Study on the role of gas in Belgium’s future energy system

EXECUTIVE SUMMARY

April 23, 2018

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Organisation of the presentation

A transformative energy transition in Belgium and Europe

- **Major transformation of Belgium's energy system underway due to :**
  - **Decarbonisation, renewables and energy efficiency objectives**
  - **Nuclear phase-out**

- **Policy debate on possible pathways towards a reliable and decarbonised energy system raises key issues regarding the enabling technologies and necessary policy measures :**
  - **Comprehensive approach**: each energy source should be used where it brings most benefits
  - **Direct vs indirect use** : 'end to end' assessment necessary
  - **Transition vs. destination**: roles of energy sources to evolve in short term vs. long term

Need for robust assessment of alternative energy transition pathways, key enabling technologies and policy measures

Identifying the potential for efficient use of gas in different sectors as an enabler for the energy transition

- **The study aims to address a set of questions related to the potential role of gas in Belgium's energy transition:**
  - Could gas be an **enabler for the energy transition in some sectors**?
  - Could **green gas (biogas, Power-to-Gas)** facilitate the energy transition in some sectors?

- **The study aims to identify practical policy actions and technology options to maximise the efficiency of Belgium's energy transition :**
  - Reduce the **carbon footprint** of the Belgian economy;
  - Limit **pollution**;

  While :
  - Keeping **costs for Belgian consumers** as low as possible;
  - Maintaining **security of energy supply and diversity of supply**.

The study aims to provide fact-based evidence of the role that gas could play to facilitate the energy transition and the decarbonisation at an acceptable cost for Belgian consumers.

Modelling technology options for greater use of gas in different sectors to decarbonize Belgium's economy

- **The study complements the existing literature by providing fact-based evidence of the potential contribution of gas in different sectors through a bottom up modelling of the impact of different technologies.**
  - Not intending to provide new prospective scenarios, rather starting from an **existing macro scenario from the European Commission (EUCO30),** and…
  - … leveraging on publications from ENTSO-E, Federal Planning Bureau and DELTA to **build up a micro-modelling at sector level** (incl. power sector)

- **The study considers how existing technology options at sector level could impact the evolution of Belgium's energy system as forecasted in the EC macro-scenario.**
  - The study explores **different sensitivities regarding energy usages**, and their impact on Belgium's energy demand, CO_2 and pollutant emissions as well as overall costs/savings for end-customers.
  - The study considers the **potential for production of green gas** (biogas and Power-to-Gas) from renewable energy sources in Belgium and their contribution to further decarbonisation.

The study complements existing prospective studies on Belgium's energy transition by modelling the potential contribution of gas and technology options using gas in a number of sectors.

Note : BFP = Bureau Fédéral du Plan; EC = European Commission.

Bottom-up modelling based on pre-existing macro scenarios to evaluate the potential of different technologies

- **The study is based on a EC macro-scenario for the decarbonisation of Belgium's energy system, 2000 – 2050 and on ENTSO-E's simulations to assess the impact of electrification.**
- **The study provides a bottom-up detailed modelling of a range of technologies using gas to assess their potential contribution to decarbonisation of Belgium's economy at a sector level.**

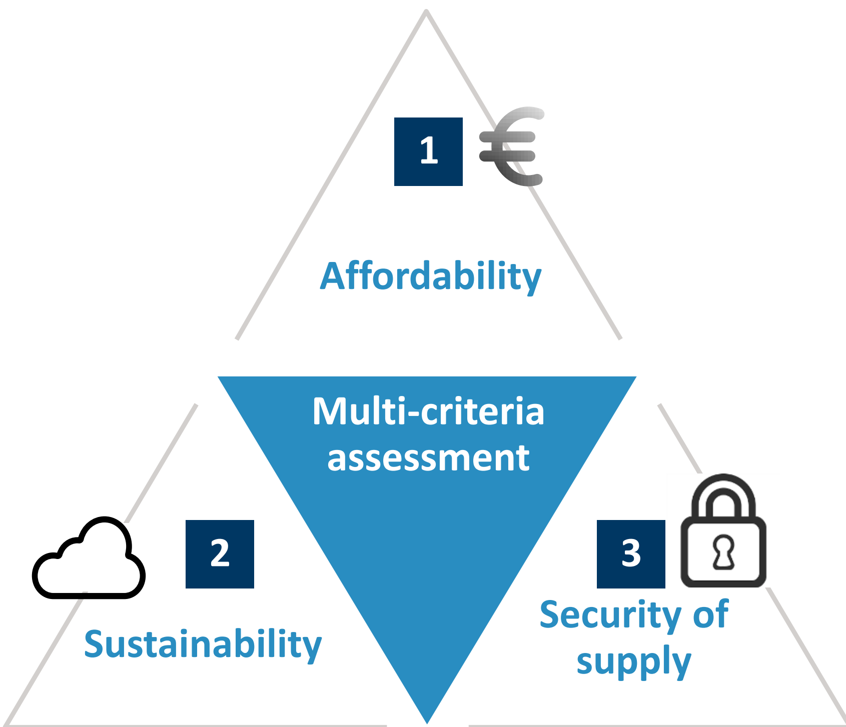
Sector	Modelling	Technology choices
Residential **Phase-out of oil boilers**	▪ **Switching behaviour** from one heating technology to another ▪ **Accounting for characteristics of each technology** as well as change in **load profile**	**Phase-out of 100% oil boilers by** : ▪ gas condensing boilers ▪ electric heaters ▪ heat pumps and gas boilers ▪ hybrid heat pumps and gas boilers ▪ gas heat pumps
Transport **Replacement of gasoline and diesel vehicles**	▪ **Switching behaviour** from one type of vehicle to another ▪ Accounting for **characteristics of each type of vehicle** and change in **load profile**	▪ All new and replacement cars are **CNG cars** except for electric cars. ▪ All new and replacement trucks are **LNG trucks**.
Industry **Replacement of coal- and oil-based industrial heating processes**	▪ Accounting for **characteristics of each type of process**	▪ All coal- and oil-based processes are replaced by gas processes, especially in the **petro-chemical** and **paper industries**
Supply **Potential for green gas**	▪ Based on third party estimates and sensitivity analyses	▪ **Power-to-Gas** ▪ **Biogas / Biomethane**

Multi criteria analysis

- Impact on **final and equivalent primary energy demand**[(i)]
- Impact on **security of electricity supply**
- Impact on **CO_2 emissions**
- Impact on **emissions of pollutants**
- Impact on **costs of the energy** system

Note: (i)Equivalent primary energy demand corresponds to the energy demand including energy used for electricity production. It includes imports.

Multi-criteria analysis of technology options at sector level



1 Affordability

- **Implementation costs for the society** (fuel, equipment, infrastructure)

2 Sustainability

- **Energy Efficiency** (equivalent primary energy demand, final energy demand)
- **Emissions** (CO_2, pollutants)

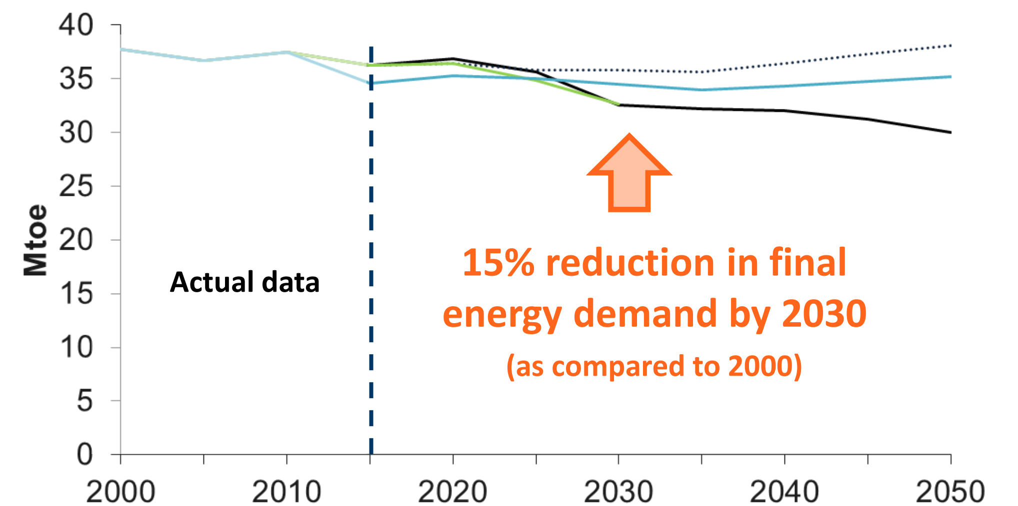
3 Security of supply

- **Import dependency**
- **Electricity system reliability** (peak demand)
- **Gas system reliability** (well-interconnected system, diversified supply)

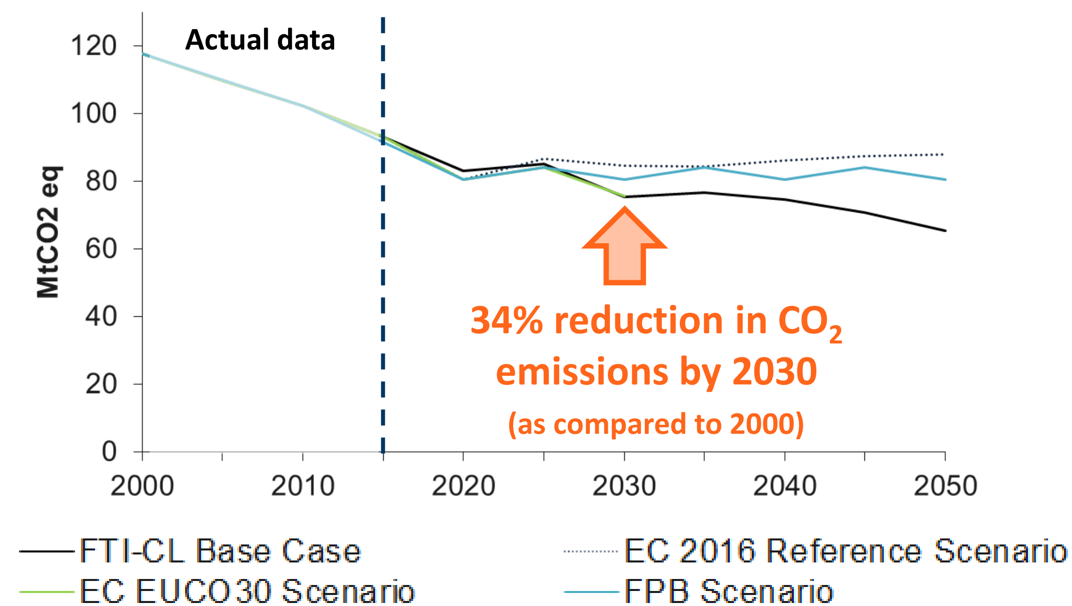
Top-down methodology - building on the EUCO30 scenario

- **Our base case starts from the <u>EUCO30 scenario for Belgium</u>, extended over the 2030 – 2050 period**
  - Accounts for **targets and policy measures identified in the Commission's "Clean Energy Package"**
  - However, **not in line with** long-term ambitions of the **"Paris Agreement".**
- **Further penetration of existing gas technologies does not solve everything but could <u>contribute to meet decarbonisation objectives</u>**

Final energy demand, 2000 - 2050



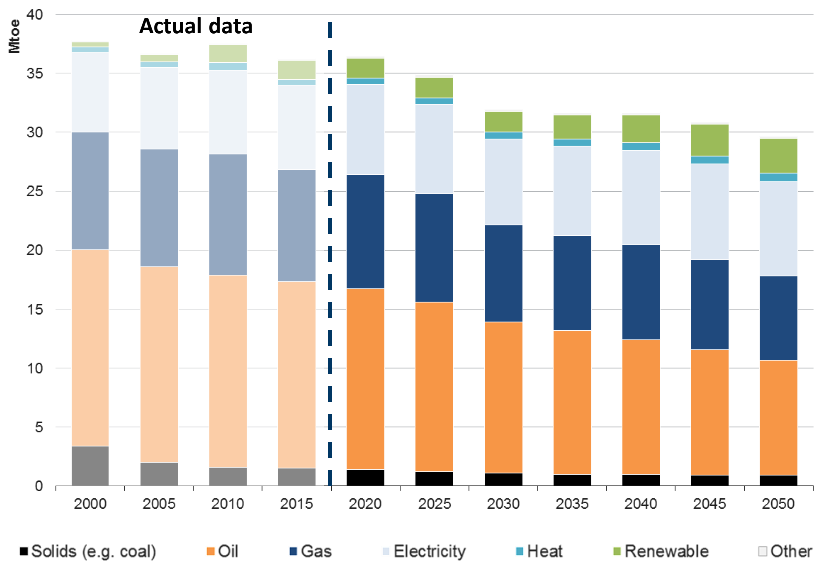
CO_2 emissions (excl. energy branch), 2000 - 2050



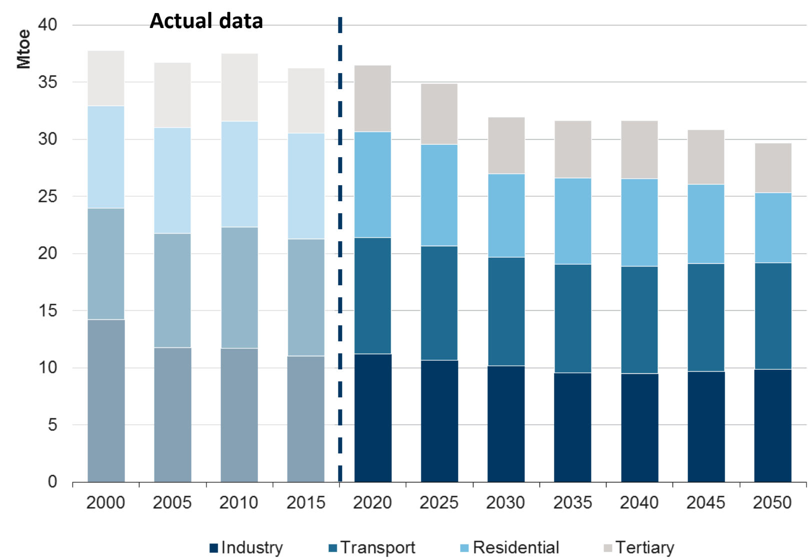
<u>Sources</u>: European Commission, https://ec.europa.eu/energy/en/data-analysis/energy-modelling; FPB, "Le paysage énergétique belge à l'horizon 2050 - Perspectives à politique inchangée".

Final energy demand by fuel and by sector

Final energy demand, by fuel, 2000 - 2050



Final energy demand, by sector, 2000 - 2050



- Significant switching from oil towards electricity:
  - **Share of oil** of **40% in 2030** decreases to 33% in 2050.
  - **Share of gas** of **26% in 2030** remains stable to 24% in 2050.
  - **Share of electricity** of **23% in 2030** increases to 27% in 2050.

- As energy use is modified in all sectors, their share in final demand remains fairly stable:
  - **Industrial sector** accounts for **32%** in 2030 and 33% in 2050.
  - **Residentiel sector** accounts for **23%** in 2030 and 21% in 2050.
  - **Tertiary sector** accounts for **16%** in 2030 and 15% in 2050.
  - **Transport** accounts for **30%** in 2030 and 32% in 2050.

Note : Renewable energy sources include wind power, solar power (thermal, photovoltaic and concentrated), hydro power, tidal power, geothermal energy, biofuels and the renewable part of waste.

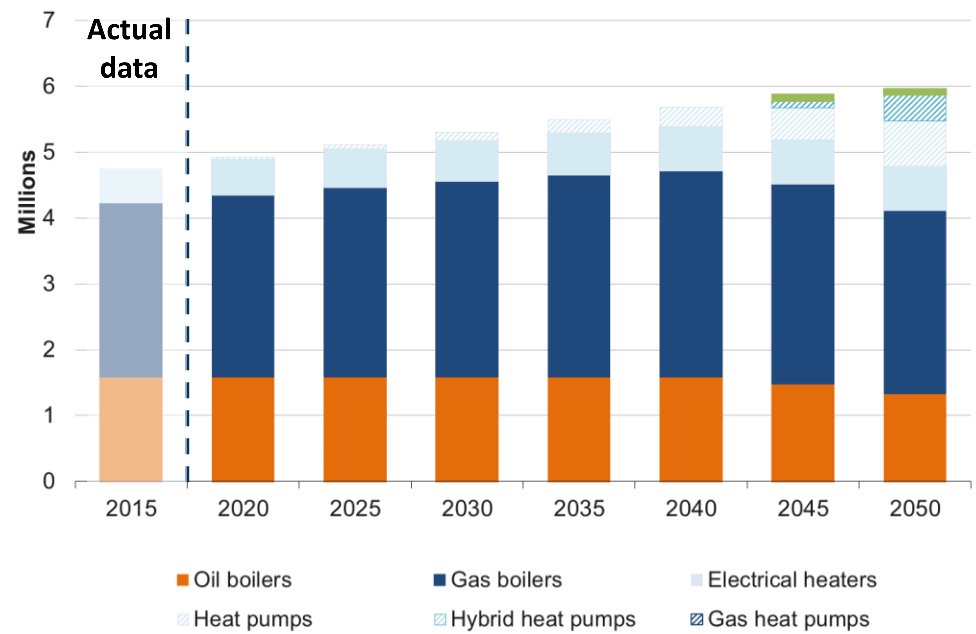
Sources: European Commission, https://ec.europa.eu/energy/en/data-analysis/energy-modelling; FPB, "Le paysage énergétique belge à l'horizon 2050 - Perspectives à politique inchangée".

Sensitivities : Five sensitivities for the phase-out of oil boilers by 2050 that reduce both energy consumption and CO_2 emissions

- **Bottom-up modelling of the residential sector based on DELTA's study**
  - In 2030, **oil boilers account for 48% of (direct) CO_2 emissions**.

- **Five sensitivities for the (realistic) phase-out of half of oil boilers in 2030 (towards 100% oil boilers by 2050) through replacement by:**
  - Sensitivity 1: **gas condensing boilers**
  - Sensitivity 2: **electric heating**
  - Sensitivity 3: **electric heat pumps**
  - Sensitivity 4: **hybrid heat pumps**
  - Sensitivity 5: **gas heat pumps**

Number of heating appliances, base case, 2015 - 2050



Sources : Delta, « ARGB future of gas demand, forecasting the evolution of gas demand & peak gas demand in Belgium to 2030.

Key findings: Gas condensing gas boilers are effective to decarbonise heating and reduce pollution at least cost

Residential
Phase-out of oil boilers replaced by…

Sensitivity (2030) with respect to base case	Energy demand (% of sectorial energy demand)	Pollutant emissions	CO_2 emissions (% of sectorial CO_2 emissions)	Implementation costs (as compared to base case)
Gas condensing boilers	orange (-1%)	green	green (-6%)	green (- €72m p.a)
Electric heaters[i]	red (+15%)	red	red (+12%)	green (-€43m p.a.)
Heat pumps[i]	red (+3%)	orange	orange (-3%)	red (+€13m p.a.)
Hybrid heat pumps[i]	orange (-2%)	green	green (-9%)	red (+€41m p.a.)
Gas heat pumps	green (-6%)	green	green (-12%)	orange (- €2m p.a.)

Whilst different heating technologies have pros and cons, gas condensing boilers would reduce CO_2 emissions and pollution and are the cheapest solution as no network reinforcement is required.

Note : *(i) With the electricity generation mix expected in 2030 according to ENTSO-E (Vision EUCO30).*

Modelling results: Gas condensing boilers are effective to decarbonise heating and reduce pollution at least cost

Residential — Phase-out of oil boilers replaced by…

Sensitivity (2030) with respect to base case	Energy demand in 2030 (% of sectorial energy demand)	Emissions in 2030 (% of sectorial emissions)	Implementation costs (as compared to base case)
Gas condensing boilers	✓ - 32 ktoe (-1%)	✓ - 0.8 Mt CO_2 eq. (-6%) Decrease in pollutant emissions	✓ - €72 million per year
Electric heaters[i]	× + 1,077 ktoe (+15%)	× + 1.9 Mt CO_2 eq. (+12%) Mild impact on pollutants	✓ - €43 million per year
Heat pumps[i]	× + 212 ktoe (+3%)	✓ - 0.4 Mt CO_2 eq. (-3%) Mild impact on pollutants	× + €13 million per year
Hybrid heat pumps[i]	✓ - 164 ktoe (-2%)	✓ - 1.2 Mt CO_2 eq. (-9%) Decrease in pollutant emissions	× + €41 million per year
Gas heat pumps	✓ - 421 ktoe (-6%)	✓ - 1.7 Mt CO_2 eq. (-12%) Decrease in pollutant emissions	✓ - €2 million per year

Note : (i) With the electricity generation mix expected in 2030 according to ENTSO-E (Vision EUCO30).

Sensitivity analysis: Higher of penetration of RES would reduce emissions of electric technologies but raise other issues

- In order to test the robustness of the study findings, we run a **sensitivity analysis on the penetration of renewables for electricity production**.
- Relying on our bottom-up modelling of the residential sector, we assess the impact of each technology option on CO_2 emissions, for different penetration of RES by 2030.

CO_2 emissions in 2030 (% of sectorial emissions)

Residential: Phase-out of oil boilers replaced by…	Sensitivity (2030) with respect to base case	+5 GW of RES in generation mix[i] (+35% RES vs base case)	+10 GW of RES in generation mix[i] (+69% RES vs base case)	+20 GW of RES in generation mix[i] (+138% RES vs base case)
	Gas condensing boilers	✓ - 0.8 Mt CO_2 eq. (-6%)	✓ - 0.8 Mt CO_2 eq. (-6%)	✓ - 0.8 Mt CO_2 eq. (-6%)
	Electric heaters	✓ - 1.2 Mt CO2 eq. (-9%)	✓ - 1.7Mt CO2 eq. (-13%)	✓ - 2.3Mt CO2 eq. (-18%)
	Heat pumps	✓ - 1.7 Mt CO_2 eq. (-13%)	✓ - 1.9 Mt CO_2 eq. (-15%)	✓ - 2.1 Mt CO_2 eq. (-17%)
	Hybrid heat pumps	✓ - 1.5 Mt CO_2 eq. (-12%)	✓ - 1.5 Mt CO_2 eq. (-12%)	✓ - 1.5 Mt CO_2 eq. (-12%)
	Gas heat pumps	✓ - 1.7 Mt CO_2 eq. (-12%)	✓ - 1.7 Mt CO_2 eq. (-12%)	✓ - 1.7 Mt CO_2 eq. (-12%)

In the longer term, higher penetration of renewables for electricity production and electrification of heating could reduce emissions but would raise a number of issues:

- **Significant network investment would be required by 2030;**
- **Need for additional peak capacity (e.g. from gas plants).**

Note : (i) Additional RES are located in Belgium. Mix of Solar and Wind generation (in %) remains unchanged.

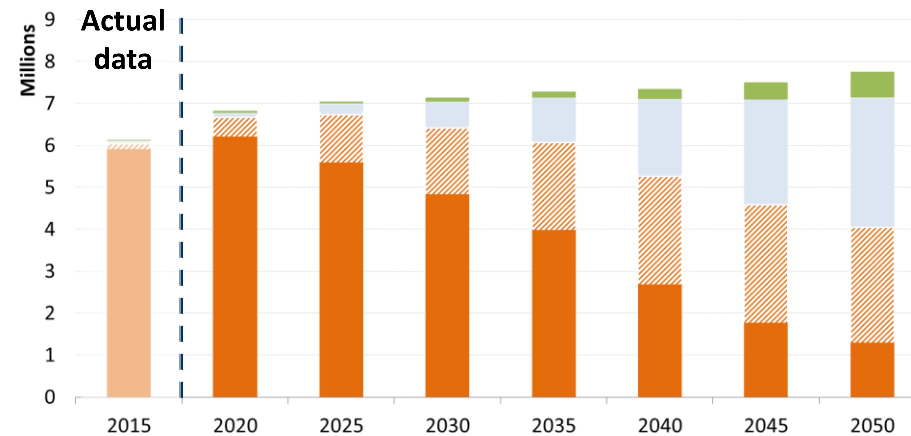
Sensitivity 1 : CNG cars could reduce pollution in the transport sector as a complement to electrification

- **Bottom-up modelling of the transport sector based on BFP's study**
  - In 2030, **gasoline and diesel cars account for 94% of (direct) CO_2 emissions**
  - We have considered a sensitivity where all gasoline and diesel cars are replaced by CNG cars

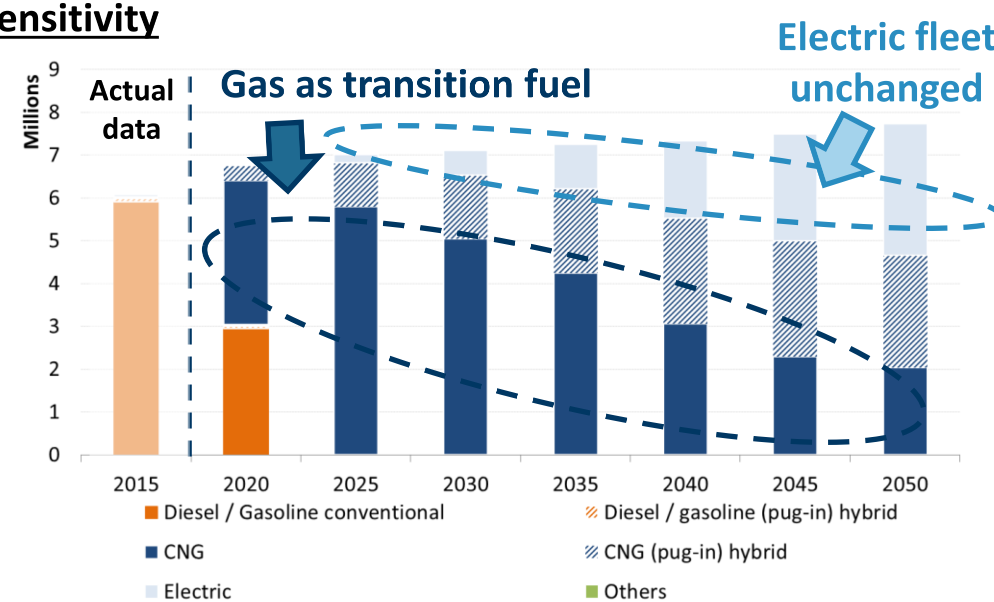
  ⇒ **CNG cars** could be an efficient transition towards **electrification** while reducing CO_2 emissions and pollution significantly

Number of passenger cars, 2015 - 2050

base case



Sensitivity

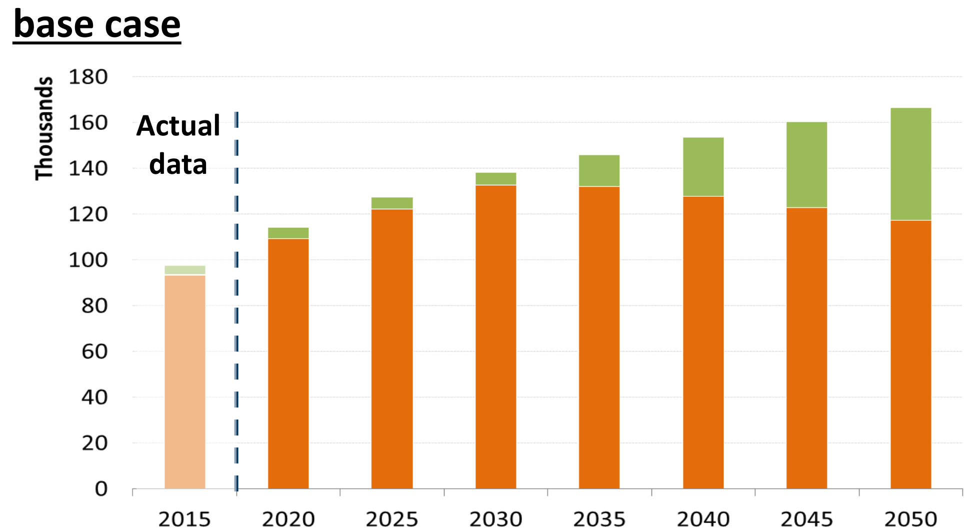


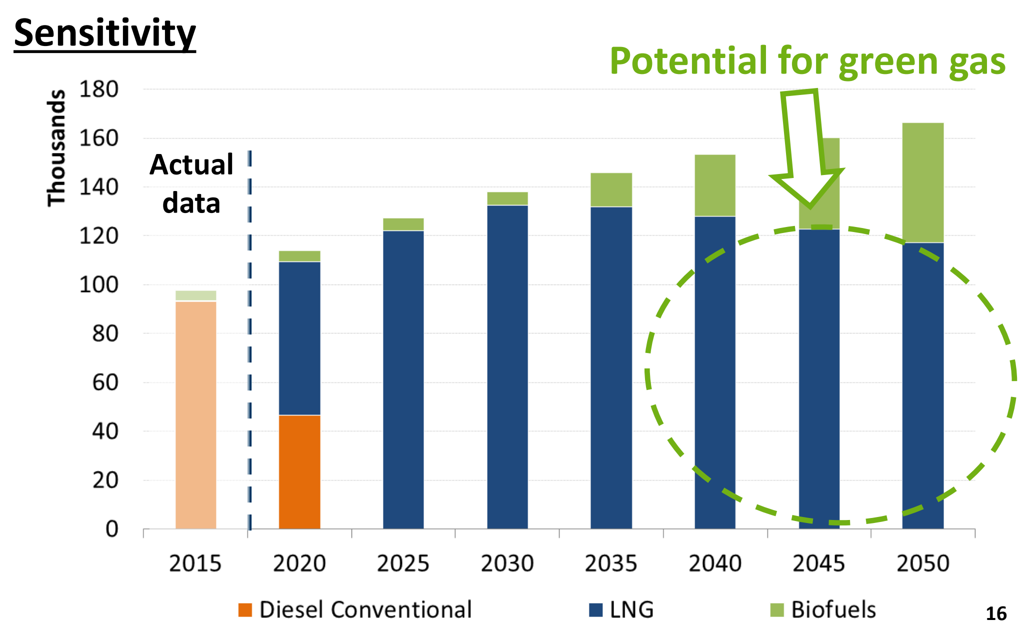
Source : FPB, "Le paysage énergétique belge à l'horizon 2050 - Perspectives à politique inchangée".

Sensitivity 2 : LNG trucks could reduce pollution in the transport sector now and in the long term

- **Bottom-up modelling of the transport sector based on Ricardo's studies**
  - In 2030, **diesel trucks account for 100% of (direct) CO_2 emissions**
  - **LNG trucks** are the **best alternative technology for heavy-duty transport** given constraints in fuel density, autonomy and emissions of particulate matters
  - We have considered a sensitivity where **all trucks are progressively replaced by LNG trucks**
  - ⇒ **LNG trucks** could be an efficient alternative to reduce CO_2 emissions and improve air quality. In the long term, the sector can be **decarbonised using green gas**.

Number of Trucks, 2015 - 2050





Source : Ricardo, "The role of natural gas and biomethane in the transport sector".

Key results: CNG cars and LNG trucks could reduce pollutants and CO_2 emissions of the transport sector

Transport
Replacement of gasoline and diesel vehicles

Sensitivity (2030) with respect to base case	Energy demand (% of sectorial energy demand)	Pollutant emissions	CO_2 emissions (% of sectorial CO_2 emissions)	Implementation costs[i] (as compared to base case)
CNG cars	red (+6%)	green	green (-22%)	half green / half red (+ €376m p.a)
LNG trucks	red (+6%)	green	green (-33%)	green (-€387m p.a.)

- **The higher penetration of electric cars by 2030 in our base case triggers significant decrease in energy demand as well as CO_2 emissions.**
- **Developing CNG cars is an interesting complementary solution to electrification in the short to medium term to reduce further CO_2 and pollutant emissions.**
- **The promotion of LNG trucks would significantly reduce CO_2 and pollutant emissions but would require significant infrastructure investments.**
- **In the long term, the sector can be decarbonised using green gas.**

Note : (i) Under the assumption of the electrification of the power sector in the long term.

Modelling results : CNG cars and LNG trucks could reduce pollutants and CO2 emissions of the transport sector

Transport
Replacement of gasoline and diesel vehicles

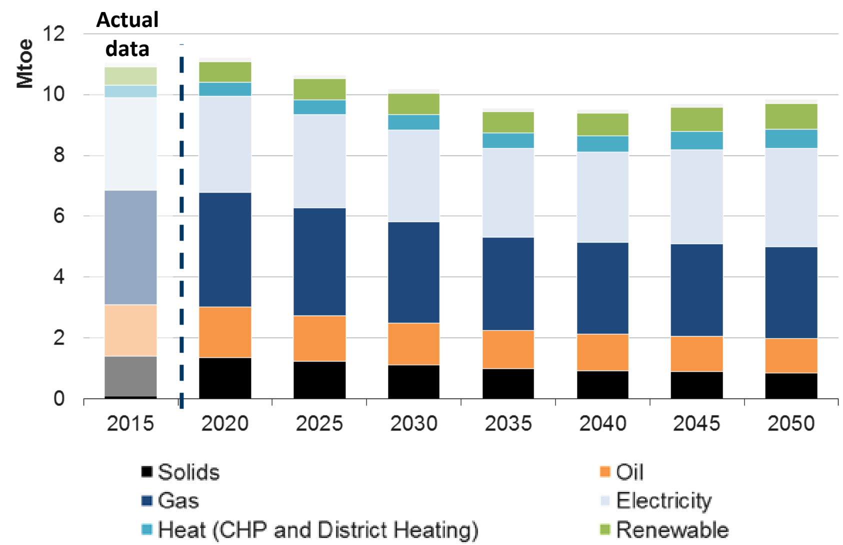
Sensitivity (2030) with respect to base case	Energy demand in 2030 (% of sectorial energy demand)	Emissions in 2030 (% of sectorial emissions)	Implementation costs (as compare to base case)
CNG cars	× + 616 ktoe (+6%)	✓ - 2.4 Mt CO_2 eq. (-22%) Strong reduction in pollutants	× + €376 million per year
LNG trucks	× + 623 ktoe (+6%)	✓ - 3.5 Mt CO_2 eq. (-33%) Strong reduction in pollutants	✓ - €387 million per year

A significant potential for gas to substitute oil and coal in a number of industrial heating processes

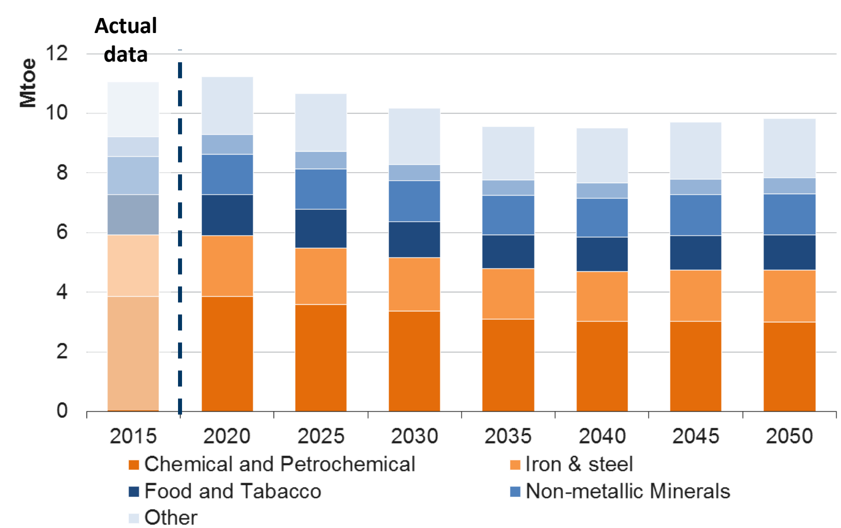
- **The replacement of oil-based technologies for heating in industry could reduce the CO2 emissions**:
  - Although coal accounts for only 14% of final energy demand, industrial oil usage account for 27% of (direct) CO2 emissions of the sector in 2030.
- **The replacement of coal-based technologies for heating in industry could reduce the CO2 emissions**:
  - Although coal accounts for only 11% of final energy demand, industrial coal usage account for 37% of (direct) CO2 emissions of the sector in 2030.

The phase-out of oil and coal-based technologies for heating by 2030 could be an efficient way to reduce both energy consumption and CO_2 emissions, and therefore make a significant contribution to Belgium's decarbonisation objectives.

Final energy demand, by energy type, 2015 - 2050



Final energy demand, by industrial sector, 2015 - 2050



Successful development of gas- and biogas-based technologies in Belgium's industry

- **Oil/coal-to-gas heating process switches in Belgium's industry could significantly reduce direct CO_2 emissions as compared to base case.**
- **Combined with green gas, it could support efficient decarbonisation of Belgium's industry.**

Examples of successful process switches to gas and biogas in the petro-chemical industry

Dow – ExxonMobil

Shale natural gas (ethane) as the primary feedstock to make chemicals and plastics

INEOS

Oil-to-ethane switch in EU petrochemical plants

Burgo Group

Oil-to-natural gas conversion project for heating processes

Substantial potential for biogas in Belgium and neighbouring countries

Up to 2 Mtoe potential for Power-to-Gas in Belgium

(8% of Belgium's final energy demand)

- Maintaining a reliable energy system
- Facilitating development and integration of intermittent RES by providing system flexibility

Up to 1 Mtoe potential for biogas production from sustainable biomass in Belgium

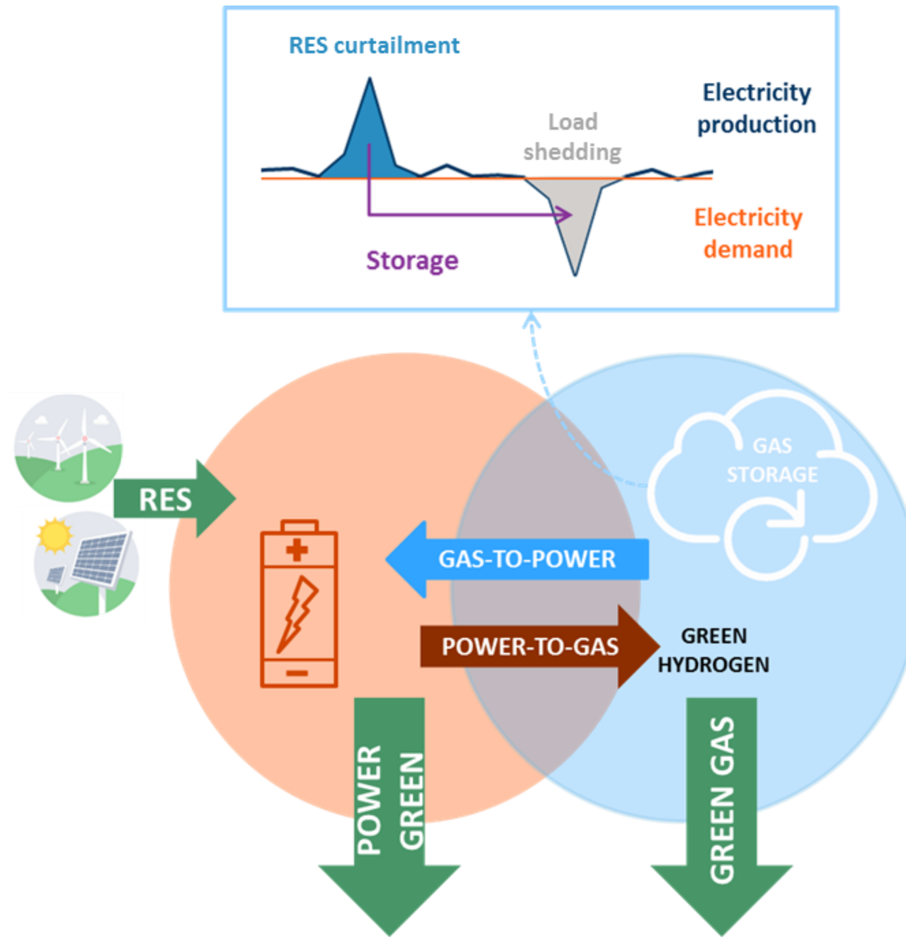
(4% of Belgium's final energy demand)

- Locally from readily available waste
- Biomethane offers decarbonisation and flexibility

88 Mtoe biomethane potential by 2050 within the EU (Ecofys)

(10% of EU final energy demand)

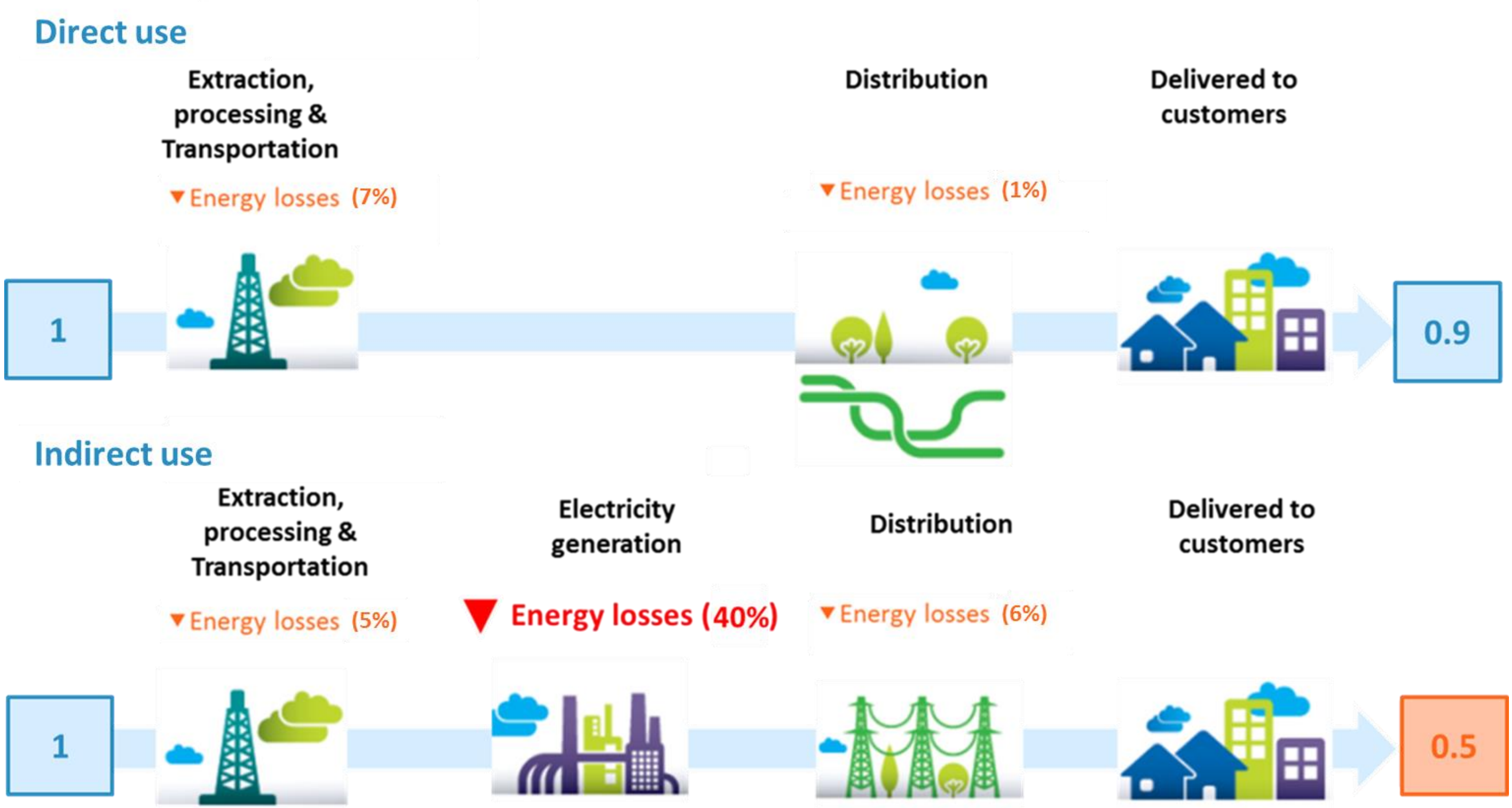
Bringing value with Power-to-Gas



According to several studies, green gas could represent up to 10% of EU energy demand and 48% of gas use (Ecofys)

Source :*Power-to-gas Industry cluster Flanders, "Power-to-gas Roadmap for Flanders"; Ecofys, "The role of gas in a net-zero emission European energy system".*

Direct use of gas is more efficient than electrification in some usages and leverage on existing affordable gas infrastructure



6 - Key messages

Gas can play a decisive role as an enabler of an efficient energy transition both in the short and long term

2030

Gas as <u>transition fuel</u> towards a decarbonised energy sector

Reduce emissions and improve air quality when substituting for other fuels in transport, residential, and industry sectors

Enable energy transition thanks to the **maturity of efficient technologies** and **existing infrastructures**

Play a **bridging role in power generation** after the nuclear phase-out

Long term (2050 - onwards)

Green gas as a <u>long-term sustainable source of energy</u>

Substantial potential for biogas in Belgium that could progressively replace natural gas by renewable gas

Enable development of intermittent RES by providing **flexibility and seasonal storage** through Power-to-Gas and **leveraging existing infrastructures**

Support efficient sector coupling and synergies for an efficient and affordable decarbonisation

Do not hesitate to contact us for further information on detailed results or/and underlying assumptions

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