High Council
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Study Committee on Public Investments & FPS Public Health, DG Environment

Methodological appendix to the report

“Additional investments in existing net-zero emissions scenarios for Belgium”

March
2025

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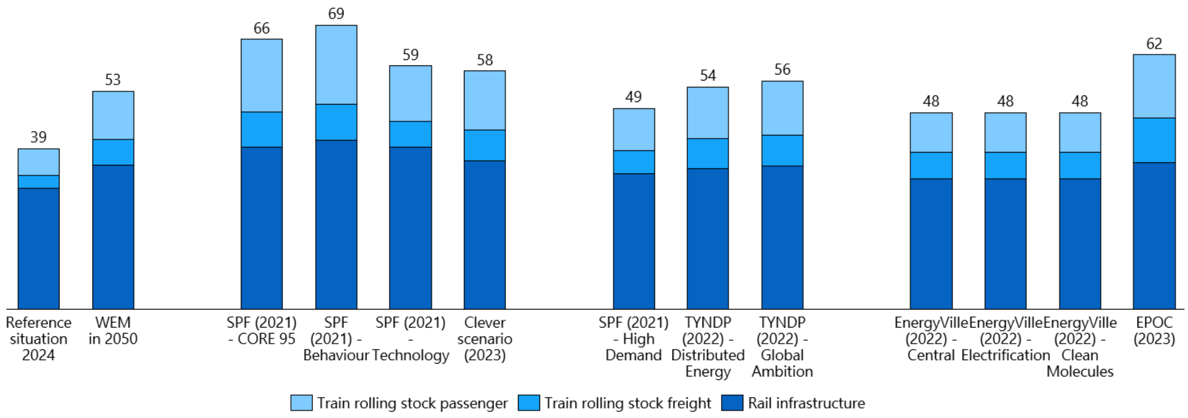
Appendix 1: Specific zooms

Appendix 1.1: Zoom on rail infrastructure and rolling stock investments

Total railway transport investments consist of rolling stock and infrastructure investments. Infrastructure investments account for approximately one-third of total rail investments. Passenger train rolling stock represents a higher investment than freight vehicles.

Graph 1 Rail Investments - cumulated CAPEX 2025-2050 (in Bn EUR)



Comments: reference situation value is the 2024 value multiplied by 25 to cover the 2025-2050 period, i.e. maintaining investments constant
Source: SCPI model

In 2022, development plans for the Belgian railway sector were published under the label "Rail 2040 Vision", foreseeing a significant modal shift towards rail. In this vision, Infrabel and SNCB/NMBS estimated respectively yearly investment objectives of 1,25 billion euros/year and 0,92 billion euros/year (from which 0,42 billion euros/year specifically for rolling stock) during the next ten years. The SPF CORE 95 scenario was identified as the closest match to the Rail 2040 Vision in terms of targets for passenger-kilometers and modal shares. Investment levels of the SPF CORE 95 scenario have therefore been calibrated based on the Rail 2040 Vision in the coming years. More details of our methodology are provided in Appendix 6.

Appendix 1.2: System costs of electricity across transition scenarios

When adding up the average yearly CAPEX[1] and the projected OPEX in 2050 in the different transition scenarios, and relate them to total electricity supply, one can have a rough idea of the system cost of electricity. On average across all the scenarios, the system cost of electricity hovers around 0,095 euros per kWh (equivalent to 95 euros per MWh), with limited variability between the various transition approaches. This system cost of electricity, consistent across transition scenarios, is slightly lower than for reference WEM scenario in 2050, thanks to reduced operational expenses and in spite of a higher CAPEX

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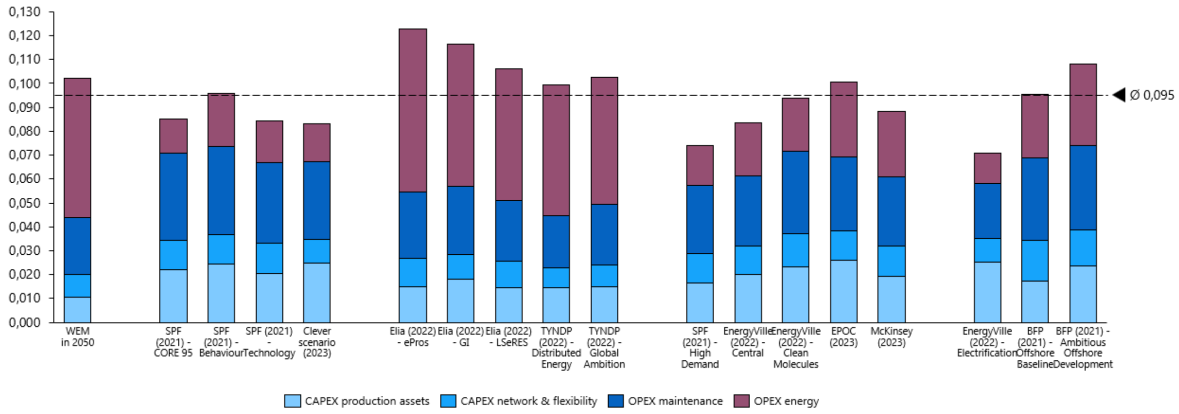
[1] Cumulated CAPEX over the 25-year period divided by an assumed and simplified lifetime of 25 years

intensity. Note that the energy vector prices differ between the WEM and transition scenarios (see Appendix 3.2).

The low demand and reliance on biogas approach (Elia and TYNDP scenarios) is an exception, as it shows a higher cost of electricity relative to the reference WEM scenario. This is driven by important energy expenditures, i.e., biogas for electricity production and imported electricity.

An important caveat to these observations is that scenario authors use different energy modelling techniques when it comes to ensuring adequacy of electricity supply and demand. Notably Elia, TYNDP and BFP (and EnergyVille/EPOC to some extent) use “hourly” adequacy models. Such models are better able to simulate peak periods. Other scenarios (including the reference WEM scenario) use instead “annual” adequacy models and make less precise assumptions to account for capacity requirement of peaks vs. annual average volume.

Graph 2 Relative cost of electricity for different scenarios in 2050 (in EUR per kWh)

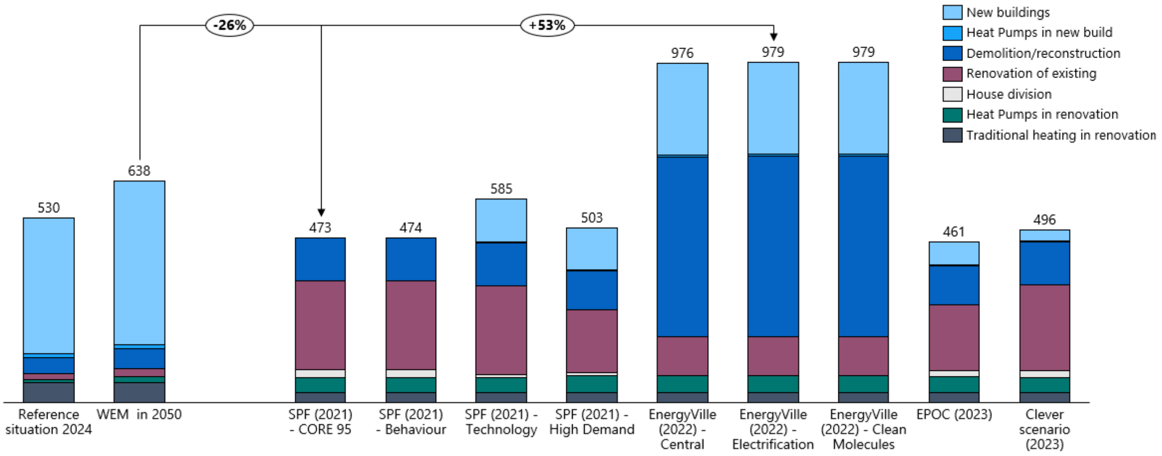


Comments: computed with yearly average CAPEX over the period 2025-2050 (roughly comparable to an amortization period of 25 years for the asset); OPEX in 2050 in a fully transitioned system; supply volumes of 2050. Takes no cost of capital into account (WACC equal to zero).
Source: SCPI model

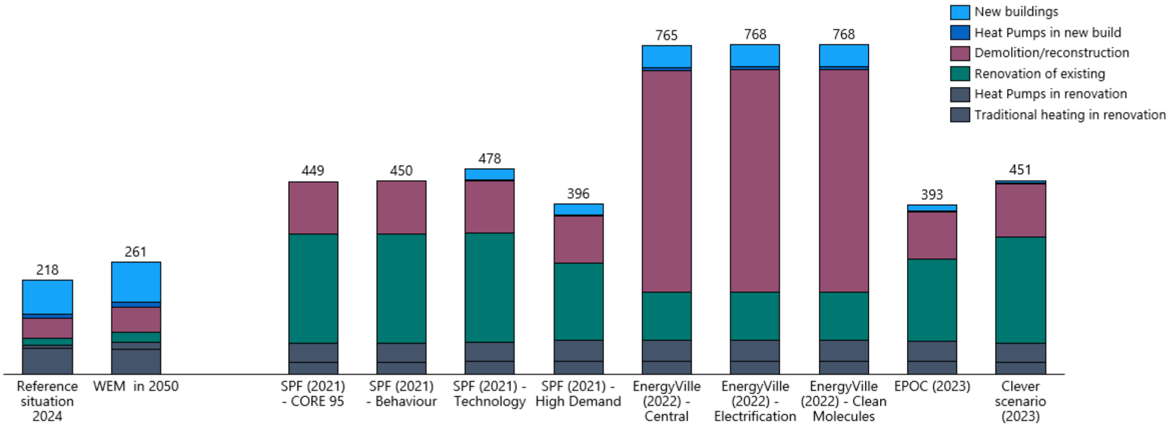
Appendix 2: Full results tables and graphs per Sector

Graph 3 Cumulated CAPEX for the Buildings sector (in Bn EUR)

With all new builds investments (decarbonisation and non-decarbonisation technology) accounted for:

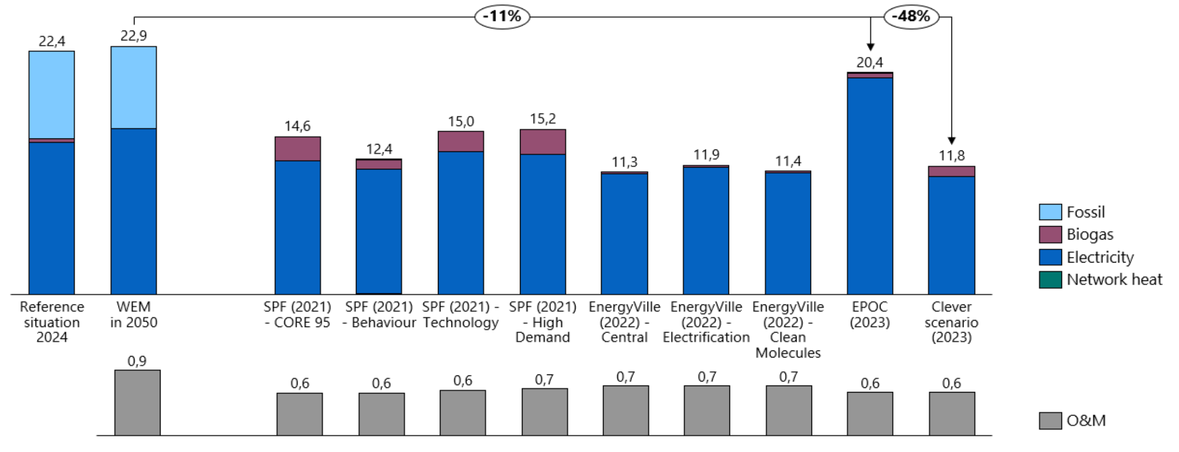


Only with decarbonization technology of new build accounted for:



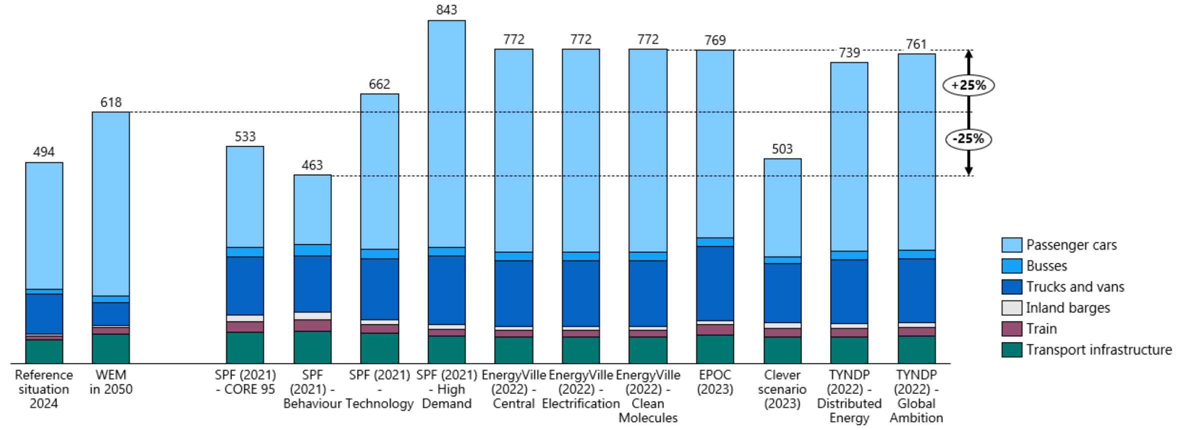
Source: SCPI model

Graph 4 OPEX in 2050 for the Buildings sector (in Bn EUR)



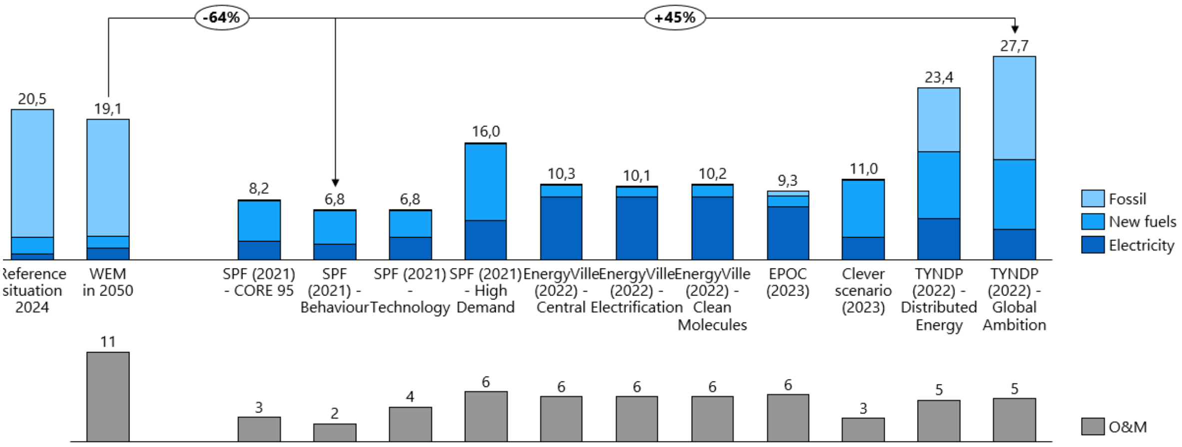
Source: SCPI model

Graph 5 Cumulated CAPEX for the Transport sector (in Bn EUR)



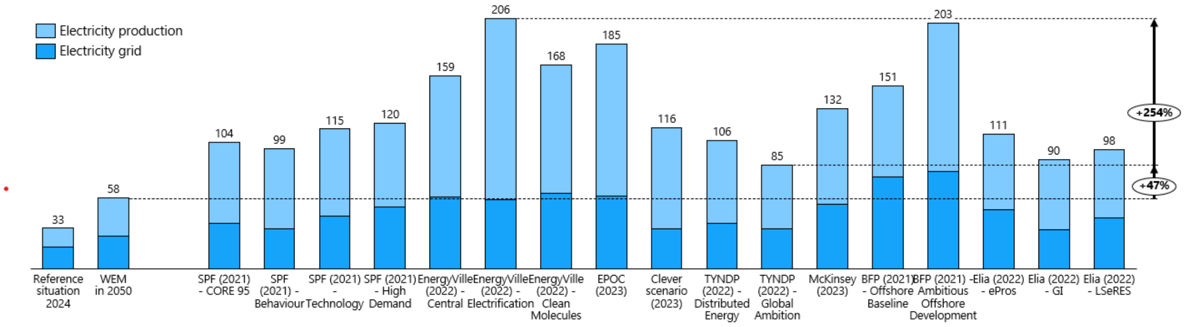
Source: SCPI model

Graph 6 OPEX in 2050 for the Transport sector (in Bn EUR)



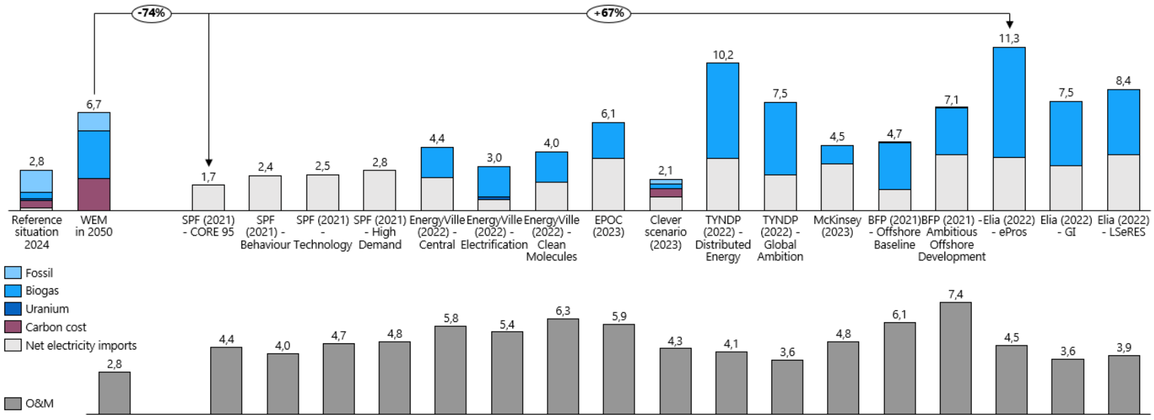
Source: SCP model

Graph 7 Cumulated CAPEX for the Electricity system (in Bn EUR)



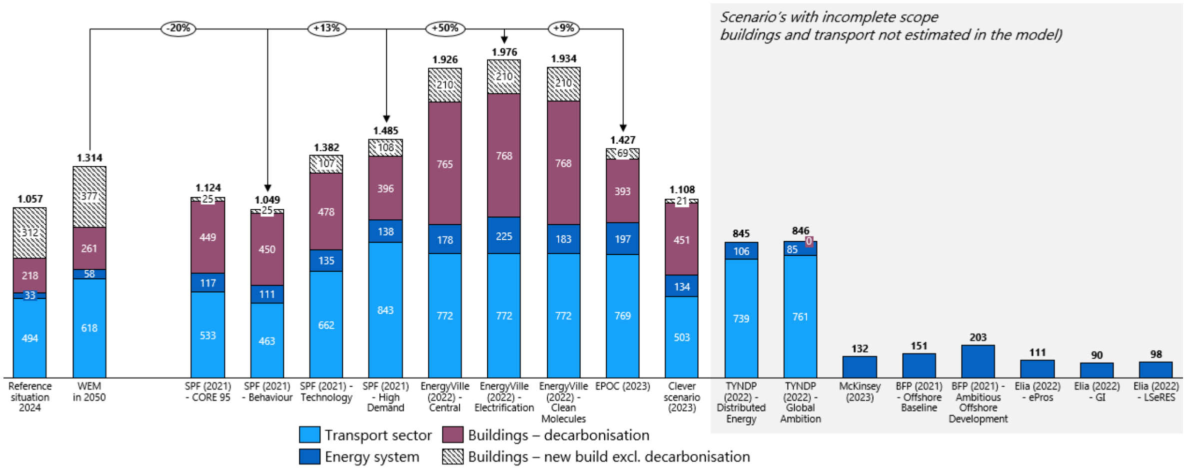
Source: SCPI model

Graph 8 OPEX in 2050 for the Electricity system (in Bn EUR)



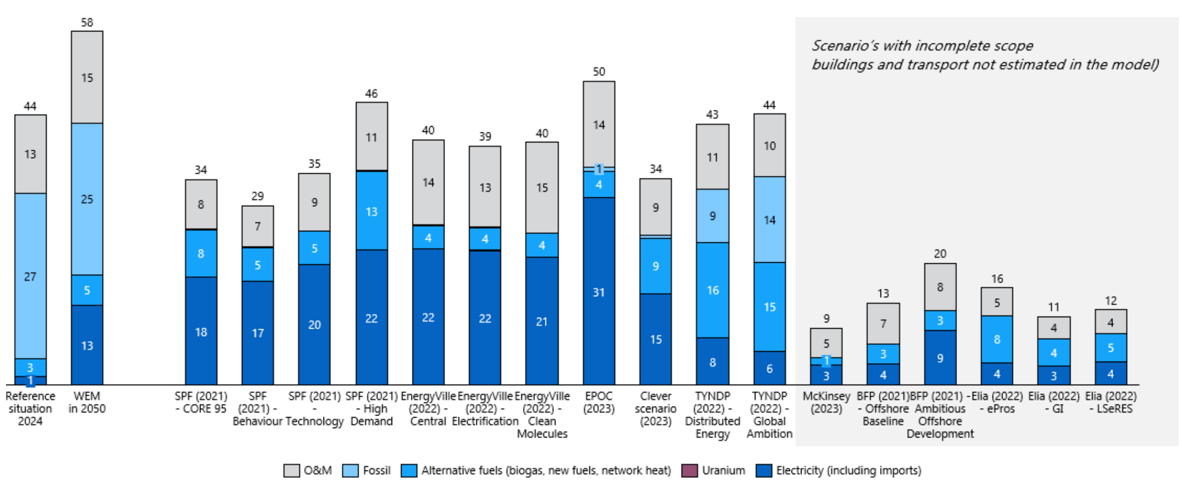
Source: SCPI model

Graph 9 Total aggregated cumulated CAPEX (in Bn EUR)



Source: SCPI model

Graph 10 Total aggregated OPEX in 2050 (in Bn EUR)



Source: SCPI model

Appendix 3: Cost and price assumptions

Appendix 3.1: Unitary CAPEX and OPEX

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
BLD	Residential	CAPEX	New construction	€/m^2	2496,61	2496,61	2496,61	2496,61	Batico (2021), Coût d'une nouvelle construction et prix au m2 [Online : www.batico.be/blog/construction/cout-nouvelle-construction/]
BLD	Non-residential	CAPEX	New construction	€/m^2	1849,62	1849,62	1849,62	1849,62	Energie-Wallonie (2011), Un immeuble de bureaux passif… Le premier en Wallonie [Online : www.energie.wallonie.be/servlet/Repository/investsud-01-09-2011maj.pdf?ID=21913]
BLD	Residential & Non-residential	CAPEX	Demolition	€/m^2	288,96	288,96	288,96	288,96	Bobex (2023), Travaux de démolition de bâtiments : Prix, informations et devis gratuits [Online : www.bobex.be/fr-be/travaux-de-demolition/#:~:text=des%20devis%20gratuits-,Prix%20de%20la%20démolition%20d'une%20maison%20ou%20d'un,et%2050%20€%20%2Fm3.]
BLD	Residential	CAPEX	In-depth renovation	€/m^2	469,61	469,61	469,61	469,61	BPIE (2020), COVID-19 Recovery : Investment opportunities in deep renovation in Europe [Online : www.bpie.eu/wp-content/uploads/2020/05/Recovery-investments-in-deep-renovation_BPIE_2020.pdf]
BLD	Non-residential	CAPEX	In-depth renovation	€/m^2	493,09	493,09	493,09	493,09	BPIE (2020), COVID-19 Recovery : Investment opportunities in deep renovation in Europe [Online : www.bpie.eu/wp-content/uploads/2020/05/Recovery-investments-in-deep-renovation_BPIE_2020.pdf]
BLD	Residential & Non-residential	CAPEX	Classical heat generation unit - Insulated buildings	€/m^2	45,99	45,99	45,99	45,99	Expert judgment. Combination of sources based on CREG, IEA, ADEME, Blunomy, Economy-energie and chauffage-info.be documentation.
BLD	Residential & Non-residential	CAPEX	New heat generation - Insulated buildings	€/m^2	62,95	49,54	47,47	45,41	Expert judgment. Combination of sources based on CREG, IEA, ADEME, Blunomy, Economy-energie and chauffage-info.be documentation.
BLD	Residential & Non-residential	CAPEX	Classical heat generation unit - Not-insulated buildings	€/m^2	60,02	60,02	60,02	60,02	Expert judgment. Combination of sources based on CREG, IEA, ADEME, Blunomy, Economy-energie and chauffage-info.be documentation.
BLD	Residential & Non-residential	CAPEX	New heat generation - Not-insulated buildings	€/m^2	137,67	119,71	104,75	104,75	Bobex (2023), Travaux de démolition de bâtiments : Prix, informations et devis gratuits [Online : www.bobex.be/fr-be/travaux-de-demolition/#:~:text=des%20devis%20gratuits-,Prix%20de%20la%20démolition%20d'une%20maison%20ou%20d'un,et%2050%20€%20%2Fm3.]
BLD	Residential	CAPEX	House division	€/house to divide	52786,80	52786,80	52786,80	52786,80	BE-Designer (2023), Transformer une maison en plusieurs appartements : nos conseils ! [Online : www.be-designer.be/architecture/transformer-une-maison-en-plusieurs-appartements-nos-conseils/] & Démarrez les Travaux (2023), Diviser une maison en appartements : comment faire ? A quell prix? [Online : www.demarrezlestravaux.fr/diviser-une-maison-en-appartements/] & Izi (2022), Comment transformer une maison en 2 appartements ? [Online : www.izi-by-edf.fr/blog/maison-transformation-appartement/]
BLD	Residential	CAPEX	House division in demolition/ reconstruction	€/house to divide	26393,40	26393,40	26393,40	26393,40	BE-Designer (2023), Transformer une maison en plusieurs appartements : nos conseils ! [Online : www.be-designer.be/architecture/transformer-une-maison-en-plusieurs-appartements-nos-conseils/] & Démarrez les Travaux (2023), Diviser une maison en appartements : comment faire ? A quell prix? [Online : www.demarrezlestravaux.fr/diviser-une-maison-en-appartements/] & Izi (2022), Comment transformer une maison en

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
									2 appartements ? [Online : www.izi-by-edf.fr/blog/maison-transformation-appartement/]
EN	Electricity	CAPEX	Transmission grid	€/TWh_additionnal prod	225577833,60	225577833,60	225577833,60	225577833,60	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Hydrogen	CAPEX	Hydrogen Import/Export - Terminals	€/terminal	2639340000,00	2639340000,00	2639340000,00	2639340000,00	ENTEC. (2022). The role of renewable H_2 import & storage to scale up the EU deployment of renewable H_2. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab70e32-a5a0-11ec-83e1-01aa75ed71a1/language-en
EN	CO_2	CAPEX	DACS installations	€/tCO_2	33,93	33,93	33,93	33,93	International Energy Agency Greenhouse Gas Programme. (2021). EAGHG Technical Report 2021-05 – Global assessment of direct air capture costs. IEAGHG. https://ieaghg-publications.s3.eu-north-1.amazonaws.com/Technical+Reports/2021-05+Global+Assessment+of+Direct+Air+Capture+Costs.pdf
EN	CO_2	CAPEX	Export value chain annualized development cost	€/tCO_2	121,64	121,64	121,64	121,64	Zero Emissions Platform. (2020). The costs of CO_2 transport. Zero Emissions Platform. https://zeroemissionsplatform.eu/wp-content/uploads/CO2-Transport-Report-1.pdf
EN	Heat district	CAPEX	Heat district network	€/m	969,32	969,32	969,32	969,32	Résimont, T. (2021). Strategic outline and sizing of district heating networks using a geographic information system [Master's thesis]. Université de Liège. https://orbi.uliege.be/handle/2268/262651
EN	Heat district	CAPEX	Home heat exchanger	€/kWth	592,97	592,97	592,97	592,97	Expert judgment
EN	Heat district	CAPEX	Heat generation asset with biomass	€/kWth	817,00	817,00	817,00	817,00	Résimont, T. (2021). Strategic outline and sizing of district heating networks using a geographic information system [Master's thesis]. Université de Liège. https://orbi.uliege.be/handle/2268/262651
EN	Electricity	CAPEX	Fossil	€/kW	902,65	902,65	902,65	902,65	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	CAPEX	Nuclear	€/kW	7918,02	7918,02	7918,02	7918,02	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	CAPEX	Biomass	€/kW	2111,47	2111,47	2111,47	2111,47	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	CAPEX	Wind Offshore	€/kW	2509,484472	2509,484472	2369,071584	2227,60296	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	CAPEX	Wind Onshore	€/kW	1088,463816	1088,463816	959,664024	830,864232	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	CAPEX	Solar PV	€/kW	642,943224	642,943224	514,143432	385,34364	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	CAPEX	Hydrogen	€/kW	1957	691	517,5	344	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Electricity	CAPEX	Hydro	€/kW	3212,30	3212,30	3212,30	3212,30	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Electricity	CAPEX	Waste	€/kW	1127,53	1127,53	1127,53	1127,53	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	CAPEX	Geothermal	€/kW	1819	1637	1637	1637	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Electricity	CAPEX	Other thermal	€/kW	1127,53	1127,53	1127,53	1127,53	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	CAPEX	Battery	€/kW	1.466,79	1011,577075	758,682806	758,682806	Elia. (2017). Electricity scenarios for Belgium towards 2050. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system---document-library/adequacy---studies/2017/20171114_electricity-scenarios-for-belgium-towards-2050.pdf
EN	Electricity	CAPEX	Hydro - Pumped storage	€/kW	1212,43	1212,43	1212,43	1212,43	Elia. (2017). Electricity scenarios for Belgium towards 2050. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system---document-library/adequacy---studies/2017/20171114_electricity-scenarios-for-belgium-towards-2050.pdf

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
EN	Electricity	CAPEX	DSM - Industry	€/kW	0,00	0,00	0,00	0,00	Elia. (2017). Electricity scenarios for Belgium towards 2050. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system---document-library/adequacy---studies/2017/20171114_electricity-scenarios-for-belgium-towards-2050.pdf
EN	Hydrogen	CAPEX	Electrolyzer	€/kW	1957	691	517,5	344	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	CO_2	CAPEX	CO_2 network pipes	€/km/ tCO_2	0,0319561	0,0319561	0,02747305	0,02299	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Hydrogen	CAPEX	Hydrogen network - New lines costs per km	€/km	2533766,40	2533766,40	2533766,40	2533766,40	ENTEC. (2022). The role of renewable H_2 import & storage to scale up the EU deployment of renewable H_2. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab70e32-a5a0-11ec-83e1-01aa75ed71a1/language-en
EN	Hydrogen	CAPEX	Hydrogen network - Repurposed lines costs per km	€/km	422294,40	422294,40	422294,40	422294,40	ENTEC. (2022). The role of renewable H_2 import & storage to scale up the EU deployment of renewable H_2. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab70e32-a5a0-11ec-83e1-01aa75ed71a1/language-en
EN	Hydrogen	CAPEX	Hydrogen network - Compressor costs	€/km	416779,35	416779,35	416779,35	416779,35	ENTEC. (2022). The role of renewable H_2 import & storage to scale up the EU deployment of renewable H_2. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab70e32-a5a0-11ec-83e1-01aa75ed71a1/language-en
EN	Electricity	CAPEX	Distribution grid	€/GW peak load	48345371,74	39317972,33	40135392,57	37626930,53	Expert judgment & Blunomy. (2024). Economics for Belgium's net zero plan [Unpublished internal document].
EN	Electricity	CAPEX	DSM - Residential	€/device	545,60	545,60	545,60	545,60	Elia. (2017). Electricity scenarios for Belgium towards 2050. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system---document-library/adequacy---studies/2017/20171114_electricity-scenarios-for-belgium-towards-2050.pdf
TRA	Trucks	CAPEX	ICE Trucks	€/vehicle	90.000,00	90000,00	90000,00	90.000,00	Expert judgment
TRA	Vans	CAPEX	ICE Vans	€/vehicle	45.000,00	45000,00	45000,00	45000,00	Expert judgment
TRA	Trucks	CAPEX	ZEV Trucks	€/vehicle	189.714,29	182857,1429	171428,5714	160.000,00	Ptolemus. (2023, March 6). Is Tesla Semi a game changer? Part 1: Tesla Semi versus other electric trucks. Ptolemus. https://www.ptolemus.com/insight/is-tesla-semi-a-game-changer-part-1-tesla-semi-versus-other-electric-trucks/
TRA	Vans	CAPEX	ZEV Vans	€/vehicle	55.000,00	55000,00	55000,00	55000,00	Automobile Propre. (n.d.). Voitures utilitaires électriques. Automobile Propre. Retrieved March 7, 2025, from https://www.automobile-propre.com/voitures/electriques/utilitaires/all/
TRA	Passenger cars	CAPEX	Public charging stations	€/station	2000,00	2000,00	2000,00	2000,00	MobilityPlus. (n.d.). Coût pour l’employeur et le collaborateur d’une borne de recharge à domicile. MobilityPlus. https://www.mobilityplus.be/fr/blog/co%C3%BBt-employeur-collaborateur-domicile-borne-recharge
TRA	Passenger cars	CAPEX	Public fast charging stations	€/station	100000,00	100000,00	100000,00	100000,00	SparkCharge. (n.d.). EV charging station infrastructure costs. SparkCharge. https://www.sparkcharge.io/blogs/leadthecharge/ev-charging-station-infrastructure-costs
TRA	Passenger cars	CAPEX	Private charging stations	€/station	2000,00	2000,00	2000,00	2000,00	MobilityPlus. (n.d.). Coût pour l’employeur et le collaborateur d’une borne de recharge à domicile. MobilityPlus. https://www.mobilityplus.be/fr/blog/co%C3%BBt-employeur-collaborateur-domicile-borne-recharge
TRA	Trucks	CAPEX	Truck charging station - 100 kW (overnight)	€/station	68.156	51.969	45472,49766	38.976	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Trucks	CAPEX	Truck charging station - 350 kW (fast)	€/station	188.039	152.781	137503,3359	122.225	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Vans	CAPEX	Van charging station - private	€/station	5.000	4.300	4294,0875	4.288	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
TRA	Vans	CAPEX	Van charging station - public	€/station	12.500	9.375	9357,421875	9.340	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Freight	CAPEX	Railcar	€/railcar	176531,05	176531,05	176531,05	176531,05	Expert judgment
TRA	Passenger	CAPEX	Railcar	€/railcar	1233081,81	1233081,81	1233081,81	1233081,81	Expert judgment
TRA	Passenger & Freight	CAPEX	Locomotive	€/locomotive	5000000,00	5000000,00	5000000,00	5000000,00	Expert judgment
TRA	Bike	CAPEX	Cycling lane - separated, classic	€/km	228882,80	228882,80	228882,80	228882,80	Gracq. (2021). Combien coûte une infrastructure cyclable séparée ? Gracq. https://www.gracq.org/actualites-du-velo/cout-infrastructure-cyclable
TRA	Bike	CAPEX	Cycling lane - separated, express lane	€/km	1716621,01	1716621,01	1716621,01	1716621,01	Gracq. (2021). Combien coûte une infrastructure cyclable séparée ? Gracq. https://www.gracq.org/actualites-du-velo/cout-infrastructure-cyclable
TRA	Passenger cars	CAPEX	Voitures urbaines - électrique	€/car	33540,00	33540,00	33540,00	33.540,00	Automobile Propre. (n.d.). Voitures électriques citadines – Comparatif et guide d'achat. Automobile Propre. https://www.automobile-propre.com/voitures/electriques/citadines/all/
TRA	Passenger cars	CAPEX	Voitures "familliale" - électrique	€/car	44892,00	44892,00	44892,00	44.892,00	Automobile Propre. (n.d.). Voitures électriques citadines – Comparatif et guide d'achat. Automobile Propre. https://www.automobile-propre.com/voitures/electriques/citadines/all/
TRA	Passenger cars	CAPEX	Voiture SUV - électrique	€/car	61920,00	61920,00	61920,00	61.920,00	Automobile Propre. (n.d.). Voitures électriques SUV – Comparatif et guide d'achat. Automobile Propre. https://www.automobile-propre.com/voitures/electriques/suv/all/
TRA	Passenger cars	CAPEX	Voitures urbaines - thermique	€/car	15996,00	15996,00	15996,00	15.996,00	Caroom. (n.d.). Petites voitures pas chères : Comment bien choisir ? Caroom. https://www.caroom.fr/guide/voiture-neuve/comment-choisir/taille/petite-voiture/pas-cher
TRA	Passenger cars	CAPEX	Voitures "familliale" - thermique	€/car	31992,00	31992,00	31992,00	31.992,00	Turbo. (n.d.). Vous cherchez la voiture familiale idéale ? Quel modèle vous conviendrait le mieux ? Turbo. Retrieved March 7, 2025, from https://www.turbo.fr/conseils/acheter-voiture/vous-cherchez-la-voiture-familiale-ideale-quel-modele-vous-conviendrait-le-mieux-149584
TRA	Passenger cars	CAPEX	Voiture SUV - thermique	€/car	51600,00	51600,00	51600,00	51.600,00	Caroom. (n.d.). Comment choisir un SUV neuf ? Caroom. https://www.caroom.fr/guide/voiture-neuve/comment-choisir/carrosserie/suv
TRA	Bus	CAPEX	New ICE Bus	€/bus	293506,58	293506,58	293506,58	293506,58	Institut Montaigne. (2020). Municipales 2020 – Remplacer les bus gaz ou diesel par des bus électriques ou à hydrogène. Institut Montaigne. https://www.institutmontaigne.org/municipales-2020/montpellier/clothilde-ollier/remplacer-les-bus-gaz-ou-diesel-par-des-bus-electriques-ou-a-hydrogene
TRA	Bus	CAPEX	New EV Bus	€/bus	481350,80	481350,80	481350,80	481350,80	Institut Montaigne. (2020). Municipales 2020 – Remplacer les bus gaz ou diesel par des bus électriques ou à hydrogène. Institut Montaigne. https://www.institutmontaigne.org/municipales-2020/montpellier/clothilde-ollier/remplacer-les-bus-gaz-ou-diesel-par-des-bus-electriques-ou-a-hydrogene
TRA	Freight IWW	CAPEX	ICE boats	€/boat	2.785.420,00	2.825.431,07	2.865.926	2.906.420,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Freight IWW	CAPEX	H2 boats	€/boat	8.409.500,00	7.106.330,00	6.777.815	6.449.300,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Freight IWW	CAPEX	methanol boats	€/boat	2998380,00	2998380,00	2998380,00	2998380,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Freight IWW	CAPEX	electric boats	€/boat	4127794,00	4127794,00	4127794,00	4127794,00	Expert judgment & Blunomy. (2024). Economics for Belgium's net zero plan [Unpublished internal document].
TRA	Freight maritime	CAPEX	ICE boats	€/boat	54.450.000,00	54.450.000,00	54.450.000,00	54.450.000,00	Expert judgment

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
TRA	Freight maritime	CAPEX	H2 boats	€/boat	108.900.000,00	108.900.000,00	108.900.000,00	108.900.000,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Freight maritime	CAPEX	methanol boats	€/boat	108.900.000,00	108.900.000,00	108.900.000,00	108.900.000,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Freight maritime	CAPEX	electric boats	€/boat	0,00	0,00	0,00	0,00	Expert judgment
TRA	Bus	CAPEX	Infrastructure bus and coach	€/1000 pkm	30,15	30,15	30,15	30,15	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1
TRA	Passenger cars	CAPEX	Infrastructure car	€/1000 pkm	17,84	17,84	17,84	17,84	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a2
TRA	Freight trains	CAPEX	Infrastructure freight train	€/1000tkm	30,77	30,77	30,77	30,77	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a3
TRA	Trucks	CAPEX	Infrastructure HDV	€/1000tkm	18,46	18,46	18,46	18,46	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a4
TRA	Freight IWW	CAPEX	Infrastructure IWW	€/1000tkm	43,07	43,07	43,07	43,07	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a5
TRA	Passenger trains	CAPEX	Infrastructure passenger train	€/1000 pkm	188,28	188,28	188,28	188,28	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a6
BLD	Residential & Non-residential	OPEX	New heat generation - Insulated buildings	€/m2/yr	1,65	1,65	1,65	1,65	Expert judgment Combination of sources based on CREG, Engie, ADEME, Blunomy documentation.
BLD	Residential & Non-residential	OPEX	New heat generation - Not-insulated buildings	€/m2/yr	1,88	1,88	1,88	1,88	Expert judgment Combination of sources based on CREG, Engie, ADEME, Blunomy documentation.
BLD	Residential & Non-residential	OPEX	Classical heat generation unit - Insulated buildings	€/m2/yr	0,65	0,65	0,65	0,65	Expert judgment Combination of sources based on CREG, Engie, ADEME, Blunomy documentation.
BLD	Residential & Non-residential	OPEX	Classical heat generation unit - Not-insulated buildings	€/m2/yr	0,74	0,74	0,74	0,74	Expert judgment Internal documentation.
EN	CO_2	OPEX	DACS O&M	€/tCO_2	90,70	90,70	90,70	90,70	International Energy Agency (IEA). (2021). *EAGHG technical report 2021-05: Global assessment of direct air capture costs*.
EN	CO_2	OPEX	Export value chain costs	€/tCO_2	12,54	12,54	12,54	12,54	Zero Emissions Platform. (2020). The costs of CO_2 transport. Zero Emissions Platform. https://zeroemissionsplatform.eu/wp-content/uploads/CO2-Transport-Report-1.pdf
EN	Electricity	OPEX - variable	Electricity transmission grid O&M	€/MWh	0,95	0,95	0,95	0,95	Trinomics, & European Commission. (2020). Final report – Network costs: Energy costs, taxes and the impact of government interventions on investments. European Commission.

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
EN	Electricity	OPEX - variable	Electricity distribution grid O&M	€/MWh	11,31	11,31	11,31	11,31	Trinomics, & European Commission. (2020). Final report – Network costs: Energy costs, taxes and the impact of government interventions on investments. European Commission.
EN	Heat district	OPEX	Heat generation asset with biomass	€/kWhth	0,04	0,04	0,04	0,04	Résimont, T. (2021). Strategic outline and sizing of district heating networks using a geographic information system [Master's thesis]. Université de Liège. https://orbi.uliege.be/handle/2268/262651
EN	Electricity	OPEX - fixed	Fossil	€/kW/y	22,17	22,17	22,17	22,17	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	OPEX - fixed	Nuclear	€/kW/y	87,94	87,94	87,94	87,94	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	OPEX - fixed	Biomass	€/kW/y	33,78	33,78	33,78	33,78	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	OPEX - fixed	Wind Offshore	€/kW/y	72,85	72,85	64,40	55,95	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	OPEX - fixed	Wind Onshore	€/kW/y	47,51	47,51	45,40	42,23	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	OPEX - fixed	Solar PV	€/kW/y	23,23	23,23	23,23	22,17	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	OPEX - fixed	Hydrogen	€/kW/y	78,00	21,00	14,00	7,00	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	OPEX - fixed	Hydro	€/kW/y	150,00	150,00	147,00	144,00	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	OPEX - fixed	Waste	€/kW/y	55,95	55,95	55,95	55,95	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	OPEX - fixed	Geothermal	€/kW/y	33,00	33,00	33,00	33,00	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	OPEX - fixed	Other thermal	€/kW/y	55,95	55,95	55,95	55,95	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	CO_2	OPEX	CO_2 network pipes	€/km/tCO_2	0,00	0,00	0,00	0,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Hydrogen	OPEX - variable	Electrolyzer - O&M	€/kg H2	0,64	0,18	0,11	0,05	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Hydrogen	OPEX	Hydrogen Import/Export - Terminals	€/kg H2	0,34	0,34	0,31	0,28	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Hydrogen	OPEX	Hydrogen network	% of CAPEX/y	0,01	0,01	0,01	0,01	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Hydrogen	OPEX	Hydrogen network - Compressor costs	% of CAPEX/y	0,04	0,04	0,04	0,04	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Electricity	OPEX - fixed	Battery and other flexibility assets O&M	% of CAPEX	0,03	0,03	0,03	0,03	DTU. (2024). Techno-economic comparison of grid reinforcement and battery-buffered electric vehicle fast charging stations. DTU. https://utiligize.com/wp-content/uploads/2024/02/Comparison-of-grid-reinforcement-and-batteries.pdf

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
TRA	Trucks	OPEX	ZEV Trucks maintenance	€/vehicle/year	4687,47	4687,47	4687,47	4687,47	CCG Business Intelligence. (2022). On costs for electric trucks. ECG Association. https://www.ecgassociation.eu/wp-content/uploads/2022/04/ECG-Business-Intelligence-22.04-Cost-of-going-electric.pdf
TRA	Trucks	OPEX	ICE Trucks maintenance	€/vehicle/year	15624,89	15624,89	15624,89	15624,89	CCG Business Intelligence. (2022). On costs for electric trucks. ECG Association. https://www.ecgassociation.eu/wp-content/uploads/2022/04/ECG-Business-Intelligence-22.04-Cost-of-going-electric.pdf
TRA	Vans	OPEX	ZEV Vans maintenance	€/vehicle/year	513,00	513,00	513,00	513,00	Expert judgment Internal documentation.
TRA	Vans	OPEX	ICE Vans maintenance	€/vehicle/year	1200,00	1200,00	1200,00	1200,00	Expert judgment Internal documentation.
TRA	Freight Ports	OPEX	Infrastructure Ports	€/tonne	0,01	0,01	0,01	0,01	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1
TRA	Passenger cars	OPEX	Public charging stations	€/station/year	550,00	352,00	320,50	289,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Passenger cars	OPEX	Private charging stations	€/station/year	150,00	150,00	150,00	150,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Trucks	OPEX	Truck charging station - 100 kW (overnight)	€/station/year	1635,73	1635,73	1635,73	1635,73	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Trucks	OPEX	Truck charging station - 350 kW (fast)	€/station/year	4080,00	4080,00	4080,00	4080,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Vans	OPEX	Van charging station - private	€/station/year	150,00	150,00	150,00	150,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Vans	OPEX	Van charging station - public	€/station/year	550,00	352,00	320,32	288,64	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Buses	OPEX	ICE maintenance (buses)	€/km	0,34	0,34	0,34	0,34	Expert judgment Internal documentation.
TRA	Buses	OPEX	EV maintenance (buses)	€/km	0,63	0,63	0,63	0,63	Expert judgment Internal documentation.
TRA	Bus	OPEX	Infrastructure bus and coach	€/km	6399,23	6399,23	6399,23	6399,23	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1
TRA	Passenger cars	OPEX	Infrastructure car	€/km	6399,23	6399,23	6399,23	6399,23	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1
TRA	Freight trains	OPEX	Infrastructure freight train	€/km	104602,75	104602,75	104602,75	104602,75	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1
TRA	Trucks	OPEX	Infrastructure HDV	€/km	6399,23	6399,23	6399,23	6399,23	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1
TRA	Freight IWW	OPEX	Infrastructure IWW	€/km	63992,27	63992,27	63992,27	63992,27	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1
TRA	Passenger trains	OPEX	Infrastructure passenger train	€/km	104602,75	104602,75	104602,75	104602,75	European Commission & CE Delft. (2019). Overview of transport infrastructure expenditures and costs. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
TRA	Passenger cars	OPEX	EV maintenance	€/car/ year	513,00	513,00	513,00	513,00	Expert judgment. Combination of sources based on EV Connect and Forbes documentation.
TRA	Passenger cars	OPEX	ICE maintenance	€/car/ year	1200,00	1200,00	1200,00	1200,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Freight IWW	OPEX - fuel (and docked)	ICE boats	€/boat/ year	301290,00	355666,19	422858,10	490050,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Freight IWW	OPEX - fuel (and docked)	H2 boats	€/boat/ year	608630,00	384780,00	314600,00	244420,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Freight IWW	OPEX - fuel (and docked)	methanol boats	€/boat/ year	642510,00	359370,00	359370,00	359370,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
TRA	Freight IWW	OPEX - fuel (and docked)	electric boats	€/boat/ year	801020,00	801020,00	801020,00	801020,00	Expert judgment. Internal documentation. & Blunomy. (2024). Economics for Belgium's net zero plan [Unpublished internal document].

Note: Prices are in 2024 euros and include VAT

Appendix 3.2: Energy price assumptions

Energy unitary prices are necessary to estimate energy costs of the scenarios and put them into perspective with the investments. For each price projection, the historical data for 2024 is used and then the trend is a linear interpolation towards the projected price estimates for 2030 and 2050. We choose different price projections for the reference scenarios and for transition scenario since net zero transition will fundamentally change the energy landscape in Belgium and internationally, and hence energy prices. We assume Belgium evolves coherently with the international context: in case of net zero scenario, Belgium and the world evolve together in that direction, and the same hold in a reference scenario.

Final energy prices are used in the demand sectors, and wholesale commodity prices are used for the power generation sector.

For all scenarios, “2024 historic” data are based, due to availability, on historic data collected for 2023 which we consider to be a year where prices come back to pre-energy crisis levels.

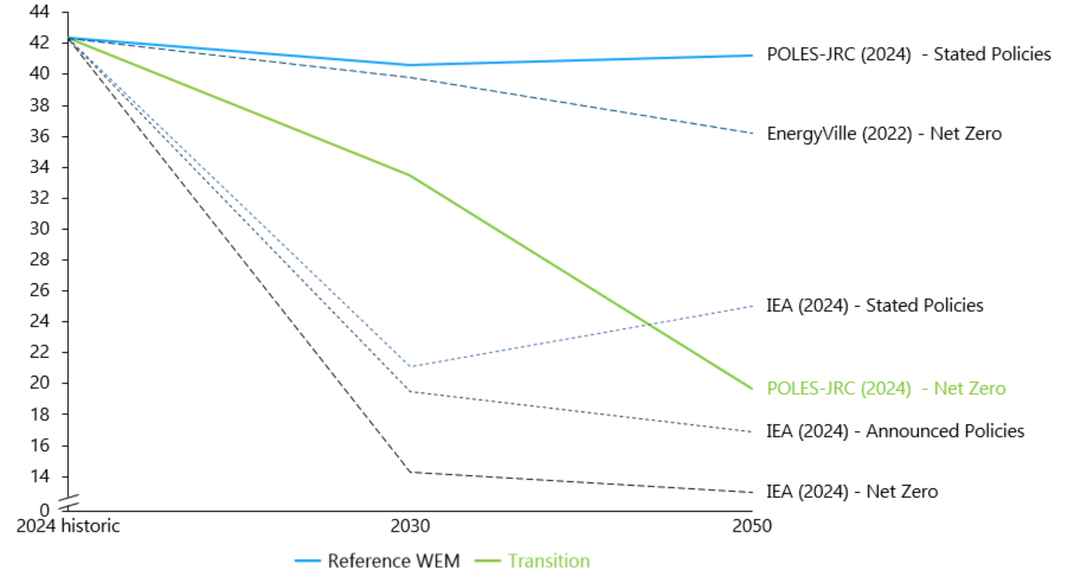
Prices estimates for 2030 and 2050 are based on a literature review and are completed with own hypotheses when necessary (see subsequent paragraphs).

Note: Prices are in 2024 euros and include all taxes.

Gas prices

Wholesale gas prices are dependent on the international context. A few studies publish projections on wholesale price of gas (POLES-JRC (2024), EnergyVille (2022), BFP (2024), IEA (2024). The graph below shows the projections according to those different sources. The selected values are the POLES-JRC (2024) Stated Policies for reference WEM scenario, and POLES-JRC (2024) Net Zero for transition scenarios, as this common source enables to keep consistency between a reference and a transition scenario.

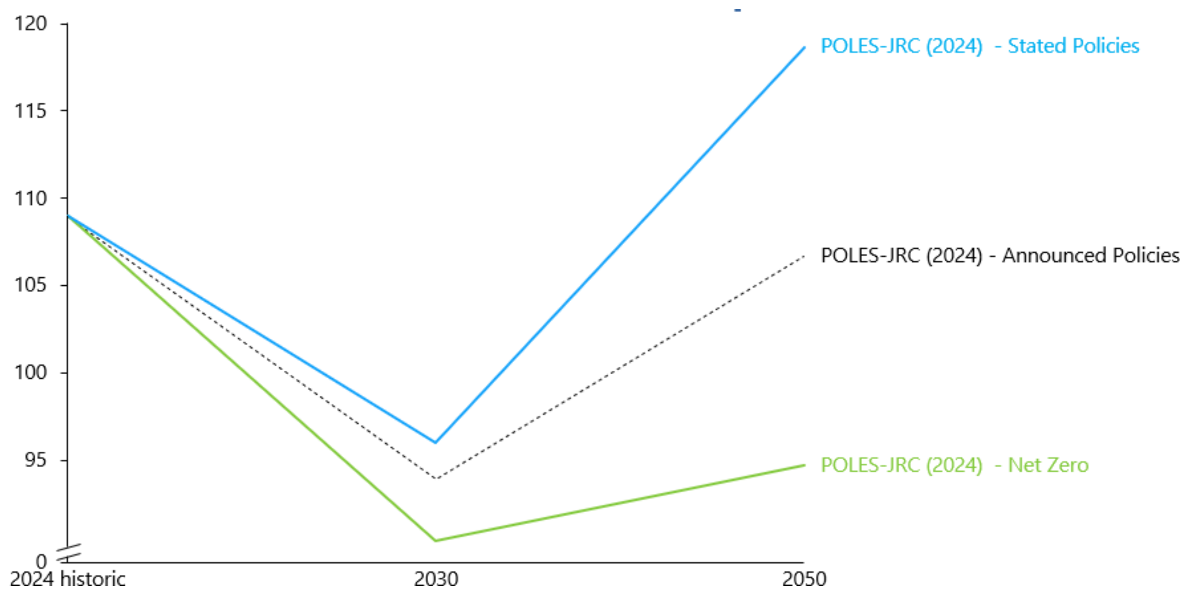
Graph 11 Review of sources - Wholesale price of gas (€2024/MWh)



Comment: Historic price comes from « Quarterly report on European Gas markets » published by the European Commission
Sources: SCPI, IEA (2024), EnergyVille (2022), BFP (2024), POLES-JRC (2024)

The final price of gas includes commodity costs, network costs and taxation. This is therefore country or even region specific. Fewer sources project such prices at Belgian scale. The graph below shows the POLES-JRC (2024) projections selected for this exercise, as they are coherent with selected wholesale price shown above.

Graph 12 Review of sources - Final price of gas (€2024/MWh)



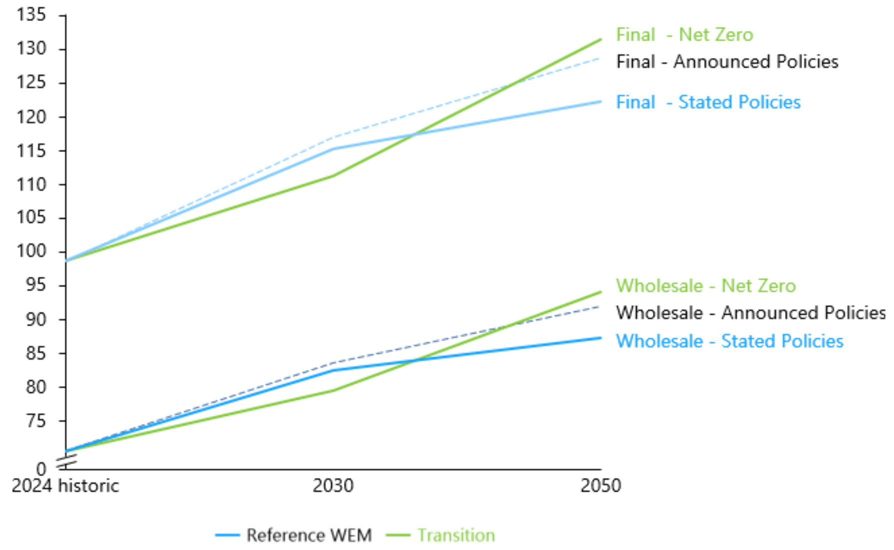
Sources: SCPI, POLES-JRC (2024), EC (2024)

Biogas prices

Wholesale biogas prices are used to estimate electricity generation costs. Biogas prices have been estimated considering it as a substitute for gas. Its price equals the wholesale price of gas to which we add ETS1 prices.

Final biogas prices are used to estimate biogas consumption costs in building sectors. It is estimated based on wholesale price estimation to which we added excise duties (12% of wholesale price), VAT (6%) and an assumed transport cost of 17% of wholesale price.

Graph 13 Wholesale and final price of biogas (€2024/MWh)

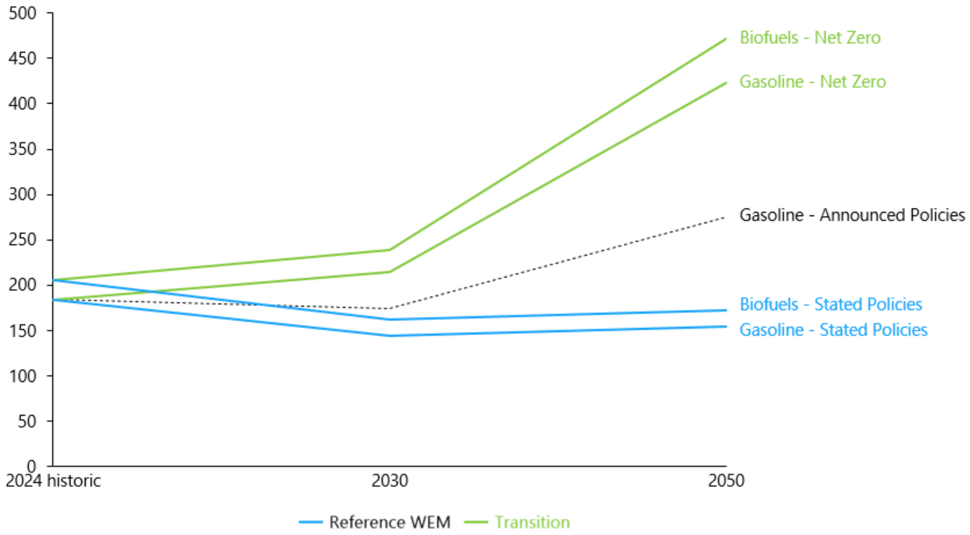


Comments: 1) Construction wholesale: POLES-JRC wholesale gas prices to which we add IEA carbon prices.
2) Construction final price biogas: wholesale price to which we add network costs, excise duties and VAT
Source: SCPI

Gasoline and biofuel prices

Gasoline and biofuels final prices are used to compute energy consumption expenditures in the transport sector.

Graph 14 Gasoline and biofuel final prices (€2024/MWh)



Comments: 1) Gasoline: POLES-JRC (2024) 2) Biofuels final price: construction based on production costs history (JRC, 2023), 0.6€/l duty tax and 21% VAT and gasoline growth according to POLES-JRC (2024)
Source: SCPI

Gasoline final prices are estimated by POLES-JRC (2024).

Biofuel final prices are built as follows:

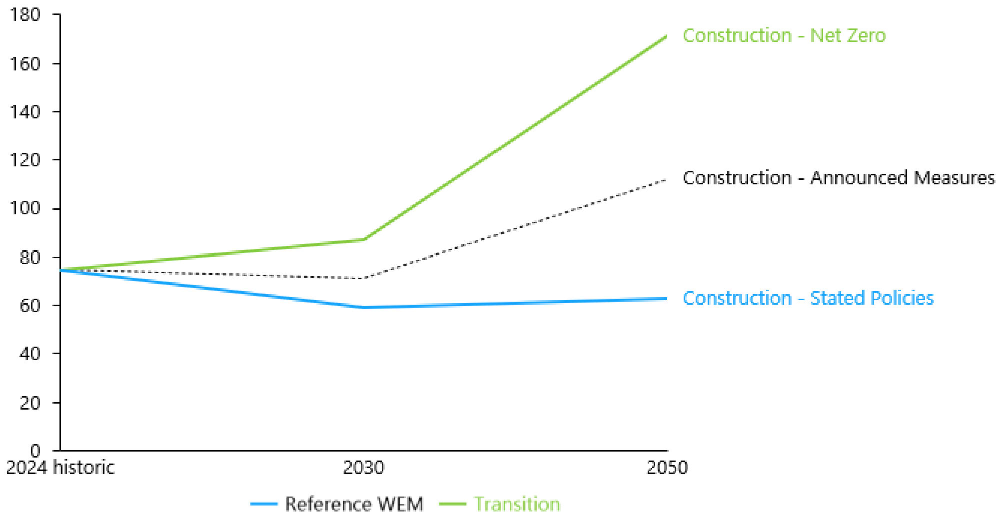
- Current production costs (JRC, 2022)
- 0.6€2024/l excise duty + 21% VAT kept constant (FPS Health, 2024)
- Growth identical to that of the price of gasoline projected by POLES-JRC (2024).

The price of biofuels remains higher than the price of conventional petrol throughout the projection period.

Heating oil prices

Heating oil price is used for their final prices in the building sector. We use the historical value of 2023, to which we apply the same growth rate as gasoline.

Graph 15 Heating oil price projection (€2024/MWh)



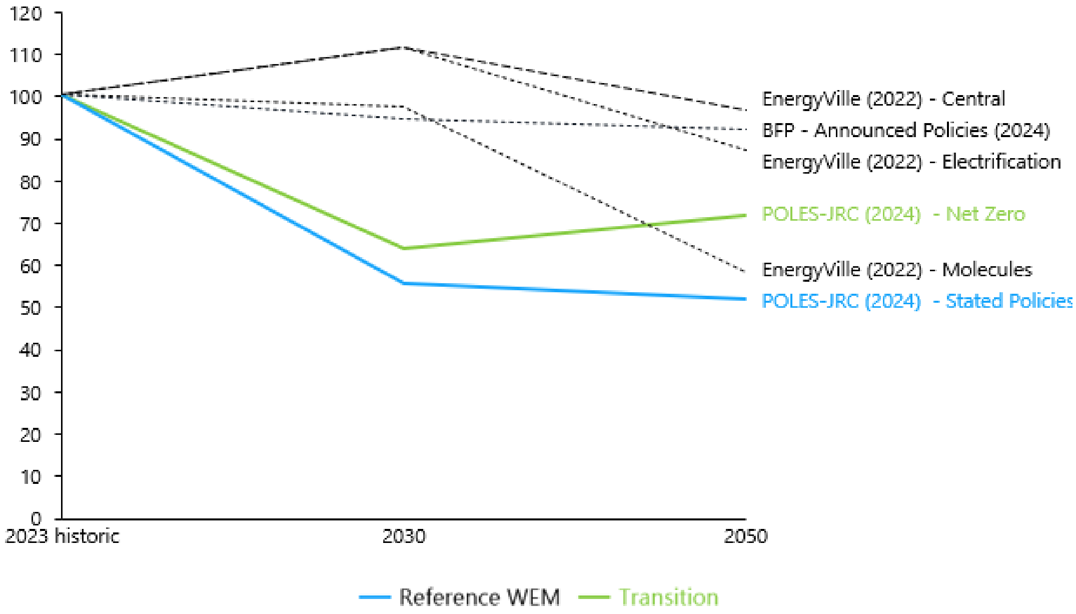
Comment: Construction is based on Weekly Oil Bulletin for historical value, to which POLES-JRC (2024) gasoline growth is applied
Source: SCPI

Electricity prices

Wholesale prices of electricity are used to estimate consumption costs of electrolyzers, DACCS, and the costs of net imports of electricity.

The projected wholesale price is the average costs of electricity generation (including ETS1). Several sources have published such projections (POLES-JRC, BFP with the PRIMES model, EnergyVille with the TIMES model). The graph below compares them. We select POLES-JRC (2024) estimates as this source enables to distinguish between a reference and a transition scenario, with consistency across both estimates.

Graph 16 Review of sources - Wholesale electricity prices in Belgium (€2024/MWh)



Source: 1) Historic wholesale price is the average of intra-day market prices in Belgium (CREG) 2) Wholesale projection price from POLES-JRC (2024)

Final electricity prices are used in this report to estimate energy consumption expenditures in all the demand sectors. The final price of electricity includes the wholesale price, transmission, distribution and sales costs, excise duties and taxes. POLES-JRC (2024) projections diverge significantly from other sources (EU 2040 Impact Assessment and BFP (2024)). Therefore, to understand the price evolution of each component of the final price, we suggest a price reconstruction based on POLES-JRC (2024) wholesale electricity prices, to which we add:

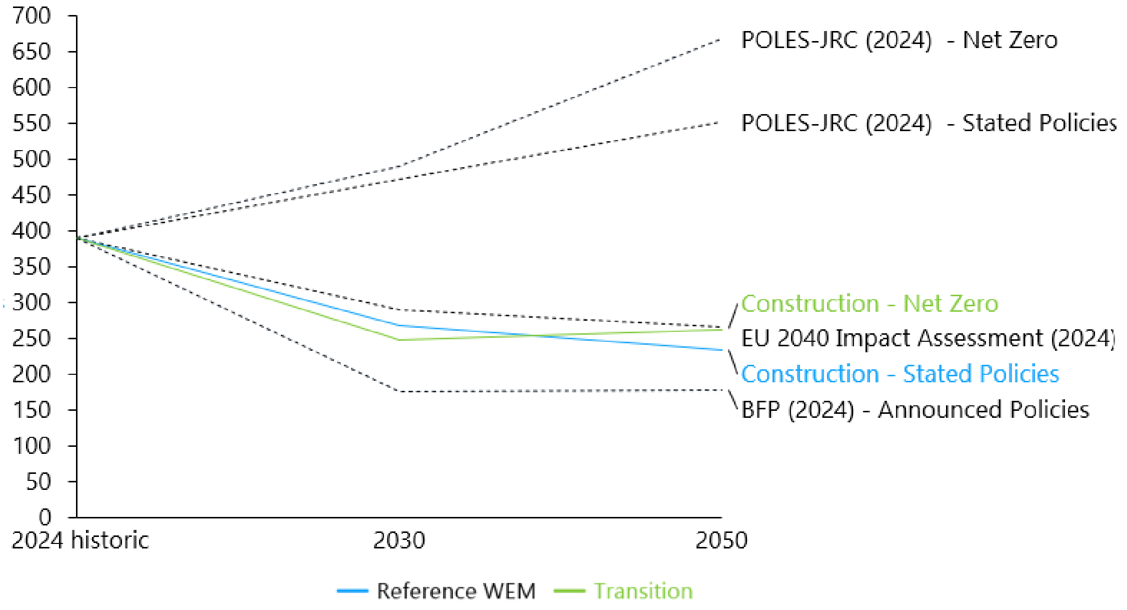
– Network costs based on network costs estimated in our model, distinguishing between a reference (68€/MWh) and transition scenario (78€/MWh)

– Excise duties, derived from their historical value published by the CREG (€101.52024/MWh), held constant over the projection period

– VAT of 6%, held constant throughout the projection period.

This construction is selected for final prices in this report, as it keeps consistency with the main source used, the distinction between a reference and a transition context. This gives us a projected final price in the same order of magnitude as that estimated by the European Commission at European level in its publication 'Impact Assessment 2040'. The POLES-JRC (2024) final electricity price projections will be used in a sensitivity study to vary the price of electricity upwards and test the messages with these assumptions.

Graph 17 Review of sources - Final electricity prices in Belgium (€2024/MWh)

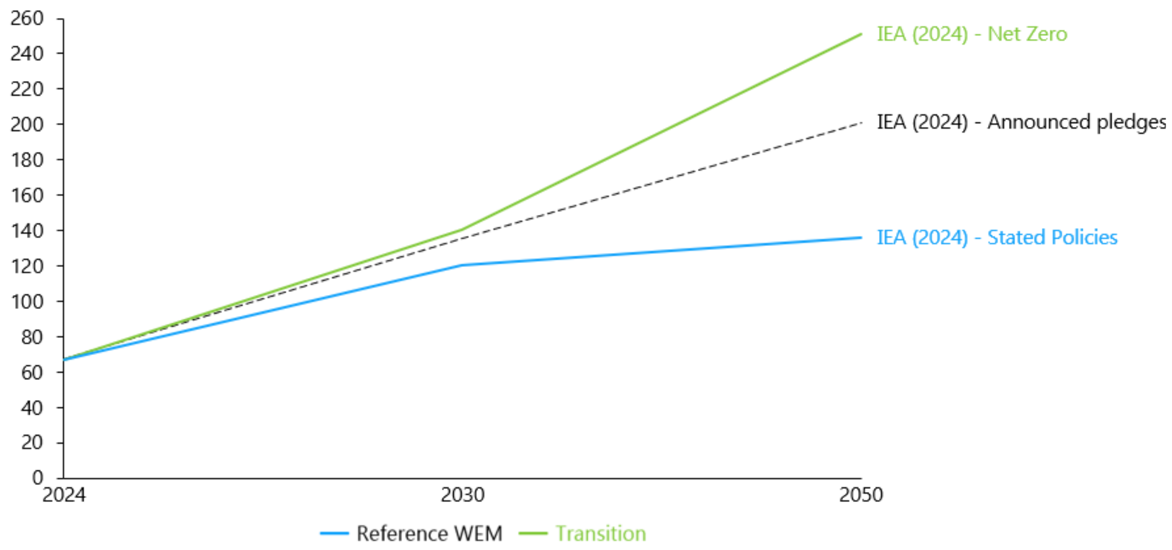


Comment: 1) historic value: Eurostat 2023-S2 value. 2) projection of final electricity prices is a construction based on wholesale electricity prices, network costs modelled by SCPI and current excise duties and VAT.

Carbon prices

The ETS1 price is used in the model to estimate the energy expenditures for electricity generation, as well as the wholesale price of biogas. We use the IEA projections (WEO 2024) which distinguishes a reference scenario from a "net zero" scenario.

Graph 18 ETS1 prices (€2024/tCO$_2$)



Sources: 1) historic: Ember 2) Projections: IEA World Energy Outlook (2024)

EST2 has not been studied in the context of this analysis. The projection of this price itself is not available and copes with significant uncertainty.

Other unitary costs

- Uranium: the price of uranium comes from ENTSOE (€1.752024/MWh). We assume that this price will remain constant
- Solid biomass: as solid biomass is a minor lever in decarbonization, and is used in a decreasing manner, the activity data for the scenarios has been assimilated to biogas.
- Waste: waste is assumed to be free

Alternative fuel in transport: as alternative fuel consumption in transport is often aggregated in transport, we use biofuel prices as a proxy for all alternative fuels

Appendix 4: Technology assumptions

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
EN	Electricity	Lifetime	Fossil	years	25,00	25,00	25,00	25,00	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	Lifetime	Nuclear	years	60,00	60,00	60,00	60,00	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	Lifetime	Biomass	years	40,00	40,00	40,00	40,00	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	Lifetime	Wind Offshore	years	30,00	30,00	30,00	30,00	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	Lifetime	Wind Onshore	years	30,00	30,00	30,00	30,00	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	Lifetime	Solar PV	years	25,00	25,00	25,00	25,00	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	Lifetime	Hydrogen	years	20,00	20,00	20,00	20,00	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	Lifetime	Hydro	years	50,00	50,00	50,00	50,00	Expert judgment
EN	Electricity	Lifetime	Waste	years	25,00	25,00	25,00	25,00	Expert judgment
EN	Electricity	Lifetime	Geothermal	years	25,00	25,00	25,00	25,00	Expert judgment
EN	Electricity	Lifetime	Other thermal	years	28,33	28,33	28,33	28,33	Expert judgment
EN	Heat district	Efficiency	Heat district	%	0,87	0,87	0,87	0,87	Federal Public Service Health – Climate Change Section. (2024). *Investments needed to achieve climate neutrality in Belgium – A preliminary overall assessment* [Unpublished internal document]. Federal Public Service Health.
EN	Heat district	Load factor	Heat district	hours/year	2000,00	2000,00	2000,00	2000,00	Expert judgment
EN	Heat district	Lifetime	Heat generation	years	20,00	20,00	20,00	20,00	Expert judgment
EN	Heat district	Thermal density	Thermal density	MWh/m	2,00	2,00	2,00	2,00	Federal Public Service Health – Climate Change Section. (2024). *Investments needed to achieve climate neutrality in Belgium – A preliminary overall assessment* [Unpublished internal document]. Federal Public Service Health.
EN	Clean Molecules	Lifetime	Electrolyzer	years	25,00	25,00	25,00	25,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Clean Molecules	Load factor	Electrolyzer	%	0,55	0,55	0,55	0,55	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Clean Molecules	Efficiency	Electrolyzer	%	0,65	0,75	0,77	0,78	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Clean Molecules	Heating Value	Electrolyzer	kWh/kg H2	33,00	33,00	33,00	33,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Clean Molecules	Electric consumption	Electrolyzer	kWh/kg H2	50,00	50,00	50,00	50,00	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Clean Molecules	Efficiency	H2 liquefaction	kWh/kg LH2	6,10	6,10	6,10	6,10	ENTEC. (2022). The role of renewable H_2 import & storage to scale up the EU deployment of renewable H_2. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/7ab70e32-a5a0-11ec-83e1-01aa75ed71a1/language-en
EN	CO_2	Efficiency	Carbon Capture	kWhe/tCO_2	150,00	150,00	150,00	150,00	Federal Public Service Health – Climate Change Section. (2024). *Investments needed to achieve climate neutrality in Belgium – A preliminary overall assessment* [Unpublished internal document].
EN	Electricity	Battery penetration rate	New GW of battery installed by new GW of RES developed	GW	0,17	0,17	0,17	0,17	Blunomy. (2024). *Economics for Belgium's net zero plan* [Unpublished internal document].
EN	Electricity	Losses	Electricity losses	%	0,07	0,07	0,07	0,07	Trinomics, & European Commission. (2020). Final report – Network costs: Energy costs, taxes and the impact of government interventions on investments. European Commission.
EN	CO_2	Electric consumption	DACS installations	MWh/tCO_2	1,04	1,04	1,04	1,04	International Energy Agency Greenhouse Gas Programme. (2021). *Global assessment of direct air capture costs* (Technical Report 2021-05). IEAGHG. https://ieaghg-publications.s3.eu-north-1.amazonaws.com/2021-05+Global+Assessment+of+Direct+Air+Capture+Costs.pdf

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
EN	Heat district	Efficiency	Efficiency biomass based CHP	MWhth/MWh	0,80	0,80	0,80	0,80	International Renewable Energy Agency. (2015). Biomass for heat and power (IRENA-ETSAP technology brief E05). IRENA. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA-ETSAP_Tech_Brief_E05_Biomass-for-Heat-and-Power.pdf
EN	Electricity	Peak	Peak load value compared to total yearly power consumption	GW/TWh	0,16	0,13	0,13	0,12	Expert judgment Based on Elia. (2021). Monitoring report - Belgian electricity market implementation plan. and Elia. (2017). Electricity scenarios for Belgium towards 2050: Elia's quantified study on the energy transition in 2030 and 2040.
EN	Electricity	Capacity factor	Fossil	%	0,34	0,29	0,22	0,15	International Energy Agency. (2023). *World energy outlook 2023*. IEA. https://www.iea.org/reports/world-energy-outlook-2023 & International Renewable Energy Agency. (2022). Belgium energy profile 2022. IRENA. https://www.irena.org Data freely adapted from the capacity factors in IEA (2023) for the EU & IRENA (2022) Energy Profile Belgium.
EN	Electricity	Capacity factor	Nuclear	%	0,90	0,90	0,90	0,90	International Energy Agency. (2023). World energy outlook 2023. IEA. https://www.iea.org/reports/world-energy-outlook-2023 & International Renewable Energy Agency. (2022). Belgium energy profile 2022. IRENA. https://www.irena.org Data freely adapted from the capacity factors in IEA (2023) for the EU & IRENA (2022) Energy Profile Belgium.
EN	Electricity	Capacity factor	Biomass	%	0,67	0,67	0,67	0,67	International Energy Agency. (2023). World energy outlook 2023. IEA. https://www.iea.org/reports/world-energy-outlook-2023 & International Renewable Energy Agency. (2022). Belgium energy profile 2022. IRENA. https://www.irena.org Data freely adapted from the capacity factors in IEA (2023) for the EU & IRENA (2022) Energy Profile Belgium.
EN	Electricity	Capacity factor	Wind Offshore	%	0,41	0,41	0,41	0,41	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	Capacity factor	Wind Onshore	%	0,23	0,23	0,23	0,23	EnergyVille. (2022). *Perspective 2050*. EnergyVille. https://perspective2050.energyville.be/
EN	Electricity	Capacity factor	Solar PV	%	0,12	0,12	0,12	0,12	International Energy Agency. (2023). World energy outlook 2023. IEA. https://www.iea.org/reports/world-energy-outlook-2023 & International Renewable Energy Agency. (2022). Belgium energy profile 2022. IRENA. https://www.irena.org Data freely adapted from the capacity factors in IEA (2023) for the EU & IRENA (2022) Energy Profile Belgium.
EN	Electricity	Capacity factor	Hydrogen	%	na	na	na	na	International Energy Agency. (2023). World energy outlook 2023. IEA. https://www.iea.org/reports/world-energy-outlook-2023 & International Renewable Energy Agency. (2022). Belgium energy profile 2022. IRENA. https://www.irena.org Data freely adapted from the capacity factors in IEA (2023) for the EU & IRENA (2022) Energy Profile Belgium.
EN	Electricity	Capacity factor	Hydro	%	0,26	0,26	0,26	0,26	International Energy Agency. (2023). *World energy outlook 2023*. IEA. https://www.iea.org/reports/world-energy-outlook-2023 & International Renewable Energy Agency. (2022). Belgium energy profile 2022. IRENA. https://www.irena.org Data freely adapted from the capacity factors in IEA (2023) for the EU & IRENA (2022) Energy Profile Belgium.
EN	Electricity	Capacity factor	Waste	%	0,24	0,23	0,21	0,20	International Energy Agency. (2023). *World energy outlook 2023*. IEA. https://www.iea.org/reports/world-energy-outlook-2023 & International Renewable Energy Agency. (2022). Belgium energy profile 2022. IRENA. https://www.irena.org Data freely adapted from the capacity factors in IEA (2023) for the EU & IRENA (2022) Energy Profile Belgium.
EN	Electricity	Capacity factor	Geothermal	%	0,85	0,85	0,85	0,85	International Energy Agency. (2023). *World energy outlook 2023*. IEA. https://www.iea.org/reports/world-energy-outlook-2023 & International Renewable Energy Agency. (2022). Belgium energy profile 2022. IRENA. https://www.irena.org Data freely adapted from the capacity factors in IEA (2023) for the EU & IRENA (2022) Energy Profile Belgium.
EN	Electricity	Capacity factor	Other thermal	%	0,16	0,10	0,08	0,05	International Energy Agency. (2023). *World energy outlook 2023*. IEA. https://www.iea.org/reports/world-energy-outlook-2023 & International Renewable Energy Agency. (2022). Belgium energy profile 2022. IRENA. https://www.irena.org Data freely adapted from the capacity factors in IEA (2023) for the EU & IRENA (2022) Energy Profile Belgium.
EN	Electricity	Efficiency	Fossil	%	0,53	0,53	0,53	0,53	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx
EN	Electricity	Efficiency	Nuclear	%	0,33	0,33	0,33	0,33	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx
EN	Electricity	Efficiency	Biomass	%	0,38	0,38	0,38	0,38	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
EN	Electricity	Efficiency	Wind Offshore	%	na	na	na	na	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx
EN	Electricity	Efficiency	Wind Onshore	%	na	na	na	na	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx
EN	Electricity	Efficiency	Solar PV	%	na	na	na	na	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx
EN	Electricity	Efficiency	Hydrogen	%	na	na	na	na	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx
EN	Electricity	Efficiency	Hydro	%	na	na	na	na	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx
EN	Electricity	Efficiency	Waste	%	0,36	0,36	0,36	0,36	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx
EN	Electricity	Efficiency	Geothermal	%	na	na	na	na	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx
EN	Electricity	Efficiency	Other thermal	%	0,26	0,26	0,26	0,26	Elia. (2023). *Adequacy and flexibility study 2024-2034 - CENTRAL scenario and data: Average per fuel type* [Excel spreadsheet]. Elia. https://www.elia.be/-/media/project/elia/elia-site/electricity-market-and-system/adequacy/adequacy-studies/adequacy-studies/20230707_assumptionsworkbook_adeqflex23.xlsx
EN	Electricity	Carbon intensity	Carbon content fossil power plant	tCO$_2$e/MWh	0,20	0,20	0,20	0,20	Intergovernmental Panel on Climate Change. (2006). Stationary combustion (2006 IPCC guidelines for national greenhouse gas inventories, Vol. 2, Ch. 2). IGES. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf
TRA	Passenger cars	Lifetime	cars	km	200000,00	200000,00	200000,00	200000,00	Expert judgment
TRA	EV charging stations	Number	Average number of plugs per EV station - Cars	plug/station	2,00	2,00	2,00	2,00	Expert judgment
TRA	EV charging stations	Number	Average number of plugs per EV station - Trucks	plug/station	1,00	1,00	1,00	1,00	Expert judgment
TRA	EV charging stations	Number	Number of vehicles per public charging stations - Cars	# EV/plug	4,80	4,80	4,80	4,80	Expert judgment
TRA	EV charging stations	Number	Number of vehicles per private charging stations - Cars	# EV/plug	1,50	1,50	1,50	1,50	Expert judgment
TRA	Freight	Lifetime	Trucks	years	10,00	10,00	10,00	10,00	Expert judgment
TRA	Freight	Lifetime	Vans	years	10,00	10,00	10,00	10,00	Expert judgment

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
TRA	Passenger	Lifetime	Buses	years	12,00	12,00	12,00	12,00	Rivas, A., & D'Agosto, M. D. (2020). The life span of buses in public transport: A literature review. *Transportation Research Part D: Transport and Environment, 85*, 102413. https://doi.org/10.1016/j.trd.2020.102413
TRA	EV charging stations	Share	Share of fast charging station	%	0,10	0,10	0,10	0,10	Expert judgment
TRA	Bike lanes	Share of express lane	Share of express lane	%	25%	25%	25%	25%	Federal Public Service Health – Climate Change Section. (2024). *Investments needed to achieve climate neutrality in Belgium – A preliminary overall assessment* [Unpublished internal document].
TRA	Bike lanes	Bike lanes	km of path per km2 in the Netherlands	km/km2	0,84	0,84	0,84	0,84	Federal Public Service Health – Climate Change Section. (2024). *Investments needed to achieve climate neutrality in Belgium – A preliminary overall assessment* [Unpublished internal document].
TRA	passenger	Efficiency	Energy efficiency of EVs	Mwh/vkm	0,000200	0,000200	0,000200	0,000200	EV Database. (n.d.). *Energy consumption of electric cars*. EV Database. Retrieved from https://ev-database.org/cheatsheet/energy-consumption-electric-car
TRA	passenger	Efficiency	Energy efficiency of ICEs	Mwh/vkm	0,000467	0,000467	0,000467	0,000467	EV Life. (n.d.). *How does EV power consumption information work?* EV Life. Retrieved from https://evlife.world/en/ae/tech/how-does-ev-power-consumption-information-work/
TRA	passenger	Efficiency	Energy efficiency of FCEVs	Mwh/vkm	0,000333	0,000333	0,000333	0,000333	TotalEnergies. (n.d.). *All about FCEV*. TotalEnergies. Retrieved from https://services.totalenergies.be/nl/system/files/atoms/files/all_about_fcev.pdf
TRA	freight	Efficiency	Energy efficiency of ZEVs (trucks)	Mwh/vkm	0,001100	0,001100	0,001100	0,001100	Volvo Trucks. (2022, January). *Volvoâ€™s heavy-duty electric truck is put to the test: Excels in both range and energy efficiency*. Volvo Trucks. Retrieved from https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/jan/volvos-heavy-duty-electric-truck-is-put-to-the-test-excels-in-both-range-and-energy-efficiency.html
TRA	freight	Efficiency	Energy efficiency of ICEs (trucks)	Mwh/vkm	0,002670	0,002670	0,002670	0,002670	ClassTrucks. (n.d.). *Volvo FH Buyerâ€™s Guide*. ClassTrucks. Retrieved from https://www.classtrucks.com/en/buyers-guide/volvo-fh
TRA	freight	Efficiency	Energy efficiency of FCEVs (trucks)	Mwh/vkm	0,003333	0,003333	0,003333	0,003333	TotalEnergies. (n.d.). *All about FCEV*. TotalEnergies. Retrieved from https://services.totalenergies.be/nl/system/files/atoms/files/all_about_fcev.pdf
TRA	freight	Efficiency	Energy efficiency of ZEVs (vans)	Mwh/vkm	0,003000	0,003000	0,003000	0,003000	Mercedes-Benz. (n.d.). *e-Sprinter Panel Van Overview*. Mercedes-Benz. Retrieved from https://www.mertrux.com/new-vans/e-sprinter/panel/
TRA	freight	Efficiency	Energy efficiency of ICEs (vans)	Mwh/vkm	0,000819	0,000819	0,000819	0,000819	Autozine. (n.d.). *Ford Transit Custom review*. Autozine. Retrieved from https://www.autozine.nl/ford/transit-custom/autotest
TRA	freight	Efficiency	Energy efficiency of FCEVs (vans)	Mwh/vkm	0,000467	0,000467	0,000467	0,000467	Peugeot. (n.d.). *New Peugeot E-Expert*. Peugeot Belgium. Retrieved from https://www.peugeot.be/fr/gamme/new-peugeot-E-expert.html
TRA	passenger	Efficiency	Energy efficiency of EVs (buses)	Mwh/vkm	0,001500	0,001500	0,001500	0,001500	Sustainable Bus. (n.d.). *Electric bus range and electricity consumption*. Sustainable Bus. Retrieved from https://www.sustainable-bus.com/news/electric-bus-range-electricity-consumption/
TRA	passenger	Efficiency	Energy efficiency of ICEs (buses)	Mwh/vkm	0,003800	0,003800	0,003800	0,003800	Mercedes-Benz. (2014, August 1). *Citaro Stadt technical specifications*. Mercedes-Benz. Retrieved from https://buses.mercedesbenzmena.com/media/1503956/2014_08_01_citaro_stadt_en.pdf
TRA	passenger	Efficiency	Energy efficiency of FCEVs (buses)	Mwh/vkm	0,004400	0,004400	0,004400	0,004400	Expert judgment
TRA	freight	Number	Gross combination weight	tons	40,00	40,00	40,00	40,00	Volvo Trucks. (n.d.). *Volvo FH Aero Electric*. Volvo Trucks. Retrieved from https://www.volvotrucks.com/en-en/trucks/electric/volvo-fh-aero-electric.html

Sector	Subsector	Type	Item	Unit	2024	2030	2040	2050	Source
TRA	freight	Efficiency	Efficiency of freight trains	MWh/tkm	0,000020	0,000020	0,000020	0,000020	TNO. (2017). *HT13Na: Technical report on energy efficiency and vehicle performance*. TNO. Retrieved from https://publications.tno.nl/publication/34626344/HT13Na/TNO-2017-R11679.pdf
TRA	passenger	Efficiency	Efficiency of passenger trains	MWh/pkm	0,000042	0,000042	0,000042	0,000042	UIC & IEA. (2017). *Handbook on transport energy efficiency and emissions*. International Union of Railways & International Energy Agency. Retrieved from https://uic.org/IMG/pdf/handbook_iea-uic_2017_web3.pdf
TRA	EV charging stations	Number	Average number of plugs per EV station - Vans	plug/station	2,00	2,00	2,00	2,00	Expert judgment
TRA	EV charging stations	Number	Number of vehicles per public charging stations - Vans	# EV/plug	4,80	4,80	4,80	4,80	Expert judgment
TRA	EV charging stations	Number	Number of vehicles per private charging stations - Vans	# EV/plug	1,50	1,50	1,50	1,50	Expert judgment
TRA	Freight	Lifetime	IWW boat	years	30,00	30,00	30,00	30,00	Expert judgment
TRA	Passenger & Freight	Lifetime	train	years	30,00	30,00	30,00	30,00	Expert judgment

Appendix 5: Computation logic and scope – Buildings Sector

Scope

The building sector covers both residential and non-residential buildings. More details about the scope of this analysis for the building sector is given in the Tables hereunder.

Included in CAPEX estimations	Not included in CAPEX estimations
Energy renovation estimations for residential & non-residential buildings include: - Thermal insulation - Ventilation - Heating system adaptations (distribution & emission systems) - Demolition/reconstruction - *Only for residential:* House division to compensate for new construction slow-down	Energy renovation estimations do not include: - Solar photovoltaic installation (included in energy sector) - Structural reinforcements - Additional costs in case of listed or heritage buildings - Additional costs for architects & engineers studies
New construction estimations include costs for the construction of new residential and non-residential buildings with today's practices & energy performances. Cost of new construction is considered to be the same in all scenarios.	New construction estimations do not include land purchase, permits, architects & engineers' studies
New and renewal of heating systems (boilers)	Renewal of appliances & lighting with more energy efficient appliances is not included

Included in OPEX estimations	Not included in OPEX estimations
Energy costs due to energy consumption from - Heating systems - Appliances & lighting Energy vectors considered are coal, oil, natural gas, electricity, biogas, biomass and heat from heating networks (costs are estimated assuming heat is produced from biomass). No distinction was made between electricity consumption from heating system and from appliances & lighting, both are aggregated in the total electricity consumption of the sector.	No distinction between biomass and biogas, which are aggregated in the same category and priced as biogas.
Operation and maintenance costs for heating systems depending on insulation level	

Calculation logic

The Table hereunder gives more details about the calculation logic that has been applied in this analysis for each investment need item identified in the scope section.

Item	Calculation logic CAPEX
Energy renovation (residential & non-residential)	- Investment needs for renovation are estimated based on the existing build surface at reference year, the renovation rate, renovation depth and a CAPEX per square meter: $I_r = A_{y0}R_rD_rCAPEX_r$ - Investment needs for demolition/reconstruction is estimated based on the existing build surface at reference year, the annual demolition rate and a CAPEX per square meter which is the sum of a demolition CAPEX and a new construction CAPEX: $I_{dn} = A_{y0}R_d(CAPEX_d + CAPEX_n)$ - *Only for residential buildings* - Investment needs for house division is estimated as follow: based on population growth, and new construction data, we estimate the number of new households that are not covered by new construction. For each household not covered, we assume an existing house has to be divided in 2 housings. Then we apply a CAPEX/house that has to be divided. $I_{div} = N_{div}CAPEX_{div}$ $N_{div} = N_{add\_hh} - \frac{A_n}{A_{avg\_hh}}$
New construction (residential & non-residential)	- Investment needs for new construction is estimated based on the new build surface and a new construction CAPEX per square meter: $I_n = A_nCAPEX_n$
Renewal of heating systems (residential & non-residential)	- For a given insulation level, investment needs for the renewal of heating systems are estimated based on the lifetime of heating units, the heated surface, the share of heat pumps installed, and the CAPEX of heating units: $I_{h,i} = A_i \frac{1}{Lifetime_h}(P_{ZEH}CAPEX_{HP,i} + (1 - P_{ZEH})CAPEX_{CB,i})$ Two insulation levels i are defined in this analysis: the “2024 average insulation” level and the “fully insulated” level.

Where:

- A_{y0}, A_n and A_{avg_hh} are the build surface at year 0, the new build surface and the average surface per household expressed in m^2
- $CAPEX_r$, $CAPEX_d$, $CAPEX_n$, $CAPEX_{div}$, $CAPEX_{HP,i}$ and $CAPEX_{CB,i}$ are the CAPEX for renovation, demolition, new construction, house division, heat pump renewal and condensing boiler renewal;
- D_r is the renovation depth

- I_r, I_{dn}, I_{div}, I_n and $I_{h,i}$ are the annual investment needs for renovation, demolition/reconstruction, house division, new construction and heating system renewal
- $Lifetime_h$ is the average lifetime of heating units
- N_{add_hh} and N_{div} are the number of additional households compared to the base year, and the number of houses that need to be divided in 2
- P_{ZEH} is the share of zero-emission heating systems (mainly heat pumps) in renewed heating system.
- R_r and R_d are the renovation rate and demolition rate

Item	Calculation logic OPEX
Maintenance costs for heating systems	The maintenance linked to the CAPEX uses the same methodology with OPEX unitary costs. $$O_h = A_wHP_tOPEX_{HP_w} + A_bHP_tOPEX_{HP_b} + A_wGB_t\ OPEX_{GB_w} + A_bGB_t\ OPEX_{GB_b}$$ Surface heated was calculated previously in the CAPEX section based on renovation rate and heat pump penetration rate
Energy consumption costs	- Energy consumption cost is estimated based on energy consumption reported in scenarios, and the projected energy prices: $$E_{e,t} = C_{e,t} * P_{energy_{MWh},t}$$

Where:

- $C_{e,t,t}$ is the annual energy vector *e* consumed at year *t*
- $CCE_{e,t,t}$ areis the annual energy consumption costs in buildings, per vector *e* at year *t*
- O_h are the maintenance costs of the heating system asset
- $OPEX_{HP}$, $OPEX_{GB}$, are the unitary costs of the heating system asset, differentiated whether heat pump or gas boiler, distinguished whether in well or badly insulated buildings, expressed in EUR/m^2/year
- $P_{energy\_MWh,t}P_{e,t}$ is the projected average final price of energy vector *e*, at year *t* projected for year *t*
- A_wHP_t , A_wGB_t , A_bHP_t A_bGB_t is the built surface heated by heat pump or gas boiler at year t, in well and badly isolated buildings respectively.

Data and hypothesis

For this sector, 5 indicators are derived from the net-zero scenarios (see Table below).

Data	Data name	Unit	Data sources & hypothesis
A	Total floor area	m²	For FPS scenarios, total floor area data is available for residential and non-residential. For Energyville scenarios, energy demand inputs from buildings are available, see Table 11 of EnergyVille's report (EnergyVille 2022). We assume floor area evolves with the same ratio. For EPOC and Clever scenario, we made the assumption that non-residential floor area evolves with the same ratio as residential floor area given in their report For Clever scenario, we assumed a constant evolution of floor area.
R_r	Renovation rate	%	For FPS, EPOC and Clever scenarios, renovation rate data is available. For Energyville scenarios, we made the assumption that renovation rate is the same as in SPF (2021) - High Demand, which is the closest scenario in general. For EPOC , we made the assumptions that the renovation rate is the same in the residential as in the non-residential.
R_d	Demolition rate	%	For FPS and EPOC scenarios, demolition rate data is available. For Energyville scenarios, we made the assumption that non-residential demolition rate is the same as in SPF (2021) - High Demand, which is the closest scenario in general. The residential demolition rate is supposed to be 1,15% between 2030 and 2050 based on a mail exchange with the modelling team. For Clever (2023), we made the assumption that demolition rate is the same as in SPF (2021) – CORE 95, which is the closest scenario in general.
D_r	Renovation Depth	%	For the reference scenario, renovation depth is assumed to be 25%, which means that the renovation costs per square meter is 25% of the costs of a deep renovation. For all other scenarios, we assume that all renovations are deep renovation (100% of costs).
P_{ZEH}	Share of HP in renewed heating systems for insulation level i	%	For the reference scenario, we assume that share of zero-emission heating systems in renewed heating system reaches 25% in the residential sector and 30% in the non-residential sector. For all other scenarios, we assume that 100% of renewed heating system are zero-emission starting from 2040, with a linear interpolation between 2022 and 2040.
$C_{e,t}$	Energy consumption per energy vector e	TWh	Consumption data for each type of energy vector is available in all scenarios where buildings are within the scope. However, EnergyVille (2022) does not provide detailed breakdowns for specific fossil fuel vectors (e.g. gas, oil, coal, etc.). Therefore, we assume that the phase-out of each specific fossil fuels follows the same trajectory as the phase-out of the total fossil fuel consumption. Energy consumption was ventilated between residential and non-residential buildings according to surface area.

In addition to those indicators, other assumptions have been made to estimate the investment needs and annual related expenditures (see Table below).

Data	Data name	Unit	Data sources & comment
A_n	New floor area	m²	The new build floor area is computed based on the total build surface difference between two years
A_{avg_hh}	Average floor area per household	m²/ household	Average housing floor area per household is computed based on the total build surface and on the number of households which is supposed to be the same across all scenarios
$Lifetime_h$	Average lifetime of heating systems	Years	The average lifetime of a heating units is supposed to be 20 years

In addition to those indicators, the other assumptions that have been made for technical technology features and the unitary CAPEX, OPEX and energy prices data are to be found in the dedicated sections of the appendix.

Reference year & reference scenario

The Table hereunder shows the values of the indicators for the reference year 2024 and for the reference scenario in 2050.

Data	Data name	Unit	2024	2024 – Data source	2050 – Ref scenario	2050 – Data source
HH	Number of households	Millions	5,16	FPB, 2024	5,74	FPB, 2024
A	Total floor area – Residential	Million m²	653	Own assumption based on [FPS, 2021] data and on Statbel data on built surface evolution	831	Based on [FPS, 2021] – WEM Scenario assumptions
A	Total floor area – Non-residential	Million m²	199	Own assumption based on [FPS, 2021] data and on Statbel data on built surface evolution	219	Based on [FPS, 2021] – WEM Scenario assumptions
R_r	Renovation rate – Residential	%	1%	Supposed to be equal to 2015 - SPF (2021)	1%	Based on [FPS, 2021] – WEM Scenario assumptions
R_r	Renovation rate – Non-residential	%	1%	Supposed to be equal to 2015 - [FPS, 2021]	1%	Based on [FPS, 2021] – WEM Scenario assumptions
R_d	Demolition rate – Residential	%	0,1%	Supposed to be equal to 2015 - [FPS, 2021]	0,1%	Based on [FPS, 2021] – WEM Scenario assumptions
R_d	Demolition rate – Non-residential	%	0,1%	Supposed to be equal to 2015 - [FPS, 2021]	0,1%	Based on [FPS, 2021] – WEM Scenario assumptions

D_r	Renovation Depth – Residential	%	25%	Expert judgment	25%	Expert judgment
D_r	Renovation Depth – Non-residential	%	25%	Expert judgment	30%	Expert judgment
P_{ZEH}	Share of HP in renewed heating systems for insulation level I – Residential	%	5%	Expert judgment	25%	Based on [FPS, 2021] – WEM Scenario assumptions
P_{ZEH}	Share of HP in renewed heating systems for insulation level I – Non-residential	%	5%	Expert judgment	30%	Based on [FPS, 2021] – WEM Scenario assumptions
$C_{e,t}$	Fossil fuel consumption	TWh	83.4	Eurostat Energy Balance, 2023	79.27	Based on [FPS, 2021] – WEM Scenario assumptions
	Electricity consumption	TWh	36	Eurostat Energy Balance, 2023	65.05	Based on [FPS, 2021] – WEM Scenario assumptions
	Biogas/biomass consumption	TWh	3	Eurostat Energy Balance, 2023	0	Based on [FPS, 2021] – WEM Scenario assumptions
	District heating	TWh	1	Eurostat Energy Balance, 2023	1.2	Based on [FPS, 2021] – WEM Scenario assumptions

Appendix 6: Computation logic and scope – Transport Sector

Scope

The transport sector covers both passenger transport and freight. More details about the scope of this analysis for the transport sector is given in the Tables hereunder.

Included in CAPEX estimations	Not included in CAPEX estimations
Road passenger transport estimates include: - CAPEX for vehicles with two categories of costs: EV or ICE. We make the hypothesis that vehicles using alternative sustainable fuels (biofuels or e-fuels) have the same CAPEX as ICE vehicles. - CAPEX for charging infrastructure (private of shared)	-
Road freight transport estimates include: - CAPEX for vehicles with two categories of costs: EV or ICE. We make the hypothesis that vehicles using alternative sustainable fuels (biofuels or e-fuels) have the same CAPEX as ICE vehicles. - CAPEX for charging infrastructure (private of shared)	-
Rail estimates include: - CAPEX for vehicles	
Other public transport estimates include: - CAPEX for Buses (EV or ICE)	- Investment in other rail public transport (metro & tram) is not included
Inland waterways estimates include: - CAPEX for boats (electric, hydrogen and bio-methanol)	
Infrastructure estimates include: - CAPEX for road infrastructure for cars, busses and trucks - CAPEX for rail infrastructure - CAPEX infrastructure for inland waterways - CAPEX for cycling infrastructure (bike lanes)	- Metro and tram infrastructure

Included in OPEX estimations	Not included in OPEX estimations
Road passenger transport estimates include: - Maintenance expenditures for vehicles (EV and ICE) - Energy expenditures for vehicles energy consumption - Maintenance expenditures for charging infrastructure (private of shared) maintenance	
Road freight transport estimates include: - Maintenance expenditures for vehicles (EV and ICE) - Energy expenditures for vehicles energy consumption - Maintenance expenditures for charging infrastructure (private of shared) maintenance	
Rail estimates include: - Energy expenditures for vehicles consumption	- Maintenance costs of vehicles
Other public transport estimates include: - Maintenance expenditures for vehicles (EV or ICE) - Energy expenditures for vehicles energy consumption - Maintenance expenditures for charging infrastructure (private of shared) maintenance	- Operational costs of other rail public transport (metro & tram)
Inland waterways estimates include: - Maintenance and energy expenditures for boats’ consumption (electric, hydrogen and bio-methanol)	
Infrastructure estimates include: - Maintenance expenditures of road infrastructure for cars, busses and trucks - Maintenance expenditures of infrastructure for rail - Maintenance expenditures of infrastructure for inland waterways	- Maintenance costs of cycling infrastructure

Calculation logic

The Table hereunder gives more details about the calculation logic for CAPEX that has been applied in this analysis for each investment need item identified in the scope section.

Item	Calculation logic CAPEX
Vehicles (cars, trucks, vans, buses)	- Investment needs for vehicles is estimated per vehicle type (cars, trucks, vans, buses) based on the vehicle stock, the renewal rate, the share of new vehicles that are zero-emissions and CAPEX per vehicle: $I_{vehicles} = (N_{additional\_vehicles} + N_{new\_vehicles,t-lifetime}) (S_{ZE}CAPEX_{ZE} + (1 - S_{ZE})CAPEX_{ICE})$ Where the additional vehicles (which can be negative) are estimated based on the evolution of the number of vehicles, which is estimated based on car occupancy and transport demand: $N_{vehicles} = \frac{T_v}{P_V} * \frac{1}{D_y}$ Where the new vehicles invested in the past are replaced at the end of their lifetime. For cars specifically, the lifetime is not estimated in years but based on the average lifetime expressed in kilometres and the average distance in km travelled by a car each year: $Lifetime_{car\ [year]} = \frac{Lifetime_{car\ [km]}}{D_{cars}}$ Estimation of the fleet size for cars takes into account the need for new vehicles, the renewal and disposal of end-of-life vehicles and the disposal of "excess capacity" vehicles. In other words, when vehicles reach the end of their lifetime and the fleet diminishes, the fleet will not be renewed. This applies both to ZE and ICE cars. The average age in terms of years of the vehicles' fleet may vary upwards or downwards according to the resizing of a larger or smaller total fleet.
Vehicles (rail)	- Investment needs for trains is estimated based on vehicle stock, renewal rate and train transport demand. All trains are assumed to be electric. $I_{train\_vehicles} = N_{passenger.train}R_{passenger.train}CAPEX_{passenger.train} + N_{freight.train}R_{freight.train}CAPEX_{freight.train}$ Where the renewal rate is the estimated based on lifetime in years $R_{vehicle} = \frac{1}{Lifetime_{vehicle\ [year]}}$ Where the number of trains is based on the initial number of trains at reference year, which evolves proportionally to train transport demand: $N_{passenger.train,t=}N_{passenger.train,t-1}\frac{T_{passenger.train,t} - T_{passenger.train,t-1}}{T_{passenger.train,t-1}}$ $N_{freight.train,t=}N_{freight.train,t-1}\frac{T_{freight.train,t} - T_{freight.train,t-1}}{T_{freight.train,t-1}}$

Vehicles (inland waterways)	- Investment needs for inland waterways boats is estimated based on the vehicle stock, the renewal rate, the share of new vehicles that are zero-emissions and CAPEX per vehicle: $I_{vehicles} = N_{vehicles}R_{vehicles}(S_{H2.boats}CAPEX_{H2.boats} + S_{methanol.boats}CAPEX_{methanol.boats} + S_{ICE.boats}CAPEX_{ICE.boats} + S_{electric.boats}CAPEX_{electric.boats})$ Where the renewal rate is the estimated based on lifetime in years. $R_{vehicle} = \frac{1}{Lifetime_{vehicle\,[year]}}$ Where the number of boats is based on the initial number of boats at reference year, which evolves proportionally to inland waterway transport demand: $N_{boat,t=}N_{boat,t-1}\frac{T_{boat,t} - T_{boat,t-1}}{T_{boat,t-1}}$
Electric charging infrastructures (cars, trucks, vans, buses)	- Investment needs for charging infrastructure is estimated per vehicle type (cars and heavy vehicles) based on the number of charging stations, the share of fast charging stations and the CAPEX of charging stations: $I_{CI\_vehicles} = N_{c-vehicles}(S_{FC}CAPEX_{FC} + (1 - S_{FC})CAPEX_{CC})$ And the number of charging stations is estimated based on the number of electric vehicles in circulation and a ratio of charging station per vehicle: $N_{c-vehicles} = N_{EV-vehicles}\,R_{CS-vehicle}$
Infrastructure - Bike lanes	- Investment needs for bike lanes is estimated based the number of kilometres of new bike lanes and a CAPEX per kilometre: $I_{bikelanes} = L_{Nbl}CAPEX_{bl}$ The total length of bike lanes is estimated based on The Netherlands example: - The Netherlands has a bike lane density of 0,84 kilometres of bike lanes per square kilometre - If applied to Belgium, this density would result on 26 000 km of bike lanes in Belgium (=25% of total road length in Belgium) - Then we apply this logic: ▪ If passenger transport per bike ≤ 3,7 bn pkm (current situation): $L_{bl} =$ 11 400 (current situation) ▪ If 3,7 < passenger transport per bike < 21: $L_{bl} = 11\,400 + \frac{(26\,000 - 11\,400)}{(21 - 3{,}7)}(T_{bike} - 3{,}7)$ ▪ If passenger transport per bike ≥ 21 bn pkm: $L_{bl} = 26\,000$
Infrastructure – Road & Inland Waterways	Investment needs for transport infrastructure (road and inland waterways) are estimated based on the transport demand (in passenger-kilometres or tonne-kilometres) and the associated unitary CAPEX for infrastructure investment.

	Infrastructure investments include all expenditures on new infrastructure or expansion of existing infrastructure with respect to its functionality and/or lifetime and expenditures associated with the renewal of the infrastructure with at least have a lifetime of more than 1 to 2 years. $I_{infra,v} = T_v * CAPEX_{infra}$ Unitary costs provided by Schoten et al. (2019) are estimated based on historical trends, and hence rather representative of a reference scenario. Profound changes in the structure and nature of transportation networks probably induce different costs than historic data can provide. However, this estimate is the most reliable available. In addition, historical values in Schoten et al. (2019) differ from historical value from OECD, likely due to larger scope including e.g. ancillary services in Schoten et al. (2019). Therefore, results were scaled to align with OECD official values.
Infrastructure – rail	Infrastructure investment estimates for rail is based on existing projections made in the rail 2040 Vision, applied in SNCB/NMBS and Infrabel investments plans. To reach rail 2040 objectives, Infrabel and SNCB/NMBS plan on 12.5 bn EUR and 5 bn EUR (excludes 4.5 bn EUR rolling stock investment to avoid double counting) investments in ten years, respectively. We assume these yearly investments of 1.74 bn EUR applies until 2040, with the assumption that investment will not be cut after 10 years but will stay at the same level until at least 2040, which is the end-year of the Vision. After 2040, we assume most investment have been done, and we return to historical level of investment in rail. $I_{infra,train} = \text{Historical investment} + \text{Additionnal invesment}$ Where historical investment is an extension of 2016 history and amounts to 1.18 bn EUR per year (OECD. Where additional investment is the difference between Rail Vision 2040 yearly investments and historical investments in 2016. This difference is then scaled based on the passenger demand of the studied scenario and a proxy scenario common for all scenarios. $\text{Scaling factor}_t = \frac{T_{passenger.trains,t} - T_{passenger.trains,t-1}}{T_{passenger.trains,t,proxy} - T_{passenger.trains,t-1,proxy}}$ The proxy scenario used is the FSP Core 95 scenario as it reached similar passenger-kilometre demand as ambitioned by the Rail Vision 2040 (we note that FSP Behaviour is the closest in terms of modal share). This methodology is a top-down methodology that enables to discriminate between scenarios and aligns with order of magnitude of existing investment plans. It does not give however a precise estimate of investment.

Where:

- $CAPEX_{ZE}$, $CAPEX_{ICE}$, $CAPEX_{FC}$, $CAPEX_{CC}$, $CAPEX_{bl}$ $CAPEX_{freight.train}$,$CAPEX_{passenger.train}$,$CAPEX_{ICE.boat}$, $CAPEX_{methanol.boat}$, $CAPEX_{H2.boat}$, $CAPEX_{electric.boats}$; are the unit CAPEX for zero-emission vehicles, internal combustion engine, fast-chargers, classic chargers, bike lanes, freight railcar, passenger railcar, conventional inland boat, bio-methanol inland boat, hydrogen inland boat and electric inland boat.
- $CAPEX_{enhancementinfra}$ and $CAPEX_{renewal}$ areare the unit CAPEX for the average annualized infrastructure investments costs for enhancement and renewal projects respectively infrastructure projects in road and inland waterways
- D_{cars} is the average distance traveled by a car each year
- $D_y$is the average distance driver by vehicle per year
- $I_{vehicles}$, $I_{CI\_vehivles}$, I_{target_rail}, $I_{bikelanes}$, $I_{infra,v}$ are the investment needs for new vehicles (cars, trucks, vans, buses), the investment needs for the deployment of charging infrastructure for EV vehicles, the target investment needs for rail, the investment needs for the deployment of new bike lanes and the investment needs for the deployment of road, rail and water infrastructure
- L_{Nbl}, L_{bl} are the length of new bike lanes and the total length of bike lanes
- $Lifetime_{car\ [km]}$ is the average lifetime of a car expressed in kilometres
- $Lifetime_{vehicle\ [year]}$ is the average lifetime in years for each type of vehicle
- $N_{boat,t}$ is the total number of inland waterways boats at year t
- $N_{passenger.train,t}$, $N_{freight.train,t}$ are the total number of passenger and freight railcars at year t
- $N_{vehicles}$, $N_{additional}$ $N_{c-vehicles}$, $N_{EV-vehicles}$ are the total number of vehicles in circulation for each type (cars, trucks, vans, buses), the additional number of vehicles per year, the number of charging stations, and the number of electric vehicles for each type of vehicle
- P_v is the number of people per vehicle
- $R_{CS-vehicle}$ is the ratio of charging station per electric vehicle in circulation
- $R_{vehicles}$ is the renewal rate of vehicles
- $S_{ICE.boats}$, $S_{H2.boats}$, $S_{methanol.boats}$, $S_{electric.boats}$: are the share of conventional, hydrogen and bio-methanol boat in total stock of boats
- S_{ZE}, S_{FC}: are the share of zero-emission (aggregated to electric specificities) vehicles in new vehicle sales and the share of fast-charger in charging stations.
- S_{train} is the modal share of train in passenger transport
- $T_{v,t}$ is the transport demand per vehicle type expressed either in billion tonne-kilometre or billion passenger-kilometre, at year t
- T_{bike} is the transport demand per bike expressed in billion pkm.
- $T_{freight.trains,t}$ is the transport demand for freight trains expressed in billion tonne-kilometre, at year t
- $T_{passenger.trains,t}$ is the transport demand for freight passenger trains expressed in billion passenger-kilometre at year t

The Table hereunder gives more details about the calculation logic for OPEX that has been applied in this analysis for each operational and maintenance needs item identified in the scope section.

Item	Calculation logic OPEX
Vehicles (road)	- Maintenance expenditures for vehicles is estimated per vehicle type (cars, trucks, vans, buses) and per fuel type (conventional fuel, sustainable fuel, electricity) based on vehicle stock: $O_{vehicles} = N_{vehicles}OPEX_{vehicle}$ - Energy expenditures for vehicle energy consumption is estimated per mode (road) and per fuel type (conventional fuel, sustainable fuel, electricity) based on energy consumption reported in scenarios (from which rail and inland waterways' vehicle consumption are deduced, and the projected energy prices: $E_{e,road} = C_{e,road} * P_{energy_{MWh}}$
Vehicles (rail)	- Energy expenditures for vehicle energy consumption for train rolling stock is estimated based on energy efficiency and train transport demand, for passenger trains and freight trains distinctively: $E_{e,passenger.trains} = EE_{\frac{MWh}{pkm}}T_{passenger.trains}P_{energy\_MWh}$ $T_{freight.trains\,P_{\frac{fuel}{MWh}}}E_{e,freight.trains} = EE_{\frac{MWh}{tkm}}T_{freight.trains\,P_{energy\_MWh}}$
Vehicles (inland waterways)	- Maintenance and energy expenditures are aggregated into a yearly cost per boat, distinct according to boat type (conventional, hydrogen, methanol and electric) $O_{boats} + E_{boats} = N_{boats}\ OPEX_{boat}$
Electric charging infrastructures (cars, trucks, vans, buses)	- Maintenance expenditures for charging stations is estimated based on stations' stock calculated in CAPEX section. $O_{charging.stations} = N_{charging.stations}\ OPEX_{charging\ sations}$
Infrastructure - Bike lanes	/
Infrastructure (road, rail, inland waterways)	Operations and maintenance yearly needs for transport infrastructure are estimated based on the length of the network and the associated costs. Maintenance expenditures are expenditures associated with ordinary maintenance that cannot be avoided, i.e. minor repairs with an economic lifetime of less than 1 to 2 years. Operational expenditures are expenditures made to enable an efficient use of the infrastructure (e.g. lighting, traffic management). $O_{infra,v} = Lenght_{m} * OPEX_{infra}$

Where:

- $C_{e,road}$ is the annual energy consumed, per energy type e and road mode
- $D_{vehicle}$: yearly vehicle distance of a vehicle, expressed in km/year
- $EC_{vehicle}, EC_{con.fuel_{vehicle}}, EC_{sust.fuel_{vehicle}}, EC_{EV_{vehicle}}$: energy consumption of a vehicle, a thermal vehicle with conventional fuel, a thermal vehicle with sustainable fuel, and an electric vehicle, expressed in MWh
- $EE_{\frac{MWh}{vkm}}, EE_{\frac{MWh}{tkm}}, EE_{\frac{MWh}{pkm}}$: efficiency of a fuel, expressed in MWh per vehicle-kilometre, in MWh per tkm, in MWh per pkm
- $E_{vehicle}, E_{passenger.trains}, E_{freight.trains}, F_{boats}$: energy costs of a vehicle, a passenger train, a freight train, expressed in EUR of 2024
- $Lenght_{m}$ is the length of the network per mode expressed in kilometres
- $N_{vehicles}, N_{total_{vehicles}}, N_{EV_{vehicles}}$: number of vehicles, total vehicles, and EV vehicles
- $OPEX_{vehicle}, OPEX_{boat}, OPEX_{charging\ sations}, OPEX_{infra}$: unitary yearly maintenance costs of a vehicle, a boat, a charging station, infrastructure
- $O_{infra,v,t}$ is the operational expenditure for maintaining road, rail and water infrastructure networks at time t
- $O_{vehicles}, O_{boats}$: O&M costs of a vehicles, excluding the fuel costs, expressed in EUR/year
- P_{energy_MWh}: unitary price of energy, expressed in EUR of 2024 per MWh
- $S_{\frac{con\_fuel}{fuel}}, S_{\frac{sus\_fuel}{fuel}}$: share of conventional fuel consumption on total fuel consumption (including sustainable) in road transport
- $T_{freight.trains,t}$ is the transport demand for freight trains expressed in billion tonne-kilometre, at year t
- $T_{passenger.trains,t}$ is the transport demand for passenger trains expressed in billion passenger-kilometre at year t

Data and hypothesis

For this sector, a set of indicators are derived from the net-zero scenarios (see Table below).

Data	Data name	Unit	Data sources & hypothesis
N_{cars}	Number of cars	#	We compute the number of cars based on 3 data from the scenarios: the car passenger demand [bn pkm], the occupancy of vehicle [person/vehicle], and the utilization of vehicles [km/vehicle/year]. The car passenger demand is available for all scenarios. Car occupancy and car utilization is only available for FPS scenarios. In all other scenarios, they are kept constant at 2022 level.
N_{trucks}	Number of trucks	#	The number of trucks is estimated based on 2023 truck fleet which is supposed to evolve with the same ratio as road freight transport demand [bn tkm]. The road freight transport demand data is available for all scenarios.
N_{vans}	Number of vans	#	The number of vans is estimated based on 2023 van fleet which is supposed to evolve with the same ratio as road freight transport demand [bn tkm]. The road freight transport demand data is available for FPS scenarios and EPOC scenarios, while it is maintained constant in other scenarios.
N_{buses}	Number of buses	#	The number of busses is estimated based on 2023 bus fleet which is supposed to evolve with the same ratio as passenger bus transport demand [bn tkm]. The passenger bus transport demand data is available for all scenarios studying the transport sector, except for the Clever (2023) scenario. For this scenario, it is kept constant at 2023 level until 2050.
N_{trains}	Number of trains	#	The number of trains is estimated based on 2024 train fleet which is assumed to evolve with the same ratio as passenger-kilometre and tonne-kilometre train demand. This train transport demand is available for all scenarios others.
N_{boats}	Number of inland waterway boats	#	The number of boats is based on 2023 inland waterway boats which is assumed to evolve with the same ratio as tonne-kilometre boat demand. This demand is available for all the scenarios.
D_{cars}	Average yearly traveled distance by a car	km /year	The average traveled distance for a car each year is kept constant at 2023 level until 2050 for all scenarios.
$T_{v,t}$	Transport demand by vehicle v at time t	bn pkm or bn tkm	Transport demand by car, bus, truck, train, inland boat and walking is available for all the scenarios.
T_{bike}	Transport demand by bike	bn pkm	Transport demand by bike is available for FSP and Clever scenarios. For Energyville scenarios and EPOC, it is kept constant at 2022 level until 2050.

In addition to those indicators, other assumptions have been made to estimate the investment needs (see Table below).

Data	Data name	Unit	Data sources & comment
S_{ZE}	Share of zero-emission vehicles in new vehicle sales	%	Share of zero-emission vehicles (mainly electric) in new sales is considered - To reach 100% in 2030 for cars and buses - To reach 100% in 2040 for vans - To reach 100% in 2050 for trucks
$R_{CS-vehicle}$	Ratio of charging station per electric vehicle	%	The ratio of charging station per electric vehicle is considered to be [acea, 2022], [I4CE, 2022]: - 0,21 for car public stations - 0,66 for car private charging points - 0,21 for truck public stations - 0,66 for truck private charging points
S_{FC}	Share of fast-charger in charging stations	%	We consider that 10% of charging stations are fast chargers.
$S_{ICE.boats}$, $S_{H2.boats}$, $S_{methanol.boats}$, $S_{electric.boats}$	Share of conventional, hydrogen and bio-methanol boats in total stock	%	We consider that today 100% of boats are equipped with internal combustion engine. This will evolve only in a neutrality scenario as such (Raftis et al. 2023) by 2050: - 16% of ICE boats - 38% of electric boats - 25% of hydrogen boats - 21% of bio-methanol boats

In addition to those indicators, unitary costs assumptions have been made to estimate the road and inland waterways investment needs (see appendix on costs), based on a publication of TU Delft for the European Commission Schoten et al. (2019). Unitary CAPEX costs were calibrated to historical transport demand in order to obtain the same investment as in Schoten et al. (2019).

Reference year & reference scenario

The Table hereunder shows the values of the indicators for the reference year 2024 and for the reference scenario in 2050.

Data	Data name	Unit	2024	2024 – Data source	2050 – Ref scenario	2050 – Data source
N_{cars}	Number of cars	#	5 947 479	[Statbel, 2023]	7 933 796	Based on [FPS, 2021] – WEM Scenario assumptions
N_{trucks}	Number of trucks	#	122 976	[Statbel, 2023]	148 627	Based on [FPS, 2021] – WEM Scenario assumptions
N_{vans}	Number of vans	#	621 164	[Statbel, 2023]	72 202	Based on [FPS, 2021] – WEM Scenario assumptions
N_{buses}	Number of buses	#	17 538	[Statbel, 2023]	21 549	Based on [FPS, 2021] – WEM Scenario assumptions
$N_{passenger.trains}$	Number of passenger trains	#	3 838	[EU Statistical pocket book, 2023]	5 418	Based on passenger train transport demand [FPS, 2021]
$N_{freight.trains}$	Number of freight trains	#	5 225	[EU Statistical pocket book, 2023]	7 805	Based on passenger train transport demand [FPS, 2021]
$N_{locomotives}$	Number of locomotives	#	1 188	[EU Statistical pocket book, 2023]	1 730	Based on passenger train transport demand [FPS, 2021]
N_{boats}	Number of inland waterways boat	#	1 089	[EU Statistical pocket book, 2023]	1 561	Based on passenger train transport demand [FPS, 2021]
D_{cars}	Average yearly traveled	km /year	12 830	[FPS, 2021]	12 830	Based on [FPS, 2021] – WEM

Data	Data name	Unit	2024	2024 – Data source	2050 – Ref scenario	2050 – Data source
	distance by a car					Scenario assumptions
S_{train}	Train modal share in passenger transport	%	7%	[FPS, 2021]	7%	Based on [FPS, 2021] – WEM Scenario assumptions
T_{bike}	Transport demand by bike	bn pkm	3.67	[FPS, 2021]	5.13	Based on [FPS, 2021] – WEM Scenario assumptions
S_{ZE}	Share of zero-emission vehicles in new vehicle sales	%	8.5	[FPS, 2021]	20	Based on [FPS, 2021] – WEM Scenario assumptions
$Lenght_m$	Rail network length	Km	6,602	PFS Mobility (2024)	Assumed constant	-
	Road network length	Km	118,000	Infrabel;	Assumed constant	-
	IWW network length	km	1,532	"Données mondiales" database, assumed constant in all scenarios	Assumed constant	-
$C_{e,t}$	Fossil fuel consumption	TWh	89.8	Eurostat Energy Balance, 2023	79.5	Based on [FPS, 2021] – WEM Scenario assumptions
	Electricity consumption	TWh	2.1	Eurostat Energy Balance, 2023	6.6	Based on [FPS, 2021] – WEM Scenario assumptions
	Sustainable fuels and e-fuels consumption	TWh	9.4	Eurostat Energy Balance, 2023	8.2	Based on [FPS, 2021] – WEM Scenario assumptions

Appendix 7: Computation logic and scope – Energy Sector

Scope

The energy sector mainly covers electricity production, electricity networks, hydrogen, CO_2 and heat district. In most of our analyses, we group electricity production and electricity grid under the label power supply, as these two subsectors are "energy supply" sectors, while we group hydrogen, CO_2 and heat districts together under the label "new energy networks" as they are "energy demand" sectors. More details about the scope of this analysis for CAPEX and their related OPEX for the energy sector is given in the Tables hereunder.

Included in CAPEX estimations	Not included in CAPEX estimations
Electricity production investment estimations include: - Electricity production capacity per vector	**Electricity production** investment estimations do not include: - CCS installations on fossil fuel electricity production plants. Although some of it may be needed in the transition process (2025-2050 period), the selected scenarios do not foresee any fossil fuel electricity production from 2050 onwards (except from Clever that does not foresee CCS anyway).
Electricity grid investment estimations include: - Transmission grid reinforcement - Distribution grid reinforcement - Flexibility assets of batteries, hydro-pumped storage and domestic Demand Side Management	**Electricity grid** investment estimations do not include: - Deployment of demand management solutions in industries (assumed part of investment needs in the industry sector)
Hydrogen investment estimations include: - Hydrogen production through electrolyzers - Hydrogen distribution network - Hydrogen import/export terminal in port of Antwerp	**Hydrogen** investment estimations do not include: - H2 storage (limited possibilities in Belgium) - H2 conversion to e-fuels and reverses
CO_2 investment estimations include: - CO_2 network - DACS installations - Carbon export value chain including shipping away and disposal (based on export capacity from Antwerp and Ghent carbon hubs)	**CO_2** investment estimations do not include: - BECCS installations - CCS installations (assumed part of investment needs in the industry sector) - CO_2 storage (limited possibilities in Belgium)
Heat district investment estimations include: - Heat district distribution grid (network and heat exchangers)	**Heat district** investment estimations do not include: - Heat production units (included in buildings sector modelization or assumed part of industry sector investment needs)
Other	Those items are not included in estimations: - Biomass conversion units - Transition of refineries (assumed part of investment needs in the industry sector) - Production of e-fuels/synfuels (assumed part of investment needs in the industry sector)

Included in OPEX estimations	Not included in OPEX estimations
Electricity production operational expenses estimations include: - O&M for production capacity assets per energy vector, i.e. an O&M hypothesis for each electricity production technology - Energy costs for electricity production (oil, natural gas, uranium, bio-fuels) - Electricity import costs - ETS 1 costs	
Electricity grid operational expenses estimations include: - O&M transmission grid - O&M distribution grid - O&M flexibility assets	
Hydrogen operational expenses estimations include: - O&M electrolyzers - Electricity consumption electrolyzers - O&M hydrogen distribution network - O&M hydrogen import/export terminal	
CO_2 operational expenses estimations include: - O&M CO_2 network - O&M DACS installations - Electricity consumption DACS installations - O&M carbon export value chain (proxy for all fixed and variable OPEX)	
	No **heat district** operational expenses estimations were included. However, heat production costs are included in buildings sector modelization (for residential volumes) or assumed part of industry sector (for commercial volumes).

Calculation logic

The Tables hereunder give more details about the calculation logic that has been applied in this analysis for each investment need item identified in the scope section.

Item	CAPEX Calculation logic
Electricity production capacity	- Investment needs for electricity production capacity is estimated based on the installed production capacity of each technology (solar, onshore wind, offshore wind, nuclear, geothermal, fossil, nuclear, hydrogen, biomass), the renewal rate, and the CAPEX: $I_{prod\_elec} = C_{pe\_new}CAPEX_{/kW\_pe} + C_{ex}R_{ex}CAPEX_{/kW\_pe}$ Renewal rate is computed as: $R_{ex} = \frac{1}{Lifetime}$ Where lifetime hypotheses are part of the technology assumptions.
Transmission grid reinforcement	- Investment needs for transmission grid reinforcement is estimated based a proxy for the unitary capex per unit of additional electricity demand compared to the previous year: $I_{tran\_grid\_elec} = D_{elec\_add}CAPEX_{/kWh\_add}$ The proxy for unitary CAPEX has been modelled by Blunomy consultants, based on various datapoints of capacities, volumes, and other stemming from a broad set of sources of different European geographies.
Distribution grid reinforcement	- Investment needs for distribution grid reinforcement is estimated based on a proxy for the unitary capex depending on the peak load estimated for the total annual electricity demand: - $I_{dist\_grid\_elec} = PL_{ratio}D_{elec}CAPEX_{/kWh\_add}$ The unitary CAPEX is a computation based on Blunomy consultants expertise and Elia peak load data. Input data in the computation include demand volumes, capacities, peak load values and other data points from various sources and different European geographies.
Flexibility assets electricity grid	- Investment needs for flexibility is estimated based on: a) the installed capacity of battery derived from a penetration rate dependent on renewables capacities, b) additional pumped hydro storage as the difference between the capacities of subsequent years (which is limited), and c) the number of households participating in demand side management. And of course, the CAPEX for each type of flexibility. These figures are hypotheses taken by the author and do not come straight from scenarios: $I_{flex\_elec} = PR_{battery}C_{res\_new}CAPEX_{/kW\_bat} + C_{PHS}CAPEX_{/kW\_PHS} + HH_{total}DSM_{device\ share/HH}CAPEX_{/device}$
H2 production	- Investment needs for hydrogen production capacity is estimated based on the installed production capacity and the unitary CAPEX: $I_{prod\_h2} = C_{h2\_new}CAPEX_{/kW\_h2}$ The installed production capacity is estimated based on the H2 production levels, and hypothesis of load factor and conversion efficiency of the process: $C_{h2\_new} = \frac{Prod_{h2}}{LF_{h2}.Ef_{h2}.365.24}$

	The load factor is supposed to be 55% and the process efficiency is supposed to evolve from 65% today to 78% in 2050.
H2 distribution network	- Investment needs for hydrogen distribution network development is based on the length of the foreseen network (supposed to be 1 100 km by 2050 based on the network described in the federal hydrogen strategy [FPS, 2021]), the share of new lines and of gas network repurposed lines, and the compressor costs: $I_{grid\_h2} = L_{grid_{h2}}(Sh_{new_{h2_{lines}}} CAPEX_{new_{h2_{lines}}} + Sh_{repurposed_{h2_{lines}}} CAPEX_{repurposed_{h2_{lines}}} + CAPEX_{compression/km})$ The same estimate is used for all the neutrality scenarios.
H2 import/export terminal	- Investment needs for hydrogen import/export terminal is considered constant for all neutrality scenarios based on the estimates for one terminal in Antwerp. $I_{h2\_term} = 1 * CAPEX_{h2\_term}$
CO_2 distribution grid	- Investment needs for hydrogen distribution grid development is estimated with the same logic as the H2 grid, based on the length of the foreseen network (supposed to be 1 100 km by 2050 based on the network described in the federal hydrogen strategy [FPS, 2021]), all lines are considered to be new, and the unit CAPEX, which also depends on the volumes transported in total (all capture with DACS, BECS and CCS in industry): $I_{grid\_CO2} = L_{grid_{CO2}} V_{total\_capture} CAPEX_{new\_CO2\_lines}$
DACS installations	- Investment needs for DACS is estimated based on the volumes of CO_2 captured by DACS and a unit levelized CAPEX over the lifetime of the asset: $I_{DACS} = V_{DACS\_capture} * CAPEX_{DACS/tCO2}$
CO_2 export value chain	- Investment needs for the CO_2 export value chain is estimated based on the volumes of CO2 captured exported and the levelized unit CAPEX: $I_{CO2\_exp} = V_{total\_capture_{CO2}} * CAPEX_{/tCO2}$ The export value chain comprises liquefaction and buffer storage installations and shipping costs to offshore storage sites around 750km away for a capacity of up to 20 Mtpa of CO2 (Data is taken from [ZERO EMISSIONS PLATFORM, 2020]. Note that this source takes into account a cost of capital (annualized with 8% interest rate over 40 years lifetime. Hence, this is the only data point in the model with a cost of capital). The storage in itself is not included.
Heat district distribution grid	- Investment needs for heat district distribution grids is estimated based on the length of heat district networks and a CAPEX: $I_{grid\_heat} = L_{grid\_heat} CAPEX_{grid\_heat}$ The length of heat district networks is estimated based on the heat demand in heat district, and an average density of heat network: $L_{grid\_heat} = \frac{E_{heat}}{d_{th}}$ The average density of heat network is supposed to be 2 MWh/m (minimum level for rentability is supposed to be 1,5 [ADEME, 2021], [AMORCE, 2020]).

Where:

- D_{elec}, D_{elec_add} are the total and additional electricity demand in TWh compared to the reference year;
- $CAPEX_{/kW\_pe}$, $CAPEX_{/kW\_bat}$, $CAPEX_{/kW\_PHS}$, $CAPEX_{/device}$, $CAPEX_{/kWh\_add}$, $CAPEX_{/kWh}$, $CAPEX_{/kW\_h2}$, $CAPEX_{new\_h2\_lines}$, $CAPEX_{repurposed\_h2\_lines}$, $CAPEX_{compression/km}$, $CAPEX_{h2\_terminal}$, $CAPEX_{new\_CO2\_lines}$, $CAPEX_{DACS/tCO2}$, $CAPEX_{/tCO2}$ and $CAPEX_{grid\_heat}$ are the unit CAPEX for electricity production units, batteries, pumped-hydro storage, domestic DMS devices, electricity network, hydrogen production units, new hydrogen distribution pipes, repurposed hydrogen distribution pipes, hydrogen compressors, hydrogen import/export terminal, new CO_2 distribution pipes, DACS installations, CO_2 export value chain assets, new heat district pipes.
- C_{pe_new}, C_{ex}, C_{res_new}, C_{PHS}, C_{h2_new} are the new capacity for electricity production, the existing capacity for electricity production, the new capacity for renewables, for pumped-hydro storage and for hydrogen production;
- $DSM_{device\ share/HH}$ is the penetration rate of DSM devices amongst households;
- E_{heat} is the heat demand in district heating, in TWh;
- Ef_{h2} is the efficiency of hydrogen production units expressed in %;
- HH_{total} is the number of households in the country;
- I_{prod_elec} , $I_{tran\_grid\_elec}$, $I_{dist\_grid\_elec}$, I_{flex_elec} , I_{prod_h2} , I_{grid_h2}, I_{h2_term} , I_{grid_CO2} , I_{DACS}, I_{CO2_exp}, I_{grid_heat} are the investment needs for electricity production, electricity flexibility, electricity transmission and distribution grid, hydrogen production, hydrogen grid and terminal, CO_2 grid, DACS installations, CO_2 export value chain assets and heat district grid;
- LF_{h2} is the load factor of hydrogen production units expressed in %;
- $L_{grid_{h2}}$, $L_{grid_{CO2}}$ and L_{grid_heat} are the total length, in km, of the hydrogen grid, CO_2 grid and heat district grids;
- PL_{ratio} is the peak load estimate for a given annual electricity demand, common for all scenarios;
- $PR_{battery}$ is the penetration rate of batteries defined as the ratio of new GW of battery installed per new GW of renewables, same hypothesis for all scenarios;
- $Prod_{h2}$ is the hydrogen production level in Belgium, expressed in energy (TWh);
- R_{ex} is the renewal rate of existing electricity production capacity;
- $Sh_{new\_h2\_lines}$, $Sh_{repurposed\_h2\_lines}$ are the share of new and repurposed lines in the hydrogen network;
- $V_{total\_capture}$, $V_{DACS\_capture}$ is the total captured CO_2 in Belgium (DACS, BECS and CCS) and the capture per DACS only;
- d_{th} is the average density factor of heat district, expressed in MWh/m;

Item	OPEX Calculation logic
O&M for production capacity assets per vector	- OPEX for O&M of electricity production capacities is estimated based on the installed production capacity of each technology (solar, onshore wind, offshore wind, nuclear, geothermal, fossil, nuclear, hydrogen, biomass), and a unitary yearly OPEX (either constant or evolving up to 2050 according to the asset): $O_{prod\_elec} = C_{pe\_total} OPEX_{/kW\_pe}$
Energy costs for electricity production	- OPEX related to energy consumption for electricity production (oil, natural gas, uranium, bio-fuels) is estimated based on the electricity supply volumes per type of vector, an efficiency rate for the asset and energy price projections for each energy vector: $F_{prod\_elec} = (S_{elec/vector} / Ef_{vector}) * P_{vector\_MWh}$ Net electricity import volumes are also included, to which wholesale electricity prices are applied. Electricity supply volumes are gross volumes, comprising technical losses. - OPEX related to carbon costs for the electricity production are computed based on electricity production volumes for the fossil fuel based production, their relative carbon content (0,202tCO_2eq./MWh for a classical natural gas power plant) and ETS1 carbon price projections. $F_{ETS1} = S_{elec\_fossil} 0{,}202tCO2eq._{elec} P_{tCO2}$
O&M for electricity grids and flexibility assets	- OPEX for O&M of electricity grids (transmission and distribution) is estimated based on the total electricity demand per year and a constant OPEX value per MWh for the transmission and distribution grid: $O_{grid\_elec} = D_{elec} OPEX_{/MWh_{tran}} + D_{elec} OPEX_{/MWh_{dist}}$ - OPEX for O&M of flexibility assets is taken as a fixed % of the CAPEX invested up until the year of interest. The value is taken at 2,5% from [DTU, 2024]: $O_{flex\_elec} = SUM\ (I_{flex_{elec}} untill\ year\ of\ interest) * 2{,}5\%$
O&M for hydrogen network assets	- OPEX for O&M of electrolyzers (excluding electricity consumption) is estimated based on the total volumes of domestically produced hydrogen and a constant OPEX value per produced kg of H2: $O_{prod\_h2} = Prod_{h2} OPEX_{kg_{h2\_prod}}$ - OPEX for O&M of H2 distribution network is estimated based on a % of the sum of CAPEX involved up to the year of interest for each of the components (pipes and compressors): $O_{grid\_h2} = SUM\ (I_{grid\_h2} untill\ year\ of\ interest) * OPEXfactor\ in\ \%$ OPEX factor for the pipes is 1,1% annually and for the compressor 4% taken from consultant Blunomy consultants expertise. - OPEX for O&M of H2 import/export terminal is estimated based on the total volumes of imported hydrogen and a constant OPEX value per kg of H2: $O_{h2\_term} = IM_{h2} OPEX_{/kg_{h2\_term}}$

Electricity consumption costs for hydrogen production	- OPEX related to electricity consumption for hydrogen production in electrolyzers is estimated based on the domestic H2 production volumes, the electricity consumption per kg hydrogen produced (50 kWh/kg taken as a constant) and the projection of wholesale electricity prices: $F_{prod\_h2} = Prod_{h2} Cons_{electrolyzer} P_{fuel\_MWh}$
O&M for CO_2 network assets	- OPEX for O&M of CO_2 network is estimated based on the total volumes of CO_2 transported (carbon captured in per DACS, BECS and CCS in industry), on the length of the pipes and with an OPEX value per ton of CO_2 and per km: $O_{grid\_CO2} = L_{grid_{CO2}} V_{total\_capture_{CO2}} OPEX_{grid\_CO2}$ - OPEX for O&M of DACS installations (excluding electricity consumption) is based on the volumes captured and a constant OPEX value per volume: $O_{DACS} = V_{DACS_{capture_{CO2}}} OPEX_{DACS_{/tCO2}}$ - OPEX for the CO_2 export value chain is estimated based on the total volumes of CO_2 transported (carbon captured in per DACS, BECS and CCS in industry) and with an OPEX value per ton of CO_2: $O_{CO2\_exp} = V_{total\_capture} OPEX_{CO2\_exp}$
Electricity consumption costs for DACS operations	- OPEX related to electricity consumption for DACS is estimated based on the domestic DACS captured volumes of CO_2, the electricity consumption per ton of CO_2 captured (1,04 MWh/t taken as a constant) and the projection of wholesale electricity prices: $F_{DACS} = V_{DACS\_capture} Cons_{DACS} P_{fuel/MWh}$

Where:

- P_{vector_MWh}, P_{tCO2}, are prices for each energy vector per MWh of energy and prices per ton of CO_2 in the ETS1 scheme;
- $S_{elec/vector}$, S_{elec_fossil} are the total annual electricity supply per vector and the electricity supply for fossil fuel based electricity specifically;
- $Cons_{electrolyzer}$, $Cons_{DACS}$ is the electricity consumption of an electrolyzer or a DACS installation expressed in kWh per ton of hydrogen produced or of CO_2 captured;
- Ef_{vector} is the efficiency rate for electricity production vectors in %;
- F_{prod_elec}, F_{ETS1}, F_{prod_h2}, F_{DACS} are the energy costs (energy vector purchase) for electricity production, ETS 1 carbon allowances, hydrogen production with electrolyzers and CO_2 capture with DACS;
- IM_{h2} is the hydrogen imported volumes in Belgium, expressed in energy (TWh);
- $OPEX_{/kW\_pe}$, $OPEX_{/MWh_{tran}}$, $OPEX_{MWh_{dist}}$, $OPEX_{kg_{h2\_prod}}$, $OPEX_{kg_{h2\_term}}$, $OPEX_{grid\_CO2}$, $OPEX_{DACS/tCO2}$, $OPEX_{CO2\_exp}$, are the unitary OPEX for electricity production, for electricity transportation and distribution grids, for electrolyzers' H2 production, for H2 import terminals, for carbon grids, DACS installations and a CO2 export value chain.
- O_{prod_elec}, O_{grid_elec}, O_{flex_elec}, O_{prod_h2}, O_{grid_h2}, O_{h2_term}, O_{grid_CO2}, O_{DACS}, O_{CO2_exp} are the yearly OPEX for electricity production, electricity flexibility, electricity transmission and distribution grid, hydrogen production, hydrogen grid and terminal, CO_2 grid, DACS installations and CO_2 export value chain assets;

Data and hypothesis

For this sector, a set of indicators are derived from the net-zero scenarios (see Table below).

Data	Data name	Unit	Data sources & hypothesis
C_{pe_new}	New capacity for electricity production	MWe	The total installed capacity for fossil, nuclear, onshore and offshore wind, PV, hydro, geothermal are available in all scenarios. In FPS 2021 and in Clever scenarios, the need for flexible capacity (biomass or hydrogen for example) is not estimated. Flexible capacity has therefore been added, based on the other scenarios estimates, proportionally to the total capacity of PV and wind turbines.
C_{res_new}	New explicitly renewable energy sources capacity (PV, offshore and onshore wind)	MWe	
C_{ex}	Existing capacity for electricity production	MWe	
$S_{elec/vector,}$	Annual electricity supply per vector	TWh	The electricity supply volumes are available in all scenarios. As part of these datapoints, even though it is not a “vector” as such, net electricity import volumes are also available per scenario.
S_{elec_fossil}	Annual electricity supply for fossil fuel based electricity specifically	TWh	
D_{elec}	Total electricity demand	TWh	Total electricity demand is available in all scenarios and additional demand is the difference with the reference year.
D_{elec_add}	Additional electricity demand compared to a reference year	TWh	
HH_{total}	Number of households in the country	#	Total number of households in the country, hypothesis common for all reference and neutrality scenarios.
C_{PHS}	Capacity for pumped-hydro storage	MWe	For PHS, only EnergyVille, Elia, EPOC and TYNDP scenarios include flexibility capacity data. Additional capacity for PHS is computed as the difference between two years. For batteries, a uniform method for all scenarios is applied. Battery capacity is based on the additional RES capacities and a penetration rate. DSM at the household level (excluding industrial DSM) is estimated with a penetration rate (share amongst households) common for all neutrality scenarios. This rate increases gradually to 20% of households with a DSM device in 2030 and then to 100% in 2050.
$DSM_{device\ share/HH}$	Penetration rate of DSM devices amongst households	%	
$Prod_{h2}$	Hydrogen production level in Belgium	TWh	Hydrogen volumes are available in most transition scenarios. We have used data for all of them except for TYNDP, McKinsey and Elia scenarios for which no electrolyzer capacities could be modelled.
IM_{h2}	Hydrogen imported volumes	TWh	
E_{heat}	Heat demand in district heating	TWh	Heat demand volumes are available in all transition scenarios except for TYNDP, McKinsey, BFP and Elia scenarios.

$V_{total\_capture}$	Total captured CO_2 in Belgium (DACS, BECS, CCS)	tCO_2	CO_2 captured volumes are available in all transition scenarios except for Clever, TYNDP, McKinsey and Elia scenarios. Scenarios usually have a breakdown between industrial (CCS) capture and other capture (DACS and BECS). The share between DACS and BECS has been deemed equal 50-50.
$V_{DACS\_capture}$	DACS captured CO_2 in Belgium	tCO_2	
$L_{grid_{h2}}$	Length of the H2 grid	km	Hypothesis of a 1 100 km network by 2050 based on [FPS, 2021]
$Sh_{new\_h2\_lines}$	Share of new lines in the hydrogen network	%	Hypothesis of 62% of new lines based on [ehb, 2023] and [FPS, 2022]
$Sh_{repurposed\_h2\_lines}$	Share repurposed lines in the hydrogen network	%	Hypothesis of 38% of repurposed lines based on [EHB, 2023] and [FPS, 2022]
$L_{grid_{CO2}}$	Length of the CO_2 grid	km	Hypothesis of a 1 100 km network by 2050 based on [FPS, 2021]

In addition to those indicators, the other assumptions that have been made for technical technology features and the CAPEX, OPEX and energy prices data are to be found in the dedicated sections of the appendix.

Reference year & reference scenario

The Table hereunder shows the values of the indicators for the reference year 2024 and for the reference scenario in 2050.

Data	Data name	Unit	2024	2024 – Data source	2050 – Ref scenario	2050 – Data source
$C_{ex-fossil}$	Existing electricity production capacity - fossil	MWe	6836	[FPS, 2024] – BeCalc – WEM Scenario	5854	[FPS, 2024] – BeCalc – WEM Scenario
$C_{ex-nuclear}$	Nuclear	MWe	3929	[FPS, 2024] – BeCalc – WEM Scenario	0	[FPS, 2024] – BeCalc – WEM Scenario
$C_{ex-biomass}$	Biomass	MWe	706	[FPS, 2024] – BeCalc – WEM Scenario	0	[FPS, 2024] – BeCalc – WEM Scenario
$C_{ex-wind\_onshore}$	Onshore wind	MWe	3208	[FPS, 2024] – BeCalc – WEM Scenario	7005	[FPS, 2024] – BeCalc – WEM Scenario
$C_{ex-wind\_offshore}$	Offshore wind	MWe	2262	[FPS, 2024] – BeCalc – WEM Scenario	5462	[FPS, 2024] – BeCalc – WEM Scenario
C_{ex-PV}	Photovoltaic	MWe	7977	[FPS, 2024] – BeCalc – WEM Scenario	20814	[FPS, 2024] – BeCalc – WEM Scenario
C_{ex-h2}	Hydrogen	MWe	0	[FPS, 2024] – BeCalc – WEM Scenario	0	[FPS, 2024] – BeCalc – WEM Scenario
$C_{ex-Hydro}$	Hydroelectric	MWe	110	[FPS, 2024] – BeCalc – WEM Scenario	110	[FPS, 2024] – BeCalc – WEM Scenario
$C_{ex-waste}$	Waste	MWe	375	[FPS, 2024] – BeCalc – WEM Scenario	0	[FPS, 2024] – BeCalc – WEM Scenario
$C_{ex-geothermal}$	Geothermal	MWe	0	[FPS, 2024] – BeCalc – WEM Scenario	0	[FPS, 2024] – BeCalc – WEM Scenario
D_{elec}	Electricity demand	TWh	77	SPF Economie, DG Energie	117	[FPS, 2024] – BeCalc – WEM Scenario
$S_{elec/fossil}$	Existing electricity supply - fossil	TWh	19	SPF Economie, DG Energie	43	[FPS, 2024] – BeCalc – WEM Scenario
$S_{elec/nuclear}$	Nuclear	TWh	33	SPF Economie, DG Energie	0	[FPS, 2024] – BeCalc – WEM Scenario
$S_{elec/biomass}$	Biomass	TWh	2	SPF Economie, DG Energie	14	[FPS, 2024] – BeCalc – WEM Scenario

Data	Data name	Unit	2024	2024 – Data source	2050 – Ref scenario	2050 – Data source
$S_{elec/wind\_onshore}$	Onshore wind	TWh	7	SPF Economie, DG Energie	16	[FPS, 2024] – BeCalc – WEM Scenario
$S_{elec/wind\_offshore}$	Offshore wind	TWh	8	SPF Economie, DG Energie	20	[FPS, 2024] – BeCalc – WEM Scenario
$S_{elec/PV}$	Photovoltaic	TWh	7	SPF Economie, DG Energie	22	[FPS, 2024] – BeCalc – WEM Scenario
$S_{elec/h2}$	Hydrogen	TWh	0	SPF Economie, DG Energie	0	[FPS, 2024] – BeCalc – WEM Scenario
$S_{elec/hydro}$	Hydroelectric	TWh	0.3	SPF Economie, DG Energie	0.3	[FPS, 2024] – BeCalc – WEM Scenario
$S_{elec/waste}$	Waste	TWh	2	SPF Economie, DG Energie	0	[FPS, 2024] – BeCalc – WEM Scenario
$S_{elec/geothermal}$	Geothermal	TWh	0	SPF Economie, DG Energie	0	[FPS, 2024] – BeCalc – WEM Scenario
S_{elec/net_import}	Net imports	TWh	2	SPF Economie, DG Energie	0	[FPS, 2024] – BeCalc – WEM Scenario
HH_{total}	Number of households	million	5,16	Federal Planning Bureau, 2024	5,73	Federal Planning Bureau, 2024
C_{PHS}	Capacity of pumped-hydro storage	MWe	1200	Assumed constant from historic value	1200	Assumed constant from historic value
$DSM_{device\ share/HH}$	Share of households with participating in DSM	%	0	Own hypothesis	0	Own hypothesis
$Prod_{h2}$	Hydrogen production	TWh	0	[FPS, 2024] – BeCalc – WEM Scenario	0	[FPS, 2024] – BeCalc – WEM Scenario
E_{heat}	Heat district energy demand	TWh	1,22	SPF Economie, DG Energie	1,19	[FPS, 2024] – BeCalc – WEM Scenario
$V_{total\_capture}$	Total captured CO_2 in Belgium (DACS, BECS, CCS)	tCO_2	0	[FPS, 2024] – BeCalc – WEM Scenario	0	[FPS, 2024] – BeCalc – WEM Scenario
$V_{DACS\_capture}$	DACS captured CO_2 in Belgium	tCO_2	0	[FPS, 2024] – BeCalc – WEM Scenario	0	[FPS, 2024] – BeCalc – WEM Scenario