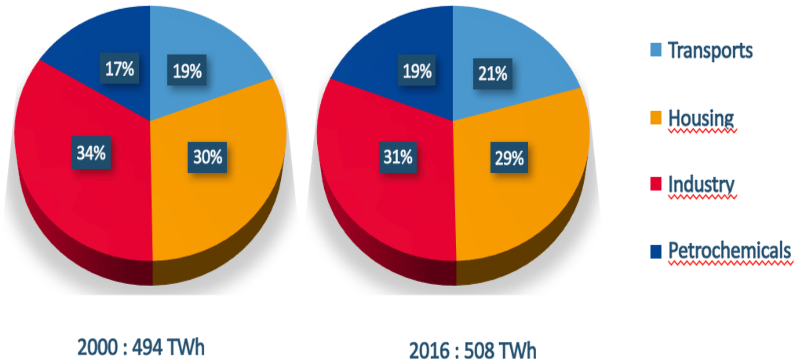
[5] Load factor is the percentage of the annual period during which electrical equipment generates electricity at full power.

However, Flemish housing stock is 20 years younger than its Walloon counterpart. As for Brussels, 75% of its housing units pre-date the 1960s and 50% pre-date the 1940s.



Final energy consumption by use
Data Source : calculation FABI from usages

The average surface area of Belgian homes is 82m² which corresponds to 38m² per occupant. Since the beginning of the 21st century, Belgian housing stock has increased annually by 41,000 new homes.

Since the turn of the century, the share of industry has contracted in favour of services. In 2016, industry was responsible for only 20% of Belgian GDP but accounted for 31% of final energy consumption.

Finally, petrochemicals are a non-energy use of fossil fuels. In 2016, they accounted for 19% of final energy consumption. Since the hydrocarbons used are «transformed» but not «burned» , they do not emit greenhouse gases.

Potential scenarios for 2050

The FABI energy transition platform proposes three scenarios.

The population (0.3% constant per year to 2050) and economic growth data (1.5% between 2017 and 2020 and 1.2% constant between 2020 and 2050) are the same for the three scenarios and are in line with Federal Planning Bureau predictions.

These assumptions lead to a population of 12.5 million in 2050 and a GDP of €644 billion (versus €424 billion in 2016).

Marmot : « business as usual »

This first scenario extends changes to the current energy mix without major modification.

Despite continued growth in the number of cars at the same rate as that observed since the turn of the century, due to the replacement of ICE vehicles (internal Combustion Engine) by 10% electric vehicles and 10% natural gas-powered utility vehicles, as well as a reduction in the fuel consumption of ICE cars (6l/100km to 5l/100km), demand for oil in transport falls by 25%.

With no investment in the renovation of old housing, ***Marmot*** sees a slight increase in final energy consumption in this sector. Despite the introduction of aerothermal heat pumps in new homes built to the new standards, the heat consumed decreases only marginally. In 2050, fuel oil has disappeared from housing while gas accounts for more than half of the energy consumed, compared with 34% for electricity and 15% for biomass.

In industry, ***Marmot*** sees a continuation up to 2050 in the downward trend in consumption observed since the beginning of the century. Without considering any major technological disruption, this reduction is achieved through an incremental improvement in energy efficiency in industrial processes and organisational structures.

In petrochemicals, ***Marmot*** extrapolates the trend for 2000 to 2016 out to 2050.

In accordance with the draft climate law, ***Marmot*** completely phases out nuclear power in 2025, mainly in favour of combined-cycle gas turbine plants (CCGT[6]). The current IRE (Intermittent Renewable Energy) implementation policy is continued and reaches 30% of electricity generation in 2030. The 2050 electricity mix then consists of 52% gas, 30% wind and solar power and 18% biomass.

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[6] A combined-cycle gas turbine plant combines both a gas and steam turbine, the steam from which is generated from the exhaust gases of the gas turbine.

Thanks to gas-fired power plants, ***Marmot*** results in a slight reduction in primary energy consumption. However, the share of fossil fuels increases. In 2050, it accounts for 75% of the primary mix compared with 70% today. This mix is then composed of 33% oil, 42% gas, 5% renewables and 19% biomass.

Between 1990 (121 Mt_{CO2}) and 2050 (83 Mt), Belgian emissions will have fallen by 30%. ***Marmot*** is clearly very far off the European targets and the draft climate law.

Marmot reduces the 2050 energy intensity to 0.95 MWh/€k, which is still higher than the asymptotic target of 0.7 MWh/€k. The carbon content declines by only 10%, while annual per capita emissions fall from 8.8 t_{CO2} to 6.6 t_{CO2}. ***Marmot*** enhances energy sobriety in Belgium which, in 2050, is 49 MWh annually (compared to 58 MWh in 2016).

Turtle : « technology-based plan »

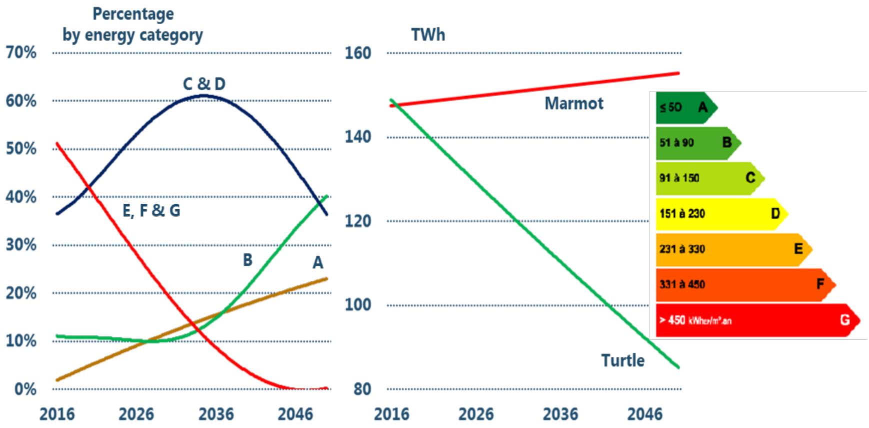
Turtle is based on a profound change in the Belgian energy mix but relies more on technology than on modification of individual behaviours.

Thanks to the development of carpooling (1.56 to 2 passengers per car) and a transfer of the mileage travelled to rail, the car fleet is no longer growing.

Turtle introduces 25% electric & hybrid cars and 40% gas-powered utility vehicles by 2050. Furthermore, thanks to aggressive R&D by car manufacturers, the average consumption of ICE vehicles falls from 6l/100km to 4l/100km.

These assumptions make it possible to reduce the share of oil in transport by 70%. In 2050, the energy mix is therefore made up of 50% petroleum products (versus 93% today), 24% gas, 19% electricity and 5% biofuels.

Turtle undertakes an ambitious « housing » plan, renovating more than 108,000 old homes annually. The least energy-efficient housing units (E/F/G) are therefore gradually insulated to D and C standards and then progressively to the B standard. Around 2045, all E, F & G housing units will have disappeared from the housing stock.



Left : Renovation of housing stock.
Right : Changes in final energy consumption

Turtle enables home energy consumption to be reduced by 40% and a sixfold decline in the share of gas. In 2050, the housing mix only contains 13% gas compared with 26% biomass and 61% electricity (mainly from the installation of aerothermal heat pumps). As for the share of heat, it is reduced threefold, falling from 20 MWh/year in 2016 to 7 MWh/year in 2050.

The total cost of the project is €41 billion over 30 years for total energy savings of €217 billion. The project permits total savings of 260 million tonnes of CO_2 and creates around 10.000 long-term jobs.

The industrial mix is broadly similar to that of ***Marmot***. Without any further technological disruption in processes and organisational structures, it changes only incrementally. However, ***Turtle*** takes advantage of the opportunities offered by the new gas-fired power plants to implement shared cogeneration[7] distributed evenly between the different industrial sectors

It permits 20% of the primary energy injected into the gas generation system to be recovered.

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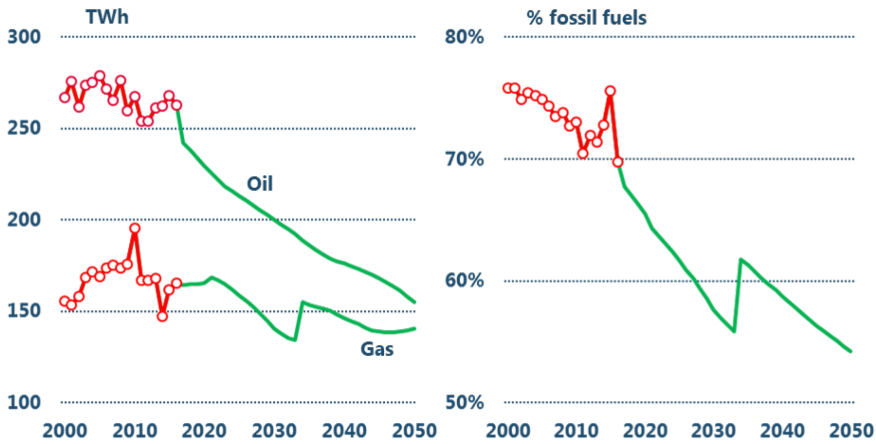
[7] Cogeneration consists of jointly generating electricity and heat from the same primary energy source.

Turtle closes the three oldest nuclear reactors[8] in 2033 but maintains the remaining nuclear capacity until 2050. The increase in IRE (30% in 2030) is identical to ***Marmot***. The nuclear reactors shut down are replaced by combined-cycle gas turbine plants (+cogeneration dedicated to industry).

Compared to 2016, final and primary energy consumption will fall by 17%. The partial phase-out of nuclear power will have played a large part in this reduction, as the nuclear reactors that have been phased out will have been replaced by more efficient combined-cycle gas turbine plants.

In absolute terms, oil consumption will have been reduced by more than 100 TWh while gas consumption will have stabilised at around 150 TWh. The Belgian mix will then contain only 54% fossil fuels, including 28% oil and 26% gas. The rest is made up of 17% nuclear, 21% biomass and 7% renewables.



Changes in oil and gas consumption (left)
and in % fossil fuels (right) - Turtle scenario

By shifting Belgian emissions of CO_2 over the 1990/2050 period from 121 million tonnes to 43 million tonnes, ***Turtle*** reduces them by 64%. If nuclear capacity had been maintained in full, these emissions would have been reduced by an additional 7 million tonnes of CO_2 (70% reduction instead of 64).

[8] i.e. Doel1, Doel2 and Tihange 1.

Turtle cuts all energy indicators in two by 2050. With a value of 0.85 MWh/€k, energy intensity is close to the asymptotic value of 0.7 MWh/€k. The carbon content is reduced to 80 kg_{CO2} /MWh, emissions per capita to 3.5 t_{CO2} per year and energy sobriety to 44 MWh per capita (compared to 58 MWh per capita in 2016).

Hare : « technology & behaviours »

Hare overlays technological changes with significant behavioural changes.

Compared to ***Marmot*** and ***Turtle***, the car fleet is 20% smaller in 2050 than in 2016. The shortfall in kilometres travelled is therefore compensated by one day per week of teleworking and/or co-working.

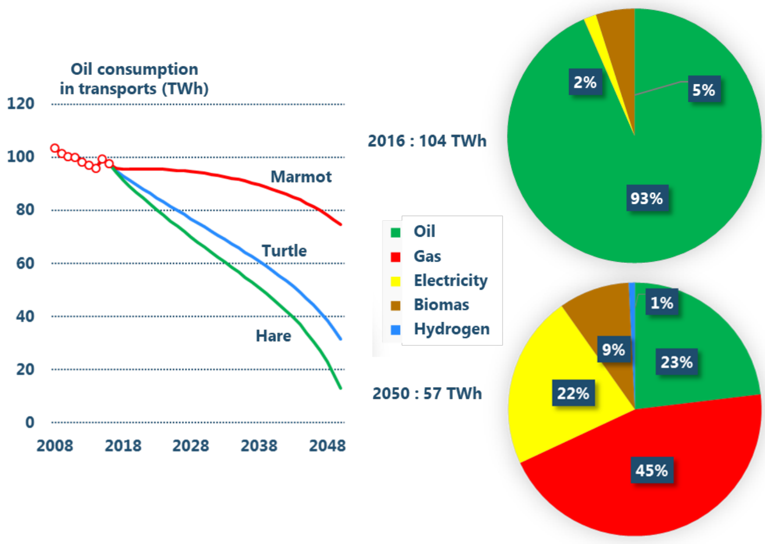
Although the absolute growth in electric cars is the same, the overall reduction in the fleet automatically increases its relative share from 25% to 35%.

Hare introduces 5% of personal vehicles powered by natural gas & hydrogen. It is assumed that this green hydrogen (electrolysis of water) is produced using surplus unused renewable energy.

In 2050, the vehicle fleet consists of 50% ICE vehicles, 45% electric and hybrid vehicles and 5% natural gas and hydrogen vehicles.

Finally***, Hare*** reduces the motorway speed limit to 100 km/h from as early as 2025, enabling a consumption low of 3 l/100 km to be achieved for ICE cars.

Between 2016 and 2050, final energy consumption in transport will have been halved. The share of oil in transport will then have fallen to 23% while gas, introduced on a wide-scale basis for utility vehicles, will account for 45% of consumption, electricity for 22%, biomass for 9% and hydrogen for 1%.



Evolution of oil consumption in transport for the three scenarios.
Evolution of the transport mix (Hare scenario)

Hare sees a slight reduction in the average surface area of homes from 82 m² in 2016 to 76 m² in 2050) but an acceleration in the home renovation plan, with an average annual rate of 150,000 homes (compared to 108,000 for ***Turtle).***

In 2050, 72% of Belgian housing will have been renovated and all housing will be in category A, B or C. ***Hare*** will have enabled fossil fuels to be phased out in housing. The energy mix will then be made up of 68% electricity and 32% biomass while energy consumption will have fallen below the threshold of 5 MWh/year (versus more than 20 MWh/year in 2016).

Representing an investment of €50 billion over 30 years, the project allows for total savings of €285 billion and a reduction in emissions of 329 Mt_{CO2} (60 Mt_{CO2} more than ***Turtle***).

Hare will completely phase out nuclear energy by 2050 but will increase the share of IRE from 30% to 50% from 2040. As in ***Turtle,*** the balance is shifted to combined-cycle gas turbine plants. The heat produced from cogeneration is entirely dedicated to industry. However, by phasing out nuclear power, ***Hare*** increases the share of gas. Electricity generation in 2050 thus consists of 30% gas, 50% IRE and 18% biomass, with the balance being imported.

The industrial mix differs from that of ***Turtle*** only by the additional cogeneration provided by the additional combined-cycle gas turbine plants. Compared to ***Marmot***, this « pooled » cogeneration between the different industrial sectors enables an overall saving of 17 TWh of final energy.

Between 2016 and 2050, ***Hare*** reduces final energy consumption by 25% and shrinks primary energy by 30%. Excluding petrochemicals, oil's energy consumption in 2050 represents only 6% of the mix. However, the phasing out of nuclear power maintains the share of natural gas at around 150 TWh, not much lower than that of 2016.

By 2050, the share of fossil fuels is 62%. However, this figure, skewed by petrochemicals, needs to be put into perspective. Excluding petrochemicals, hydrocarbons account for only 39% of the mix.

The ***Hare*** scenario reduces CO_2 emissions by 67%, bringing them from 121 million tonnes of CO_2 to 40 million tonnes of CO_2. This is not much better than ***Turtle*** (43 million tonnes of CO_2) as all the efforts made in housing and transport are almost completely wiped out by the phasing out of nuclear power and its replacement with natural gas. If nuclear capacity had been maintained in full, the 2050 emissions would have been 28 million tonnes of CO_2, i.e. a reduction of 77% compared to the 1990 value. The phasing out of nuclear energy therefore generates an additional 12 million tonnes of CO_2.

In 2050, energy intensity (0.72 kWh/€) has almost reached its asymptotic value of 0.7 kWh/€. In other words, ***Hare*** reaches the energy limits of the growth-based society. This conclusion also applies to the energy sobriety index which, by 2050, increases to 37 MWh per capita per year.

However, the phasing out of nuclear power leads to a slight rise in the carbon content, which increases during the 2040s to 86 kg_{CO2} /MWh. 2050 per capita emissions (3.2 t_{CO2}), on the other hand, are slightly lower than those for ***Turtle*** (3.5 t_{CO2}).

Conclusions

All three scenarios consider only mature technologies, acceptable behavioural changes and reasonable implementation of IRE, without any technological or societal disruption.

They assume, among other things, that the share of IRE will not exceed 50% of electricity generation by 2050. In particular, they take little account of storage technologies (batteries, hydrogen) considering their wide-scale roll-out as still too uncertain at present.

And yet, despite these strong assumptions, a reduction in emissions of between 67% (with nuclear phase-out) and 77% (by retaining nuclear power) is achievable without undermining the growth society.

	Energy intensity	Carbon content	Emissions per inhabitant	Energy sobriety	Reduction of emissions base 1990
	MWh/k€	k_{CO2}/MWh	t_{CO2}/hab	MWh/hab	%
2016	1,54	153	8,8	58	17%
Marmot	0,95	136	6,6	49	31%
Turtle	0,85	80	3,5	44	64%
Hare	0,72	86	3,2	37	67%

Synthesis of the energy indicators of the three scenarios

However, none of the three scenarios achieves the target of a 95% reduction by 2050. Is this objective actually achievable and, if yes, under what conditions? To answer this, it is essential to look more closely at the consequences of phasing out nuclear power and its replacement by gas.

While the implementation of combined-cycle gas turbine (+cogeneration) plants improves energy efficiency and significantly reduces primary energy consumption, it hampers the ability of the Belgian mix to continue with decarbonisation.

This is a logical result since, apart from industry, for which the opportunities for displacement are currently limited, transport and housing have been made almost completely carbon-free by 2050.

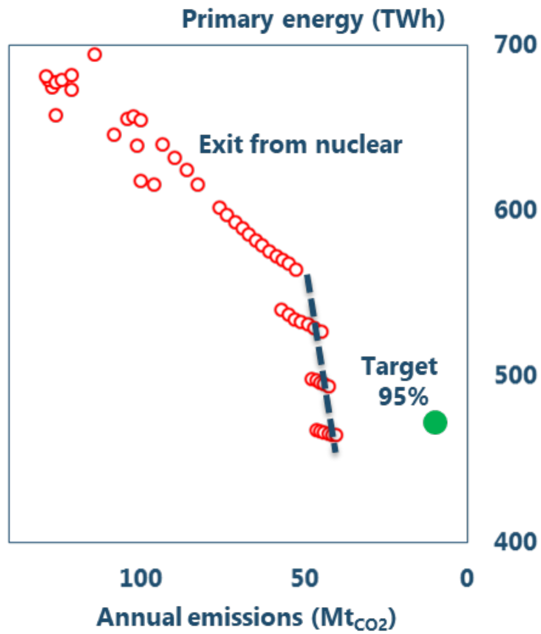
Adding electric cars or heat pumps therefore contributes to increasing emissions rather than reducing them, since the majority of them use electricity generated from gas.

Increasing the share of IRE in the electricity mix even further with the support of gas in case of intermittency has the clear drawback of requiring a double investment (renewables/CCGT) to compensate for the inevitable periods of intermittency.

When smoothed out over the year, 60% IRE generation would require at least 45 GW[9] of capacity and at least 3 GW of additional CCGT. In this scenario, emissions

[9] i.e. 22,500 wind turbines of 2MW

would be reduced to 35 Mt_{CO2}/year. Without storage, the increase in renewables does not therefore make it possible to achieve the 95% target.

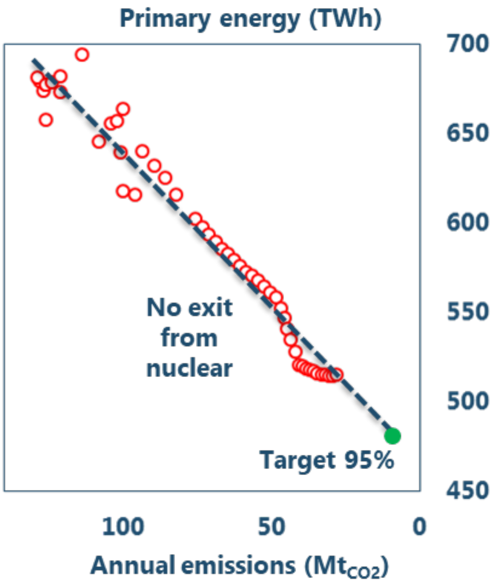


Continuing decarbonization beyond the Hare scenario with nuclear output

So what are the solutions ?

The first is to maintain nuclear capacity (which will require significant investment to extend its life) or even increase it. By maintaining the 6 GW of nuclear, 2050 emissions reach 28 Mt_{CO2}/year, i.e. a reduction of 77% compared to the 1990 level. This is 10 points higher than the 67% achieved with nuclear phase-out.

However, above all, the trend shows that the 95% target of the climate law is, this time, entirely achievable. This is confirmed by the value for energy intensity (0.80 MWh/€k), which is much higher than the asymptotic value of 0.7 MWh/€k. By maintaining nuclear power, ***Hare*** therefore has sufficient reserves of energy intensity to achieve the climate law's 95% target.



Continuing decarbonization beyond the Hare scenario without nuclear output

These reserves are to be found in the full electrification of transport as well as in nuclear cogeneration which could be implemented in new units as has been proposed for gas. Without phasing out nuclear energy, the 95% target therefore remains compatible with a society of economic growth.

The second solution is the most desirable but also the most uncertain. It assumes that it will be possible, in the medium term, to fully substitute gas and nuclear with renewable energy by increasing, thanks to information technologies, the trading of electricity on the European grid[10] but, above all, due to the mass implementation of storage units: pumping/turbines, batteries and hydrogen for the most part. However, beyond the technologies themselves (batteries, wind turbines, solar panels, hydrogen chain) which are all mature**, it is the scale of implementation that will pose a problem**.

[10] Belgium has recently invested in additional interconnection capacity with its European neighbours, making it one of the most open and interconnected networks in Europe

Large numbers of wind turbines, land area covered by solar panels, and the significant electricity capacity required to produce hydrogen are all problems that will have to be addressed. For example, replacing the petrol and diesel consumed in Belgium in 2016 with hydrogen would require 80 TWh of electricity, i.e. double current electricity generation. 80 TWh would require the output of 10 nuclear reactors or twenty thousand 2MW wind turbines.

Moreover, geopolitically, the rare metals and electrolytic materials used in batteries and/or fuel cells are unevenly distributed over the planet's surface. 100% IRE will not, any more than oil or gas, give Belgium complete energy independence.

The third solution consists of capturing and then injecting a portion of the residual CO_2 (mainly that coming from large industrial emitters and future gas-fired power plants) underground. Despite strong societal concerns, CCUS (Carbon Capture, Utilisation & Storage) is likely to play a strategic role in the future Belgian transition and contribute to further reductions in emissions.

However, in order to reduce its emissions by 95%, Belgium will have to store 20 million tonnes of CO_2 annually by 2050. This technology will mainly apply to large industrial emitters, with industry being the main usage where emissions are currently the most difficult to reduce.

Finally, the last solution would be to impose draconian societal measures (restrictions on transport, sizes of homes, temperature of houses, consumption of hot water and electricity).

Apart from the difficulty in garnering acceptance for such measures, such an option would destroy whole swathes of the Belgian economy and would, without fail, reduce a significant part of activity. The 95% target combined with a phasing out of nuclear energy would therefore come at the expense of economic growth.

The same conclusion can be reached in relation to energy intensity (0.72 MWh/€k with 50% renewables), which, for the Hare scenario, reaches the asymptotic value of 0.7 MWh/€k in 2050. An option that, apart from its consequences for society, would no longer provide the resources needed to finance a transition the best friend of which is ultimately a growth-based society.

Marmot	Turtle	Hare
Growth in number of vehicles	Freezing of number of vehicles	Decrease in number of vehicles
Reduction in mileage	Reduction in mileage	Reduction in mileage
Passengers and goods to rail	Passengers and goods to rail	Carpooling + teleworking + co-working
10% electric cars & gas-powered utility vehicles	25% electric cars & 40% gas-powered utility vehicles	25% electric cars and 40% gas-powered utility vehicles
Car consumption 5 l/100 km	Car consumption 4 l/100 km	Car consumption 3 l/100 km
No hydrogen vehicles	No hydrogen vehicles	5% gas and hydrogen-powered cars
No renovation of old housing	108,000 renovations per year	150,000 renovations per year
New homes to 2012 standards	New homes to 2012 standards	New homes to 2012 standards
Extension of industrial trend	Extension of industrial trend + cogen.	Extension of industrial trend + cogen.
Continued growth in petrochemicals	Continued growth in petrochemicals	Continued growth in petrochemicals
Nuclear phase-out by 2025	Nuclear 1/3 phase-out by 2033	Nuclear phase-out by 2050
Nuclear replaced by CCGT	Nuclear replaced by CCGT	Nuclear replaced by CCGT
30% RE by 2030	30% RE by 2030	50% RE by 2040

Fundamental indicators (annual basis):

- Energy intensity (MWh/€k): ratio between the quantity of primary energy consumed and GDP.
- Carbon content (kg_{CO2}/MWh): ratio between CO_2 emissions and the quantity of primary energy consumed.
- Per capita emissions (t_{CO2}/inhabitant)
- Energy sobriety index (MWh/inhabitant): ratio between the primary energy consumed and the number of inhabitants.

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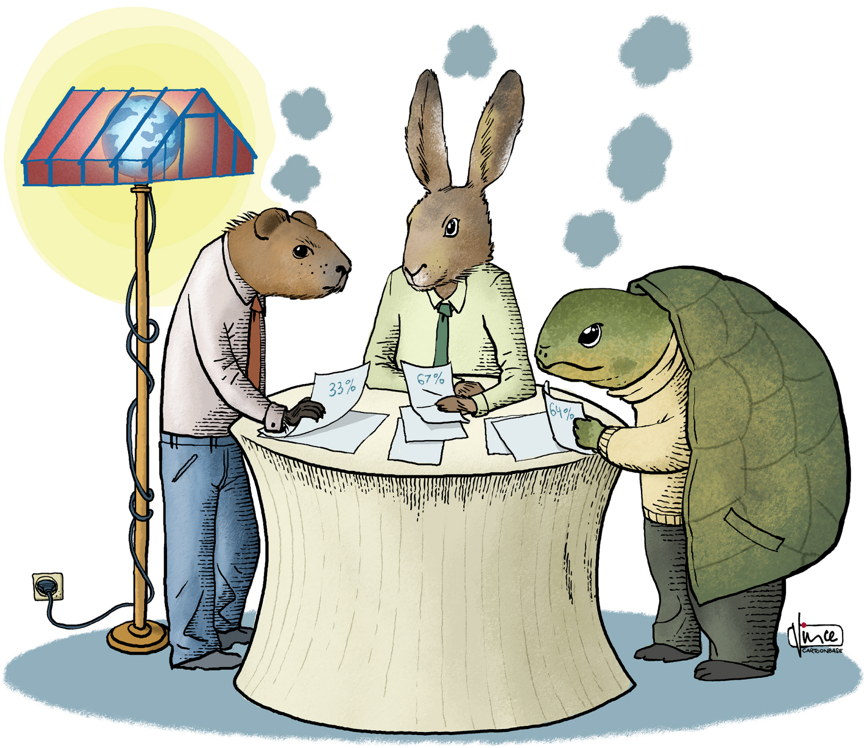

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