BELGIAN ROADMAP FOR HEALTH CARE DECARBONISATION

Technical annex

HEALTH & ENVIRONMENT

Health Care Without Harm

ARUP

THIS REPORT WAS MADE POSSIBLE BY:

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This work is the result of a collaboration between Health Care Without Harm (HCWH) Europe, ARUP and the health and environment administrations of the National Environment and Health Action Plan:

- FOD Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu
- Departement Zorg
- Departement Omgeving
- Leefmilieu Brussel
- Vivalis
- Agence Wallonne pour une vie de qualité (AViQ)
- Service public de Wallonie
- Ministerium der deutschsprachige Gemeinschaft

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A.1 Technical Annex

A.1.1 Introduction

To support targeted action on greenhouse gas emissions (GHGs), Belgium has sought to develop a decarbonisation roadmap reflecting the health care sector's current emissions, the reduction trajectory 'zone' to be pursued, and the application of future emissions scenarios. The roadmap will present the evidence base produced through this analysis and summarise the policies which have been identified as having the most decarbonisation potential for the national health system.

The roadmap has been prepared in accordance with the approach and best practices described in the "Designing a Net Zero Roadmap for Health care: Technical Methodology and Guidance" document published by Health Care Without Harm[1].

The development of the roadmap enables key stakeholders within Belgium's health care landscape to understand the current position and potential solution areas to be explored through an implementation programme, as well as help key stakeholders to best act on the recommendations and opportunities highlighted in the roadmap. This technical annex, providing detailed information on the modelling approach, data inputs, assumptions, limitations, and recommendations for future data collection derived from this process, should accompany the roadmap report.

This report is divided into five key sections, providing a comprehensive technical overview of the methodology used to develop a baseline, model trajectories, apply interventions, and highlight assumptions and limitations.

- Section A.1.2 provides a detailed overview of the approach used to model the emissions baseline.
- Section A.1.3 includes an overview of the approach and data sources used that go beyond the summary in the main report.
- Section A.1.4 discusses a high-level overview of the approach and data sources for how interventions were chosen and modelled.
- Section A.1.5 details the assumptions and limitations across the study, categorised by the emissions baseline, trajectory, and interventions modelled.
- Section A.1.6 highlights further results in tabular and graphical format.

A.1.2 Developing a baseline

High level overview of approach

Health Care Without Harm's "Designing a net zero roadmap for health care: Technical methodology and guidance"[1] was used in the development of Belgium's emissions baseline. This methodology represents sector best practice and enables better comparability of results with other global health sector actors that have deployed similar methodologies.

Belgium's health sector emissions baseline was derived using a "hybrid" approach, leveraging and combining both top-down expenditure datasets covering the national health system and bottom-up data reflecting more granular activity within the health sector. A hybrid approach combines elements of top-down and bottom-up methods to build on the respective advantages, enabling the development of an emissions baseline that is comprehensive and "zero-leakage" (i.e. captures data within the entire system boundary), while also utilising more granular, precise bottom-up data where available.

The methods selected were based on anticipated data availability and approach recommendations outlined in the HCWH Methodology. The model developed to execute this approach and used to process, calculate and consolidate the emissions footprint was built in MS Excel.

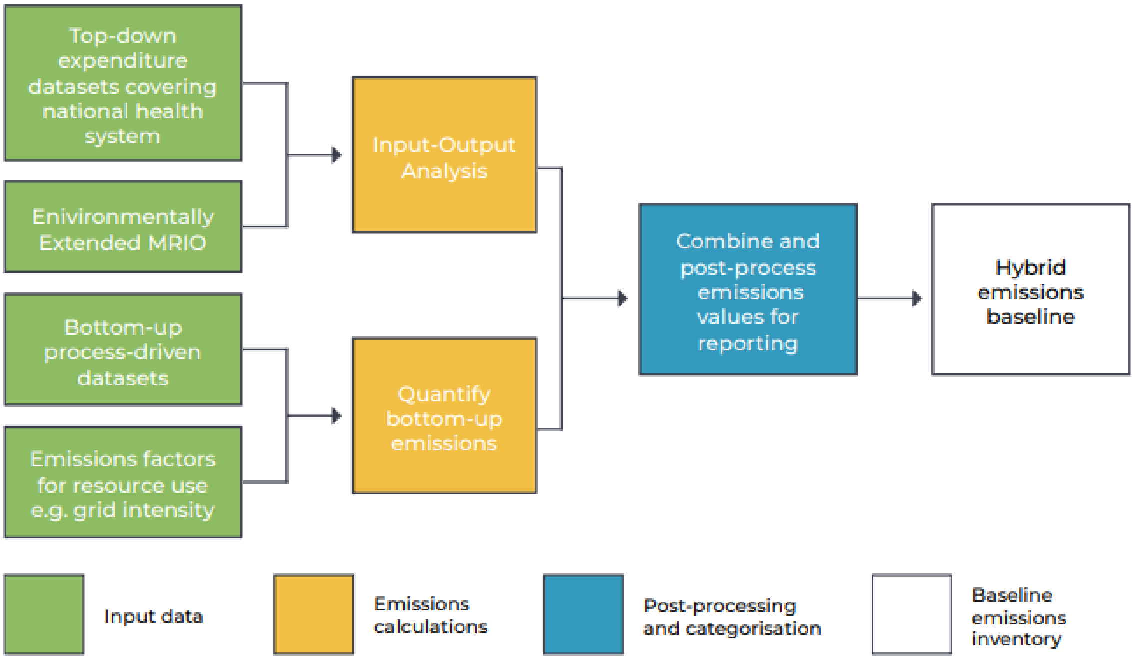

Figure 1. Hybrid approach utilised to develop the emissions baseline[1]

A top-down approach provides broad emissions estimates for large economic areas where detailed data is lacking, relying on more readily available expenditure data. However, this method is typically less precise than bottom-up approaches, as national expenditure data lacks the granularity to capture specific activities that expenditure is allocated towards. Environmentally-Extended Input-Output (EEIO) analysis was employed to produce a sector-wide footprint for Belgium's health care sector. The approach is built upon the use of global Input-Output (IO) models and data to provide insights on emissions associated with products, industries, and their value chains, with information on the financial activities within the sector providing a description of the nature of sectoral operations and procurement practices.

A bottom-up approach combines resource consumption or activity data with corresponding emissions factors, yielding more accurate results. However, sourcing this data can be highly onerous, especially for large scopes, and risks underestimating emissions if all activities aren't fully captured ("leakage"). A hybrid approach, combining top-down and bottom-up data, is recommended by the HCWH Methodology for greater precision where detailed data is available.

Data sources

Data requests (consolidated into Requests for Information (RFIs)) were developed by the Arup team and disseminated to stakeholders across the country by the Belgium team. The RFIs captured the types of information surrounding emissions activities sought. Data reflecting aggregate expenditure data and aggregate energy consumption data for each health care provider at the national- and regional-levels were communicated to be of highest priority. Additional regional data was used if it met quality standards and could be extrapolated to other regions. Data from Belgium stakeholders was assumed accurate unless specified otherwise. Some follow-ups between the Arup team and data holders help clarify limitations of certain data sets and confirm assumptions. Not all data received was suitable for inclusion in this assessment.

Expenditure data for Belgium's health care providers were taken from OECD Data Explorer – Health expenditure and financing[2]. At the time of writing, only an estimated total expenditure for 2022 was available. The 2021 percentage breakdown of health care providers was used with the 2022 estimated total to disaggregate expenditure data across health care providers typologies.

Table 1. Main data sources and use in developing Belgium's health sector emissions baseline

Dataset	Source	Use
Expenditure data & other sources leveraged in derivation of expenditure profiles	OECD national expenditure for health care providers[3]	Annual total expenditure, of which proportionate activity expenditure for each health care provider, has been applied to.
	Hospitals Expenditure Profile (collected data)	Expenditure profile for 'Hospitals'
	Residential Facilities Expenditure Profile – from singular senior living and care centre (collected data)	Expenditure profile for 'Residential Facilities'
	Belgium Federal Planning Bureau annual input-output table[4]	Alternative approach where data for health care providers were not identified during the data collection process.
Bottom-up data provided	Flanders' electricity and natural gas consumption[5] (collected data)	Electricity and natural gas consumption across health facilities (except Medical Goods Providers) for Flanders.
	Brussels' electricity and "combustibles" consumption[6] (collected data)	Electricity and natural gas consumption for Brussels' hospitals
	Emissions associated with MDI usage from national-level F gas study[7]	MDI emissions
Emissions factors	EXIOBASE industry output[8]	Utilised to derive EXIOBASE emission factors per Euro spent.
	UK DESNZ "Conversion factors 2023: full set (for advanced users)"	Utilised in bottom-up energy calculations, energy-related post processing and derivation of employee commuting figures
	Electricity (Generation) – European Energy Agency (accessed through Climatiq)	Belgium-specific factor for electricity

Dataset	Source	Use
	Electricity (WTT) – International Energy Agency (accessed through Climatiq)	Belgium-specific factor for electricity
	DEFRA spend-based emission factors from “UK Footprint Results 1990-2020”, produced by the University of Leeds (2020).	Emissions factor utilised reflects “Basic pharmaceutical products and pharmaceutical preparations”, and manipulated to reflect 2022 (considering inflation)

Generating emissions factors

Emissions factors tied to product-based expenditure for Belgium were derived using the EXIOBASE 3 environmentally extended multi-regional input-output (EE MRIO) tables[9]. EXIOBASE 3 provides year-specific tables for 44 countries, including Belgium. EXIOBASE 3 was chosen as it provides up to date (latest model year 2022) coverage of environmental impacts across 200 product types within the Belgium economy. Other available models such as the World Input Output Database only provide data up to 2014. EXIOBASE 3 is also suitable because the available years matched the baseline year and it comprises sectoral information, with data on economic sectors and their environmental impacts, which allows for consistent emissions modelling at the health care provider level across different parts of the economy. The Belgium-specific product-by-product EXIOBASE 3 version 3.8.2 data was downloaded and PyMRIO EE MRIO analysis tools[10] were used to translate environmentally extended input-output models (EE IOT), which account for all upstream emission with a product, and expenditure data in basic prices into emission factors per Euro spent.

Calculating emissions

Understanding how expenditure is allocated towards emissions-generating activities is essential for deriving emissions from high-level sectoral expenditure figures. As the seven health care providers differ in their activities and supply chains, expenditure profiles for each provider type were developed to capture the proportionate spending on activities within each health care provider.

Bespoke expenditure profiles were sourced from data holders reflecting Hospitals and Residential Facilities. For Ambulatory Care, Ancillary Services, Medical Goods Providers, Preventative Care, and System Administration, representative profiles were derived using national statistics data as expenditure profiles were not identified during the data collection process.

Proportionate activity expenditure for each health care provider was applied to the annual total expenditure (i.e. OECD data) to approximate annual spending figures associated with a range of activities within each health care provider. The EXIOBASE emission factors were then paired with associated expenditure to derive emissions estimates. Emissions results were aggregated based on the nature of their associated activity and grouped into the reporting categories used for baseline results.

Deriving emissions estimates from bottom-up activity data and integration with top-down emissions data to develop a “hybrid” baseline

The following bottom-up data sources reflecting real activity within the health care sector were leveraged and incorporated into the final “hybrid” emissions baseline:

- Electricity and natural gas consumption across health facilities
- MDI usage

Emissions associated with each of these sources were derived from activity data and activity-based emissions factors.

Data provided covering these emissions sources was of medium- or high-quality, and both energy-related emissions and emissions associated with MDIs were anticipated to contribute significantly to the national-level footprint. Accordingly, incorporating this bottom-up data was prioritised.

Where both bottom-up and top-down emissions figures reflecting the same emissions sources were available, the figure deemed to be less precise (typically expenditure-based figure) was deducted or excluded from the final baseline.

A figure estimating emissions associated with Hospitals' employee commuting was also derived using bottom-up data. However, this figure was excluded from the final baseline, as no other information was found to proxy employee commuting emissions associated with other health care providers and as employee commuting patterns are expected to differ considerably between regions and facilities of different sizes.

Adjustments were made to top-down derived emissions figures reflecting energy consumption and pharmaceutical procurement to help improve the precision of the associated emissions derivation methods and incorporate scope 1 emissions that are not captured in emissions factors (EFs) from EXIOBASE.

Accounting for combustion of direct fossil fuel usage

Emissions factors from EXIOBASE 3 reflect the upstream or "well-to-tank" emissions associated with extracting, refining, and transporting fuels to the end users but do not capture the direct emissions (i.e. scope 1 emissions) associated with the combustion of fossil fuels. To capture the scope 1 emissions, a ratio of upstream emissions (i.e. "well-to-tank" emissions) to direct, combustion-related emissions were derived from a UK Government emissions intensity dataset and applied to each fossil fuel source. The indirect emissions derived from the direct application of the original EXIOBASE emission factors are reflected under the scope 3 "fossil fuels (coal, oil, etc.)" reporting category in the baseline.

Disaggregation of scope 2 and scope 3 emissions associated with electricity and steam consumption

Emissions factors from EXIOBASE 3 capture the consolidated indirect emissions from electricity and steam consumption (i.e. scope 2 and upstream scope 3 emissions). To disaggregate emissions derived from EXIOBASE emission factors, a proportion between emissions from fossil fuel-based electricity and steam generation (scope 2) and upstream "well-to-tank" emissions and distribution losses for both energy and steam (indirect scope 3) was determined. This proportion, derived from the UK Government emissions intensity dataset, was applied to initial emissions outputs to disaggregate scope 2 and scope 3 emissions.

Adjustment to emission factors associated with pharmaceuticals

The EXIOBASE emission factor for "Chemicals nec", inclusive of upstream emissions of both pharmaceuticals and other types of chemicals, likely considerably overestimates emissions associated with pharmaceuticals. Given a substantial proportion of the sector's expenditure is associated with pharmaceuticals, using an overestimated emission factor could inflate the emissions baseline. To improve reliability for these estimates, a UK-based emission factor for "basic pharmaceutical products and preparations" adjusted for 2022 was used instead.

Reporting the results

The reporting categories used to capture results and differentiate emissions associated with different sources were based on those in the HCWH Methodology[1] to facilitate comparability between other similar baselines and roadmaps, whilst considering data availability and inclusion. Data outputs and reporting categories were further classified to be the most actionable for key user groups in the Belgian health sector and in alignment with Belgium's low-carbon health care aspirations (e.g. regional-level data outputs).

Emissions figures are consolidated into the three high-level scopes defined by the Greenhouse Gas Protocol (GHGP):

- Scope 1 – Direct emissions associated with the combustion of fossil fuels in health care facilities or during the operation of fleet vehicles[i]
- Scope 2 – Indirect emissions associated with the generation of purchased electricity, heat or steam
- Scope 3 – Indirect emissions related to an organisation's activities but generated from sources outside of its ownership and control

A.1.3 Modelling trajectories

Following completion of a baseline inventory, analysis of future emission trajectories was conducted to explore likely business-as-usual trends, and a target zone for emissions reductions from the sector. These trajectories provide the overall framing for the assessment of mitigation interventions within the decarbonisation roadmap.

High level overview of approach

BAU scenarios are developed to help understand potential future trends in emissions, relative to a base year and required reduction trajectory 'zone'. As outlined in Health Care Without Harm's methodology[1], these projections can be developed from the emissions baseline, projected growth in demand for health care services, and expected decarbonisation rates of global industries. This process is illustrated in Figure 2.

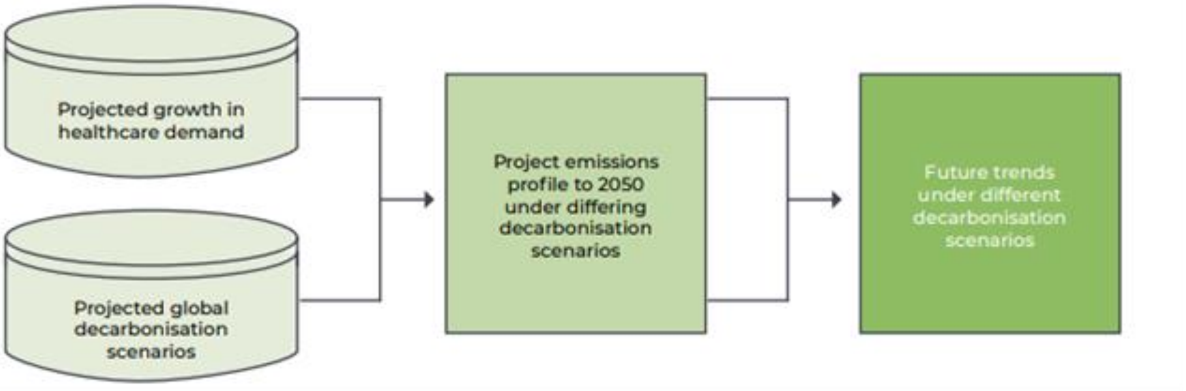

Figure 2. Process to develop a business-as-usual scenario, as outlined by the HCWH global methodology

Through reviewing datasets on projected health care demand (tailored to Belgium's national context, where possible) and emissions intensity in key sectors of the health supply chain, the following sources were identified for use in this analysis:

- The most viable option for forecasting sector growth to 2050 was found to be using health sector expenditure as a percentage of GDP.
- Global decarbonisation assumptions were sourced from the Transition Pathway Initiative's "Sectoral Decarbonisation Pathways" (V4.0).

Anticipated activity changes within Belgium's health sector

To estimate health service demand growth in Belgium by 2050, future health expenditure projections were used. Public forecasts were available through 2070[11], with growth rates expressed as a percentage of GDP. The International Monetary Fund[12] projections of Belgium's GDP were applied to predict

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[i] Other on-site emissions, like fugitive emissions from refrigerants and anaesthetics or on-site waste treatment are also classified as scope 1 emissions. However, these other emissions sources are data gaps of this analysis.

health care spending, estimating an 89% growth from 2022 to 2050 – indicating that the Belgian health system is expected to nearly double over this 28-year timeframe.

The annual rates of expenditure growth derived above, which are assumed to reflect demand for activities within the health sector, were applied to the estimated base year emissions figures of each emissions reporting category (e.g. scope 2, pharmaceuticals, food and catering, etc.) through 2050. The sum of these results yields an emissions scenario that considers demand growth only.

Anticipated changes in emissions intensity

To account for decarbonisation trends in key supply-chain industries impacting health care's footprint, projections from the Transition Pathway Initiative (TPI)'s Sectoral Decarbonisation Pathways (V4.0)[13] were used. These scenarios, based on International Energy Agency data, reflect the following sectors: air travel, aluminium, automotive (i.e. vehicle fuel efficiency), cement, diversified mining, electricity utilities, oil and gas, paper, shipping, and steel. These high-emitting sectors directly contribute to global emissions, and modelling their changes provides an approximate representation of the broader decarbonisation trends affecting the products and services consumed across the global economy, and within the health sector.

National, international, and Paris pledges scenarios were prioritized, reflecting current decarbonisation commitments. While national, international and Paris Accord targets and commitments provide a quantifiable set of decarbonisation assumptions, their legitimacy lies in the assumption that they will be reached, which may not be the case. The most recent scenarios were selected and mapped to EXIOBASE emission factors, producing a dataset of 200 product factors per year through 2050 which captures how these expected changes in emissions intensity across key industries is reflected in the emissions intensity of products globally. TPI's pathways reflect a global scale, except for the electricity utilities sector, where European data was used for this project. A Belgium-specific grid intensity forecast was excluded from this analysis because it is based on the target for a fully decarbonised grid by 2050 which was deemed more optimistic than the other trends being modelled within this BAU scenario which sought to capture current rates of progress.

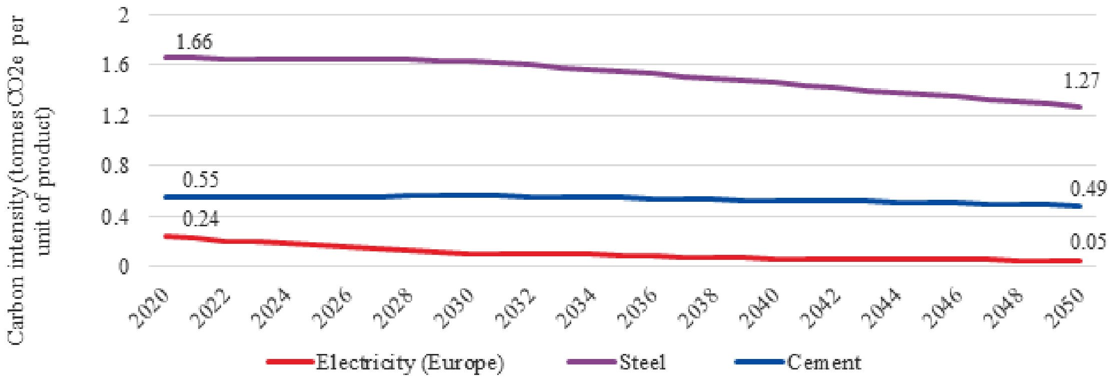

Figure 3. Sample of three emissions intensity projections from leveraged TPI pathways

The modelling trajectory yields a BAU scenario that predicts a 61.6% increase in sectoral emissions (green line), considering both anticipated growth in sector activity and trends surrounding wider economic decarbonisation. When only anticipated sector growth is considered, an 88.4% increase in emissions is anticipated (blue line). These trajectories can be seen in Figure 4.

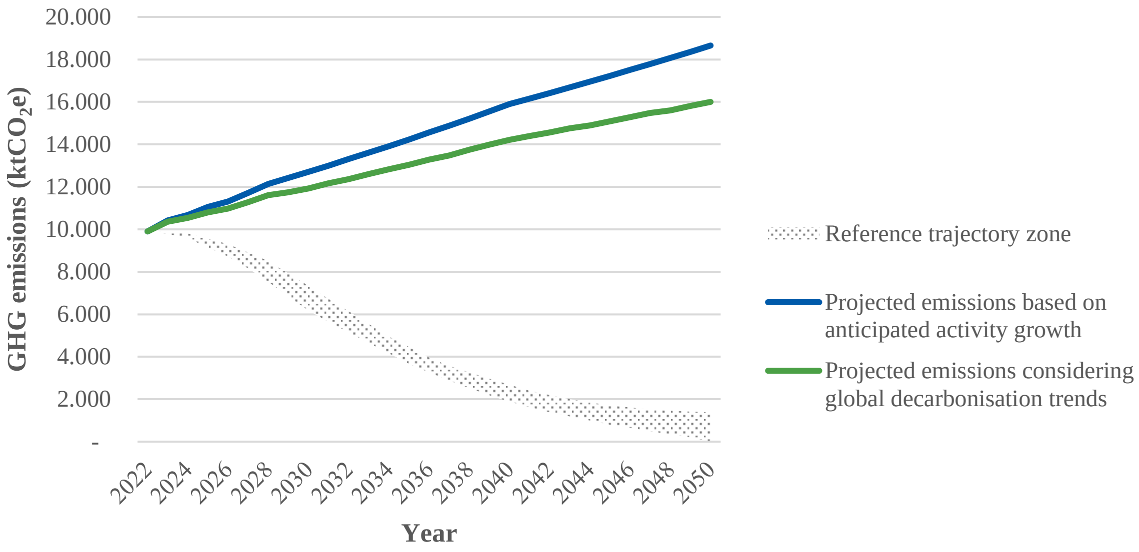

Figure 4. Comparison of projected emissions and reduction trajectory curve

A.1.4 Interventions

To better understand the Belgian health sector's ability to reduce sectoral emissions by 2050, various interventions were modelled. The approach taken for this analysis is detailed in the following sections.

Definition of decarbonisation interventions and data sources

A list of decarbonisation interventions was refined and applied to the emissions baseline and BAU projected emissions considering global decarbonisation trajectory. The interventions list was grounded in an evidence base of mitigation activities and associated magnitudes of changes in activity or emissions activity that was determined to be applicable to the sector based on Belgium sources, research, and understanding of opportunities and limitations within the sector.

Interventions and, where available, intervention rates were gathered from a combination of sources: data provided by the Belgium team, benchmarks from similar interventions by organisations such as NHS and C40 (adapted to Belgium's specific context), and relevant studies. Where intervention rates were drawn from other sectors, such as residential, adjustments were made to conservatively reflect the health sector's specific needs and operational settings. The prioritisation of interventions followed the Health Care Without Harm (HCWH) seven high-impact saction[14] to ensure alignment with strategic decarbonisation objectives.

Table 2. Decarbonisation interventions applied to emissions baseline and BAU trajectory

#	Decarbonisation intervention	Description	Intervention rate (%)	Timeframe	Relevant reporting categories	Emissions category
1	Building fabric efficiency improvements	These improvements focus on engineering solutions to enhance the thermal efficiency of buildings, therefore reducing energy demand for heating and cooling. This includes insulating walls, roofs, floors, and investing in high-efficiency glazing (glass).	20	By 2050	Stationary fuel combustion (non-vehicles), Electricity purchased (not generated on-site)	Scope 1
2	Building systems optimisation	These involves upgrading and optimising a building's operational systems (e.g., HVAC, lighting, energy management) by using smart technologies and advanced controls (e.g. programmable thermostats).	20	By 2050	Stationary fuel combustion (non-vehicles), Electricity purchased (not generated on-site)	
3	Electrification of heating	This involves replacing fossil fuel-based heating (natural gas, oil, coal) with electric heating technologies. This could include heat pumps, electric boilers, or other renewable energy-powered heating systems.	100	By 2050	Stationary fuel combustion (non-vehicles)	
4	Electrification of inter-site vehicles	This intervention involves transitioning the health sector's fleet to fully electric vehicles, including those used for patient transport, logistics, and staff commuting.	100	By 2050	Mobile combustion (i.e. vehicles)	
5	Onsite renewables or power purchase agreements	This intervention refers to generating renewable energy, primarily through solar PV systems installed directly on the premises of health care facilities. Power purchase agreements (PPAs) can be utilized to secure renewable energy from external sources.	100	By 2050	Electricity purchased (not generated on-site)	Scope 2
6	Optimised use of pharmaceuticals	Implementing strategies to reduce the over-prescription and unnecessary use of pharmaceuticals within the health care system. In their 2010 joint report, the York Health Economics consortium and the School of Pharmacy at University of London estimate that 30-50% of medicines are not used and therefore wasted[15], and this volume could	20	By 2050	Pharmaceuticals	Purchased goods

#	Decarbonisation intervention	Description	Intervention rate (%)	Timeframe	Relevant reporting categories	Emissions category
		be cost-effectively avoided. We're assuming Belgium implements policies and prescriptions practices that lead to halving of this waste, and it is not practical to reduce this waste more as there would be a risk of not having enough pharmaceuticals.				
7	Prioritising low carbon pharmaceuticals suppliers	Prioritising low carbon suppliers involves requesting for Environmental Product Declarations (EPDs) or sustainability data during the procurement process for pharmaceuticals, aiming to aid selection of lower carbon alternatives.	10	By 2030	Pharmaceuticals	
8	Shift to low carbon inhalers	Traditional inhalers, such as pressurized metered-dose inhalers (pMDIs), use hydrofluoroalkane (HFA) propellants. While effective in delivering medication, these propellants have a high Global Warming Potential (GWP), contributing significantly to greenhouse gas emissions. Transitioning from traditional propellant inhalers to low carbon inhalers with lower GWP. For example, AstraZeneca is transitioning to a propellant called HFO-1234ze[16], which has up to 99.9% less GWP compared to traditional propellants. GSK is also investing in similar technologies to reduce the carbon footprint of their inhalers by 90%[17].	90	By 2040	MDI	
9	Extending the lifespan of medical equipment	Extending the lifespan of electrical products to reduce consumption of new equipment. This could include establishing an exchange platform within the hospital (equipment lying idle in storage or under-used) and/or establishing a lifetime for medical equipment.	25	By 2050	Medical equipment/ instruments	

#	Decarbonisation intervention	Description	Intervention rate (%)	Timeframe	Relevant reporting categories	Emissions category
10	Prioritising low carbon medical equipment suppliers	This means forming agreements or partnerships with with suppliers of clinical consumables and medical devices focused on sustainability and/or publish EPD data. This could include suppliers who use renewable energy in their manufacturing processes, suppliers who implement energy-efficient technologies, suppliers who reduce waste in their operations, suppliers who reduce product packaging etc.	10	By 2030	Medical equipment/instruments	
11	Reduce food waste	Focuses on minimising the amount of waste from unconsumed meals within the health sector, involving implementing practices to improve meal planning, portion control, etc. The Belgian Federal Government indicates 41% of meals go unconsumed. This number aligns with the 30-50% food wasted in developed countries that is avoidable through behaviour change[18]. The intervention aims for a halving of this waste reduction and not more as there would be a risk of not having enough food.	21	By 2050	Food/catering	
12	Reduce meat consumption	This intervention focuses on training kitchen staff in vegetarian cooking techniques and reducing the amount of animal proteins served in patient meals to one day per week and promoting the vegetarian concept.	9	By 2050	Food/catering	
13	Reduce excess purchases	Implementing strategies to decrease over-purchasing and limit unnecessary stock acquisitions of manufactured fuels, chemicals, gases. Over purchasing can lead to excess inventory, increased storage costs, and potential waste, especially for any products with limited shelf life. Strategies to address this include accurate demand forecasting using advanced analytics, regular inventory audits, streamlining procurement procedures, buying better and/or directly demanding for alternative products and suppliers.	10	By 2050	Manufactured fuels, chemicals, gases	

#	Decarbonisation intervention	Description	Intervention rate (%)	Timeframe	Relevant reporting categories	Emissions category
14	Reducing single-use instruments and garments	Transitioning from disposable medical instruments and garments to reusable options that can be effectively decontaminated and sterilized. This should be paired with training for staff on rigorous sterilisation protocols to ensure that reusable items meet the highest standards of hygiene and safety.	10	By 2050	Other manufactured products	
15	Material efficiency in construction of new hospitals	Optimising the use of materials to minimise waste and enhance sustainability. This could include concepts such as prefabrication, modular construction, designing for efficiency, choosing sustainable materials such as bio-based products that have a lower environmental impact etc.	67	By 2050	Construction activities	Purchased services
16	Supplier decarbonisation standards	The majority of suppliers involved in procurement activities in Belgium's health sector will need to demonstrate progress toward Net Zero commitments and climate targets. Prioritising suppliers who demonstrate a commitment to sustainability ensures that Scope 3 emissions from the supply chain are lower, as suppliers align their operations with Net Zero goals such as reducing emissions, adopting renewable energy, and improving energy efficiency. This intervention assumes that 70% of suppliers successfully reach the 90% reduction threshold included in the SBTi standards.	63	By 2050	All scope 3 emissions sources	Scope 3

Electrification interventions

Separately, the rebound effects from increased electricity demand following the electrification of buildings and vehicles were accounted for in this model. To estimate the impact of this intervention for both buildings and vehicles, an S-curve multiplier was applied from 2022 to 2050 based on a threshold intervention rate to calculate the annual reductions in Scope 1 emissions, with the corresponding increase in Scope 2 electricity consumptions emissions then estimated.

For buildings, ‘Stationary fuel combustion’ (kWh) was calculated from the ‘Stationary fuel combustion’ baseline and projected emissions using DEFRA factors for natural gas. ‘Stationary fuel combustion’ (kWh) values for 2022 to 2050 are then calculated to electricity consumption (kWh) using the formula below. Electricity consumption is then multiplied by 2022 electricity generation emission factors to derive annual building electricity emissions (ktCO_2e). Finally, the electricity decarbonisation multipliers from TPI’s Sectoral Decarbonisation Pathways Europe were applied to each year’s building electricity emissions.

$$\boxed{Building\ electricity\ consumption\ (kWh) = \frac{Stationary\ fuel\ combustion\ (kWh) \times 0.9 \times 0.85}{3 \times 0.85}}$$ [ii]

For vehicles, projected vehicle emissions (ktCO_2e) for 2022 to 2050 were converted from the average diesel van to electric vehicle van using DEFRA factors. The S-curve multiplier for each year were then applied to calculate the annual electric vehicle consumption. DEFRA’s emissions factor for an average van (<3.5 tonnes) "electric vehicle" was adjusted to reflect decarbonisation trends by applying the TPI's Sectoral Decarbonisation Pathways Europe electricity decarbonisation multipliers, creating a decarbonised EV emissions factor for the years 2022-2050. The annual electric vehicle consumption was then multiplied by the decarbonised EV emissions factors to derive annual electric vehicle emissions (ktCO_2e).

[ii] In this formula, the values 0.9 and 0.85 represent the efficiencies of the condensing boiler and the system, respectively, while the factor of 3 represents the efficiency coefficient for Air source heat pumps.

A.1.5 Assumptions and limitations

Developing a baseline

In producing this baseline footprint and preparing the basis upon which future decarbonisation potential will be modelled, it was necessary to make a number of assumptions to respond to data gaps, uncertainties in model inputs and limitations of the modelling approach.

There are several broad assumptions and limitations which are foundational to the footprint and should be considered in the interpretation and application of its results. In Table 3 below, ‘Degree of uncertainty’ ranks the level of uncertainty associated with the assumption and/or source data. It reflects the extent to which the assumption or limitation can be considered reliable and accurate for use in the emissions baseline. Impact on total results ranks the extent to which an assumption or limitation will influence the overall footprint. The ranking identifies which assumptions or limitation have the most significant variabilities and effect on the results.

Table 3. Main assumptions and limitations underpinning the emissions baseline

Assumption / limitation	Justification	Degree of uncertainty	Impact
Different approaches were used to calculate emissions for different health care providers. For instance, Hospitals and Residential Facilities emissions were based on reported expenditure, while other health care providers expenditure profiles were proxied.	Deploying different approaches for different health care providers, in certain instances, has enabled the inclusion of higher quality data for some sector-sectors while ensuring that health care providers lacking data can be captured within the baseline.	Medium	Medium
Majority of proxies to disaggregate activity and expenditure figures by region are based on proportionate population. This assumes that each region provides similar health care services and have similar numbers of facilities within each health care provider, relative to population.	A breakdown of sector-wide expenditure by region was not identified. Bottom-up data sources capturing facility counts within each region appear to be inconsistent in terms of scope/inclusion and categorisation. It was decided this proxy could provide regional reporting and focus in a consistent and credible manner.	Medium	Low
2022 was selected as a base year. However, data provided for this project ranged from 2019 to 2023. The baseline assumes that sector activity in 2019, 2020, 2021 and 2023 was suitably consistent with 2022.	Utilising only data provided reflecting 2022 activity would significantly limit available methods. For instance, the Residential Facilities expenditure profile provided reflects 2023 data. Most of the footprint was calculated using data for the 2022 base year so this will have limited impact.	Low	Low
Emissions factors from EXIOBASE 3 represent averages for certain product types and do not differentiate for different emissions intensities for comparable products from different producers.	Use EXIOBASE 3 emissions factors deemed best available approach, especially as no source data provides any information reflecting supplier selection. Future, detailed, assessments may utilise product specific impact data.	Medium	Medium

Assumption / limitation	Justification	Degree of uncertainty	Impact
Belgium-specific emissions factors from EXIOBASE 3 reflect products procured in Belgium (i.e. not goods procured outside of the country).	Assuming materials are procured locally deemed best available approach. The factors are regionally valid for each area of health provision and will be representative of products purchased either in the country in question or wider region.	Low	Low
OECD spending data does not differentiate between operational expenditure on health delivery and capital investments in health infrastructure (i.e. major construction). This funding may fall into different areas of investment.	This footprint therefore represents the operational footprint of the health system. Additional analysis will be needed to incorporate capital investments in this analysis. Carbon management approaches will differ between operations and capital investment meaning this assessment is valid and actionable.	Low	Low

Emissions scenarios and interventions

Several notable assumptions and limitations outlined in Table 4 were used in determining how to apply the emissions reductions interventions through the model and in considering the practicality of the sectors' ability or influence in applying the intervention.

Table 4. Key assumptions underpinning definition of decarbonisation interventions

Applicable intervention	Assumption / limitation	Justification	Impact
1, 2	Reduction intervention rates for fabric efficiency improvements and building systems optimisation are set at half the rate of other building types and sectors.	This adjustment reflects the uniquely high and complex energy demands of hospitals, where critical systems—such as medical equipment and advanced ventilation—require consistent, intensive energy use to maintain safety and operational standards.	Medium
3	The reduction of scope 3 emissions associated with purchases fossil fuels arising from electrification from buildings and vehicles are assumed to correspond to the % of the scope 1 emissions related to fuel combustion in buildings and vehicles.	Using the ratio of buildings to vehicles provides a proportional approach to estimating scope 3 fossil fuel-related emissions reductions, ensuring that the assumptions reflect the relative energy demands and usage patterns of each sector.	Low
4	Emission factors for electric and diesel vehicles are based on the same 'average van <3.5 tonnes' category.	This standardisation allows for a clear, direct assessment of emissions differences attributable solely to the switch from diesel to electric, without the influence of vehicle size variations.	Low

Applicable intervention	Assumption / limitation	Justification	Impact
6, 11	Published waste reduction amounts/ percentages have been halved to determine the intervention rate.	Reducing waste beyond this level risks shortages that could compromise the availability of pharmaceuticals or foods to those in need, making a moderate reduction target more realistic while maintaining safety and reliability in critical supplies	Low
7, 10	Procurement teams and health care professionals can access the data and implement the policies required to shift to low-carbon alternative products.	As the end purchases are not directly controlled by the distributing organisations, this reduction assumes that the health sector actors are able to shift purchasing towards greener suppliers.	Medium
12	The emissions reduction resulting from a one-day-per-week shift to vegetarian meals is 9%	Intervention based on supplied case study from Belgium.	Low

Table 5 highlights several assumptions to appropriately apply the decarbonisation levers identified to the emissions baseline. These assumptions were made considering the nature and quality of the underlying source data leveraged to establish the emissions baseline. These provide the basis for the overall model and should be clearly communicated as part of HCWH's externally published roadmap outputs (e.g., in a technical appendix).

Table 5. Main assumptions underpinning the scenario analysis

Assumption / limitation	Justification	Impact
Decarbonisation interventions are applied uniformly nationally.	Each of the decarbonisation interventions identified were applied on a national-level, though the implementation of each intervention may be more challenging in certain regions.	Low
The sequential application of interventions assumes that each subsequent intervention is applied to an already-adjusted emissions profile rather than the baseline.	This approach prevents overestimation of total intervention effects by ensuring that each intervention's effect is compounded. By incorporating the cumulative effects of previous interventions, this approach avoids overstating the potential impact of each intervention on emissions reductions. Estimated emissions reductions for individual interventions are therefore linked to the wider application of changes, which would lead to different results should they not be applied together.	Low
Each decarbonisation intervention and its associated magnitude of impact are assumed to be additional to the "structural decarbonisation" effects applied in the development of the baseline trajectory.	It is assumed that the measures contained in the decarbonisation interventions are all additional to the wider economic trends embedded in the Business As Usual trajectory. Efforts to avoid double counting emissions reduction measures have been made through the framing of interventions according to the three pathways.	Low

A.1.6 Further results

Baseline emissions

Table 6. Health sector emissions by scope

	Emissions ktCO$_2$e	Share of total emissions, %
Non-vehicles fuel use	806	8.1%
Vehicles fuel use	277	2.8%
Scope 1	**1,084**	**10.9%**
Scope 2[iii]	**269**	**2.7%**
Pharmaceuticals[iv]	3,045	30.8%
Business services	1,625	16.4%
Medical equipment/instruments	1,346	13.6%
Food/catering	775	7.8%
Manufactured fuels, chemicals, and gases	539	5.4%
Other manufactured products	303	3.1%
Construction and maintenance services	208	2.1%
Other procurement	198	2.0%
Information and communication technologies and services	166	1.7%
Fossil fuels (coal, oil, etc.)	152	1.5%
Transport	84	0.8%
Waste, water, and sanitation	63	0.6%
Electricity and steam (scope 3)	45	0.5%
Scope 3	**8,549**	**86.4%**
Scope 1, 2, and 3 Total	**9,901**	**100.0%**

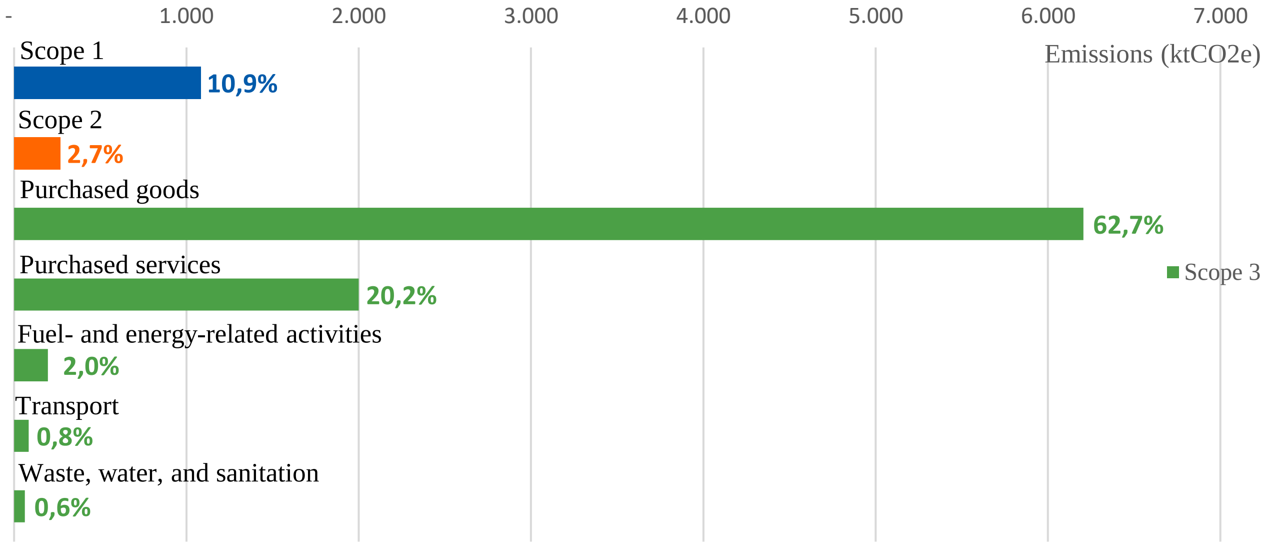

Figure 5. High-level categorisation of national health sector emissions

Table 7 illustrate the breakdown of Belgium’s emissions between each health care provider included within the scope of the baseline.

[iii] Over 99% of scope 2 emissions in this footprint are from electricity consumption. The remaining scope 2 emissions reflect purchased steam.

[iv] Emissions associated with Metered Dose Inhalers (MDIs) captured within Pharmaceuticals categorisation: 44ktCO$_2$e – approximately 0.4% of total footprint.

Table 7. Health sector emissions by health care providers

Health care providers	Total emissions (ktCO$_2$e)	*% of total emissions*	Expenditure (Million EUR)	*% of national expenditure*	Emissions intensity (kgCO$_2$e/EUR)
Hospitals	5,488	*55%*	€ 23,532	*39%*	0.23
Residential long-term care facilities	804	*8%*	€ 6,879	*11%*	0.12
Providers of ambulatory health care	2,201	*22%*	€ 17,924	*30%*	0.12
Providers of ancillary services	207	*2%*	€ 1,719	*3%*	0.12
Retailers and other providers of medical goods	897	*9%*	€ 6,331	*11%*	0.14
Providers of preventive care	133	*1%*	€ 1,161	*2%*	0.11
Providers of health care system administration and financing	170	*2%*	€ 2,548	*4%*	0.07
Sector-wide	**9,901**		**60,096**		**0.16**

Table 8 provide breakdowns of the emissions calculated for each type of health care provider considered in this study.

Table 8. Breakdown comparison between different approaches and health care providers

High level scope categories	Hospitals	Residential long-term care facilities	Providers of ambulatory health care	Providers of ancillary services	Retailers and other providers of medical goods	Providers of preventive care	Providers of health care system administration and financing
Scope 1	8%	30%	10%	8%	13%	28%	5%
Scope 2	2%	10%	1%	2%	3%	11%	<1%
Purchased goods	79%	42%	46%	47%	45%	9%	15%
Purchased services	8%	10%	38%	38%	33%	44%	75%
Fuel- and energy-related activities	2%	7%	1%	0%	3%	6%	<1%
Construction and maintenance services	1%	0%	2%	2%	2%	1%	2%
Transport	<1%	0%	2%	2%	1%	2%	3%
Waste, water, and sanitation	<1%	1%	1%	1%	1%	<1%*	<1%*
Total	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***

Table 9 and Figure 6 illustrate the breakdown of Belgian health sector's emissions by Belgium's three regions.

Table 9. Total health sector emissions by region

Region	Total Emissions (ktCO$_2$e)	% of Total Emissions	*% Population*
Wallonia	3,125	31.6%	*31.6%*
Brussels	1,057	10.7%	*10.6%*
Flanders	5,719	57.7%	*57.8%*
Total	**9,901**		

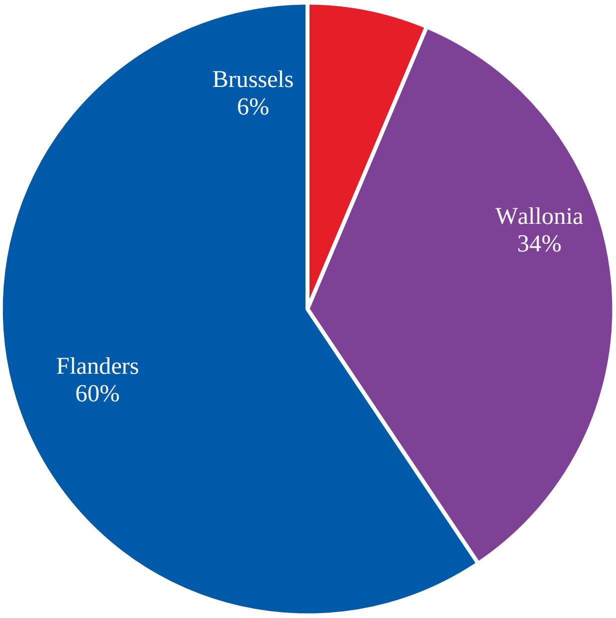

Figure 6. Health sector emissions, by region

Table 10, Figure 7, Figure 8, and Figure 9 illustrate the emissions comparison with Netherlands and Germany. Emissions for the Dutch and German health care sector were conducted using EXIOBASE input-output analysis and health care expenditure data from Statistics Netherlands[19] and German Federal Statistics Office[20]. Comparing Belgium to the Netherlands is highly feasible due to the similarities in their economic, geographic, and demographic profiles, as well as utilising similar methodologies to calculating sectoral footprint.

Table 10. Benchmark comparisons, Netherlands and Germany

	Belgium	Netherlands	Germany
Expenditure (Million EUR)	60,096	92,515	414,000
Emissions (ktCO$_2$e)	9,901	17,575	68,000
Emissions intensity (kgCO$_2$e/EUR)	0.16	0.19	0.16
Emissions per capita (kgCO$_2$e)	855	1,001	817

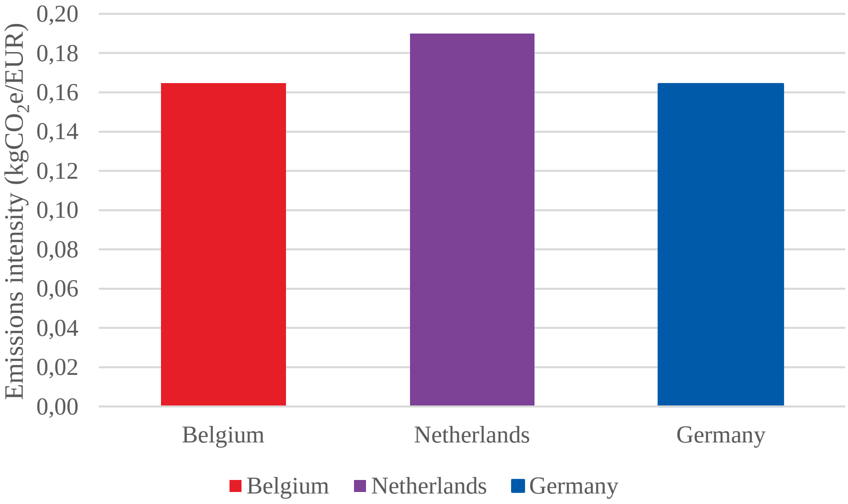

Figure 7. Emissions intensity (kgCO2e/EUR) comparison with the Netherlands and Germany

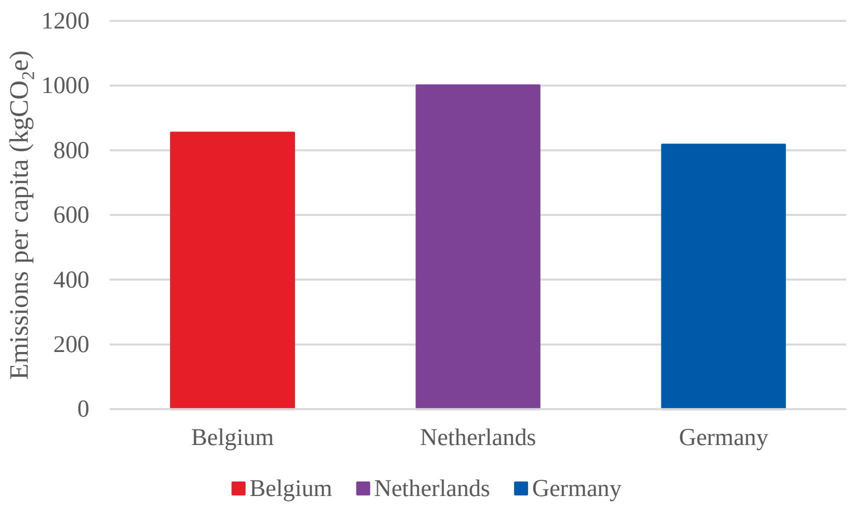

Figure 8. Emissions per capita (kgCO$_2$e) comparison with the Netherlands and Germany

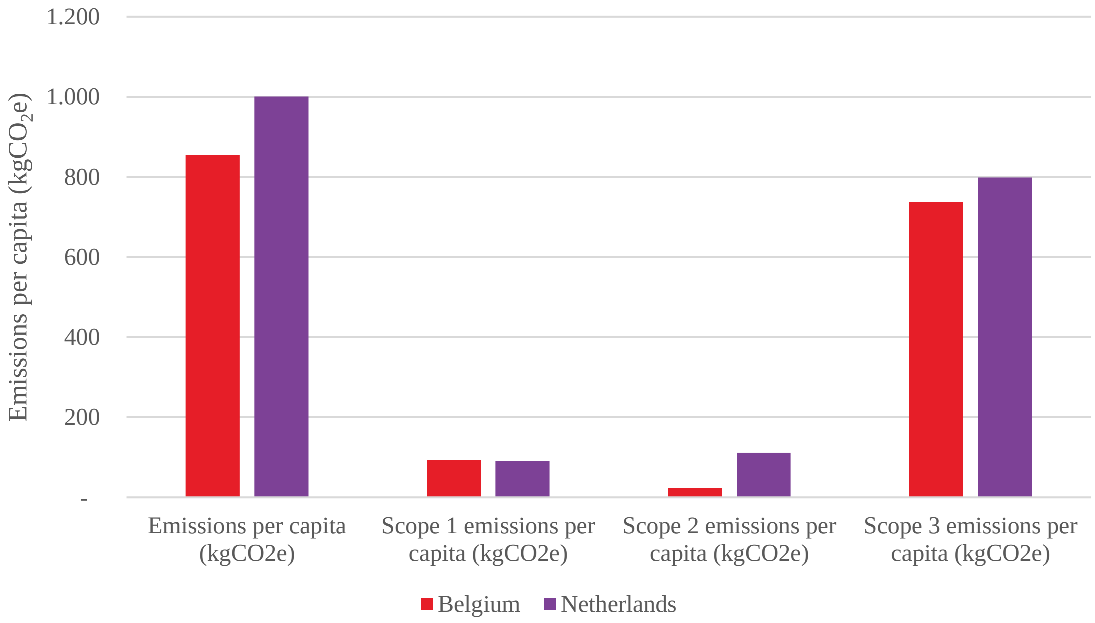

Figure 9. Scope 1, 2, 3 emissions per capita comparison with the Netherlands

Interventions emissions

Table 11. Overview of emissions impacts by interventions, detailed intervention

Intervention	Absolute emissions reductions in 2050 (ktCO$_2$e)	% 2050 emissions	Cumulative emissions reductions 2022 - 2050 (ktCO$_2$e)
Building fabric efficiency improvements	23	0.2%	682
Building systems optimisation	18	0.2%	584
Electrification of heating	1,613	13.8%	22,937

Intervention	Absolute emissions reductions in 2050 ($ktCO_2e$)	% 2050 emissions	Cumulative emissions reductions 2022 - 2050 ($ktCO_2e$)
Electrification of inter-site vehicles	451	3.9%	7,335
Onsite renewables or power purchase agreements	73	0.6%	1,310
Optimised use of pharmaceuticals	976	8.4%	14,534
Prioritising low carbon pharmaceuticals suppliers	390	3.3%	8,749
Shift to low carbon inhalers	23	0.2%	557
Extending the lifespan of medical equipment	535	4.6%	8,060
Prioritising low carbon medical equipment suppliers	160	1.4%	3,736
Reduce food waste	281	2.4%	4,133
Reduce meat consumption	23	0.2%	350
Reduce excess purchases	88	0.8%	1,307
Reducing single-use instruments and garments	42	0.4%	622
Material efficiency in new construction	39	0.3%	595
Supplier decarbonisation standards	6,941	59.4%	106,496
Total	**11,677**	***100%***	**181,986**

A.1.7 Sources

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[1] HCWH, Arup (2022) Designing a net zero roadmap for health care: Technical methodology and guidance | Health Care Without Harm (Europe)

[2] OECD (2024) OECD Data Explorer • Health expenditure and financing

[3] OECD (2024) OECD Data Explorer • Health expenditure and financing

[4] Federal Planning Bureau (2020) Federal Planning Bureau - Databases - Input-Output Tables 2020

[5] Data sources provided: "p6082 ELE Fluvius 2023_zorg" & "2023_aardgas_zrog"

[6] Data source provided: "RAPP_CPUB_Stava datacollective - WG Low Carbon_2024"

[7] Source file and link: “Update of the national emission inventory of ozone depleting substances and fluorinated greenhouse gases (1990 – 2022): Final report,” https://www.cnc-nkc.be/en/reports

[8] Derived from EXIOBASE 3: EXIOBASE 3 (zenodo.org)

[9] Stadler, Konstantin, Wood, Richard, Bulavskaya, Tatyana, Södersten, Carl-Johan, Simas, Moana, Schmidt, Sarah, Usubiaga, Arkaitz, Acosta-Fernández, José, Kuenen, Jeroen, Bruckner, Martin, Giljum, Stefan, Lutter, Stephan, Merciai, Stefano, Schmidt, Jannick H, Theurl, Michaela C, Plutzar, Christoph, Kastner, Thomas, Eisenmenger, Nina, Erb, Karl-Heinz, Tukker, Arnold. (2021). EXIOBASE 3 (3.8.2) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.5589597

[10] pymrio (N/A) Working with the EXIOBASE EE MRIO database — pymrio 0.6.dev documentation

[11] Performance of the Belgian health system – report 2024 (2024) HSPA 2024 Projection of public expenditure on health (% GDP), evolution in percentage points (S-20)

[12] International Monetary Fund (2024) World Economic Outlook database: April 2024. For years for which a forecasted GDP value was not available, values were linearly extrapolated from the provided data.

[13] Transition Pathway Initiative (2024): Sectoral Decarbonisation Pathways (V4.0)

[14] HCWH, Arup (2022) HCWH Road Map for Health Care Decarbonization - Annex C.pdf

[15] NICE (N/A) Medicines-optimisation-sustainability-report.pdf

[16] AstraZeneca (2024) AstraZeneca announces the completion of the clinical programme to support the transition of Breztri to next-generation propellant with near-zero Global Warming Potential

[17] GSK (2023) GSK announces major step towards sustainability ambitions with advancement of low carbon Ventolin programme to Phase III trials | GSK

[18] Institution of Mechanical Engineers (2013) Global Food: Waste Not, Want Not

[19] Steenmeijer, Rodrigues, Zijp, Waaijers-van der Loop (2022) The environmental impact of the Dutch health-care sector beyond climate change: an input–output analysis - The Lancet Planetary Health

[20] Pichler, P. P (2022) Sachbericht zum Projekt: Evidenzbasis Treibhausgasemissionen des deutschen Gesundheitswesens GermanHealthCFP (bundesgesundheitsministerium.de)