ACSS ADMINISTRAÇÃO CENTRAL DO SISTEMA DE SAÚDE, IP

OTIMIZAR RECURSOS
GERAR EFICIÊNCIA

CARBON FOOTPRINT OF THE PORTUGUESE HEALTH SECTOR AND WAYS FOR MITIGATION

OPERATION ZERO PROJECT

REPORT

21 de dezembro de 2022

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INTRODUCTION

Through participation in the Operação Zero (OZ) project, an initiative coordinated by the organization Health Care Without Harm – Europe (HCWH), the Central Administration of the Health System (ACSS) led the implementation of the methodology described in the document "Designing a Net Zero Road Map for Healthcare: Technical Methodology and Guidance" (HCWH, 2022).

This report presents the final result of the participation of ACSS in the OZ project, describing, with some level of detail, the options and procedures used in the implementation of the methodology produced in the project, and disclosing the following results:

• Baseline of greenhouse gas (GHG) emissions from the healthcare sector in Portugal;

• Target trajectory for emissions from the healthcare sector;

• Projection of future emissions.

The analysis of the results of the impact of sustainability measures that are already being implemented in the Portuguese public healthcare sector on future emissions are also presented, and paths of action to promote mitigation are identified.

This document is accompanied by some annexes, which provide additional details and clarifications on the procedures and calculations adopted:

ANNEX I: Schematic explanation of the procedure used to calculate the emissions baseline, which was guided by the methodology produced under the Operation Zero project

ANNEX II-A: Calculations (Baseline)

ANNEX II-B: Calculations (Projections)

ANNEX III: Coding of industries that make up the WIOD[1] database

SETTING OUR BASELINE GREENHOUSE GAS EMISSIONS

SCOPE

System Boundaries: We decided to calculate the GHG emissions baseline for the Portuguese health system, including both the private and public healthcare providers at the national level, considering the following Health Care Providers (ICHA-HP) codes from the System of Health Accounts (SHA): HP.1 (Hospitals); HP.2 (Residential long-term care facilities); HP.3 (Providers of ambulatory health care); HP.4 (Providers of ancillary services); HP.5 (Retailers and other providers of medical goods); HP.6 (Providers of preventative care); HP.7 (Providers of health care system administration and financing); HP.8 (Rest of economy) and HP9 (Rest of the world).

Reference Year: 2014 was defined as the reference year for the calculation of the emissions baseline due to the need to align our baseline expenditure data with the World Input-Output Database (WIOD) (2014) data.

[1] World Input-Output Database

Methodology and Databases

Methodology: A hybrid approach was used to calculate the carbon footprint of the Portuguese healthcare system, ie a "top-down" method was used and some "bottom-up" data were added where these were available. In the future, the intention is to develop the GHG emissions baseline through the integration of a greater amount of good quality bottom-up data, which will increase the reliability of the results.

The "top-down" approach was applied to the calculation of direct CO_2 emissions - Scope 1 of the Greenhouse Gas Protocol (GHGP)[2], and to the calculation of indirect GHG emissions (CO_2, CH_4 and N_2O) - Scope 2 and 3 of the GHGP. The "bottom-up" approach was applied to the calculation of emissions produced by the use of anesthetic gases and pressurized metered dose inhalers (MDIs).

For further clarification on baseline calculation methods, the document "Designing a Net Zero Road Map for Healthcare: Technical Methodology and Guidance", available on the HCWH - Europe website (HCWH, 2022), should be consulted.

Databases: For the implementation of the "top-down" method, the following WIOD databases were used, released in 2016: Input-Output tables (2014) and environmental accounts for CO_2 emissions (2014). To calculate CH_4 and N_2O emissions, PRIMAP environmental accounts were used, according to the method described in Annex B of the "Health Care's Climate Footprint" report (HCWH, 2019).

The health system's expenditure data, provided by the national statistics office (Statistics Portugal), to apply the "top-down" method, are relative to the whole Portuguese health system, including the private and public sectors, at the national level, and are organized according to the Health Care Providers (ICHA-HP) codes, considering the system boundaries described in the subchapter 2.1. SCOPE").

"Bottom-up" data, on the consumption of anesthetic gases, were collected and reported by the Portuguese Environment Agency (APA) under the United Nations Framework Convention on Climate Change (UNFCCC). Data on the consumption of MDIs were collected by the Shared Services of the Ministry of Health (SPMS), through the electronic drug prescription platform.

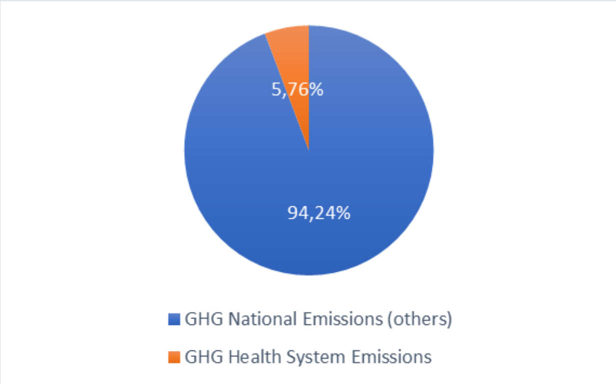
Calculations

For a detailed description of the calculations performed to determine the emissions baseline from the Portuguese health system, ANNEX II-A should be consulted.

Exploration of Results

When considering the entire Portuguese health system, covering public and private entities, the sector's total carbon footprint in 2014 was around 3.92 Mt CO2eq, representing approximately 5.8% of total GHG emissions at the national level. Considering only the public sector of the Portuguese health system, the total carbon footprint in 2014 was around 2.51 Mt CO2eq, representing approximately 3.7% of the national total.

[2]Greenhouse Gas Protocol (GHGP) - Entity internationally recognized for setting standards for accounting, reporting and managing greenhouse gas (GHG) emissions from public or private organizations.



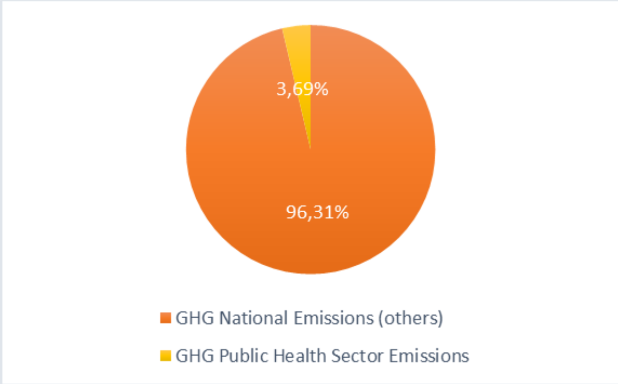


Figure 1 - Contribution of the health system (left) and the public health sector (right) to total national GHG emissions

The results obtained with the implementation of the calculation methods, in terms of the total amount of GHG generated by the activities of the Portuguese health system (carbon footprint), are also presented according to the categorization of emissions used by the GHGP, as explained below.

GHGP Scope 1 emissions – Counts direct GHG emissions from sources that belong to or are controlled by the entity (e.g., ovens, boilers, vehicles, among others);

GHGP Scope 2 emissions – Counts indirect GHG emissions from the production of electricity purchased and consumed by the entity. These emissions physically occur at the location where the electricity is generated;

GHGP Scope 3 emissões – Accounts for all other indirect GHG emissions that are a consequence of the company's activities but occur from sources that are not owned or controlled by the company (e.g., extraction and production of purchased materials).

From the specified categorization, the detailed analysis of the sector's carbon footprint allows us to conclude that, as can be seen in Figure 2, most of the health system's emissions are indirect, resulting from GHG emission sources of scopes 2 and 3 (86%). The direct emissions, from sources controlled directly by the healthcare entities represent about 14% of the total emissions footprint.

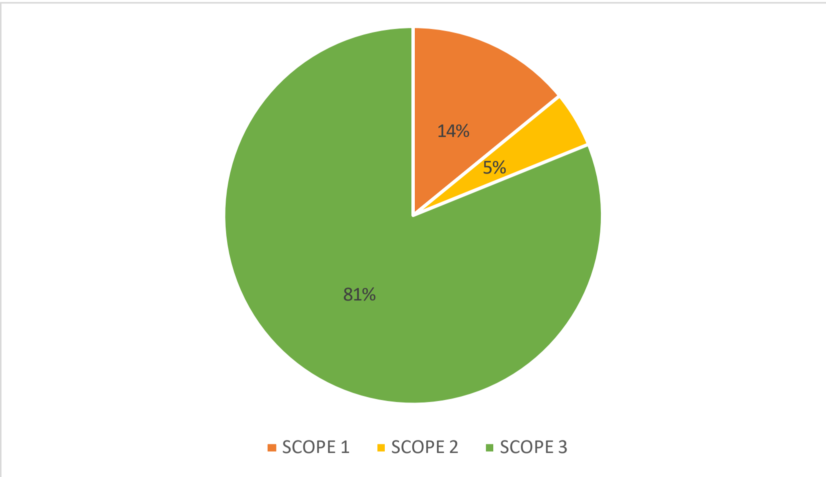


Figure 2 - Contribution of GHGP scopes 1, 2 and 3 to the total GHG emissions of the health system

Figure 3 shows the detailed inventory of the sector's carbon footprint, where some emission sources are presented with the code assumed in the WIOD table. Although the definition of the codes of each of the main contributors appears in the legend of Figure 3, additional details on the codification can be consulted in ANNEX III (Coding of the industries that make up the WIOD database).

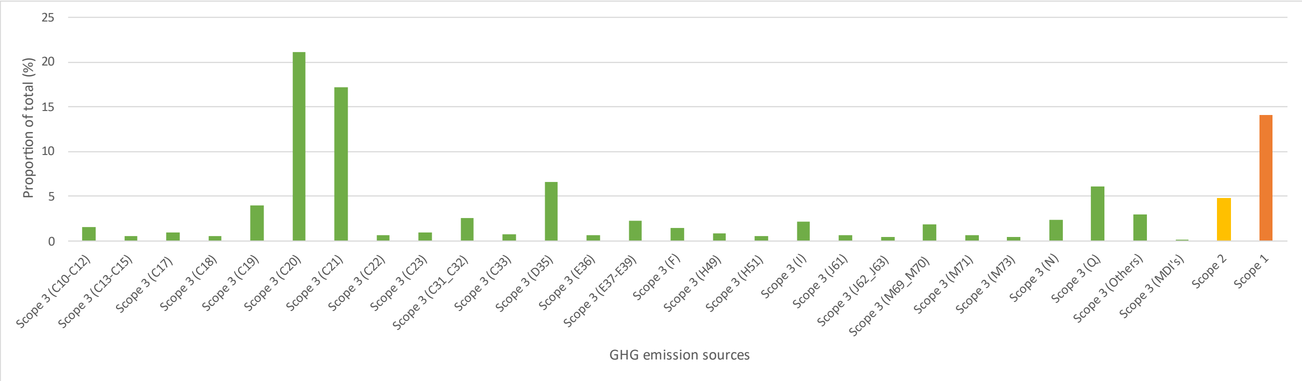


Figure 3 - Detail of the carbon footprint of the health sector in 2014, with identification of scope 1, scope 2 and scope 3[3]

From the analysis of Figure 3, it can be concluded that the indirect emissions, related to the "Manufacture of chemicals and chemical products" (C20) and to the "Manufacture of basic pharmaceutical products and pharmaceutical preparations" (C21), and the direct emissions (Scope 1), are the main sources of GHG in the Portuguese Health Sector, representing more than 50% of the total GHG footprint. Thus, these sources are assumed to be emission hotspots that require special attention in the planning of future mitigation measures.

By focusing only on the public healthcare sector, covering only the public healthcare entities, it can be seen that the distribution of emissions by sources followed the profile already described in Figures 2 and 3, therefore, it is assumed that the emission hotspots are the same.

BASELINE CALCULATION LIMITATIONS

The data used on the emissions of anaesthetic gases were reported by Portugal under the UNFCCC, and is only for N_2O, since the remaining emissions of anaesthetic gases are not included in that report. Thus, the estimates produced regarding the emission of anaesthetic gases are limited to N_2O emissions. Furthermore, the data used refer to the medicinal use of N_2O, not only for human health activities, but also for veterinary activities.

It is expected that in the future more specific information on anesthetic gas emissions from the Portuguese health system can be collected.

[3] Broken by supply-chain sector: C20 - Manufacture of chemicals and chemical products; C21 -Manufacture of basic pharmaceutical products and pharmaceutical preparations; D35 - Electricity, gas, steam and air conditioning supply; Q- Human health and social work activities; C19- Manufacture of coke and refined petroleum products; C31-C32 - Manufacture of furniture; other manufacturing; N- Administrative and support service activities; E37-E39 - Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services; I - Accommodation and food service activities.

HEALTH SECTOR EMISSIONS TARGET TRAJECTORY

A national target trajectory for the health sector GHG emissions was derived considering the "2050 Carbon Neutrality Roadmap for Portugal" (Roteiro para a Neutralidade Carbónica 2050 (RNC2050)), approved by the Resolution of the Council of Ministers No. 107/2019, of 1 July.

The following reduction targets, considering 2005 as the reference year, define the national decarbonization target trajectory established for Portugal until 2050. It should be noted that these reduction targets are in line with the 1.5°C limit established in the Paris Agreement.

- 45% to 55% reduction by 2030;
- 65% to 75% reduction by 2040;
- 85 % to 90 % reduction by 2050.

In line with the lower limit of the decarbonization trajectory for Portugal (-45%, -65%, and -85%), a target decarbonization trajectory was traced for the Portuguese health system considering the following reduction targets and taking 2014 as the reference year (since the emissions baseline was calculated for 2014):

- 29% reduction by 2030;
- 49% reduction by 2040;
- 69% reduction by 2050.

A target decarbonisation trajectory was also traced for the Portuguese public health sector, considering the reduction targets identified above. Figure 4 (left) shows the target decarbonisation trajectory for the Portuguese healthcare system up to 2050, and Figure 4 (right) shows the target decarbonisation trajectory for the public healthcare sector, defined using the method described above.

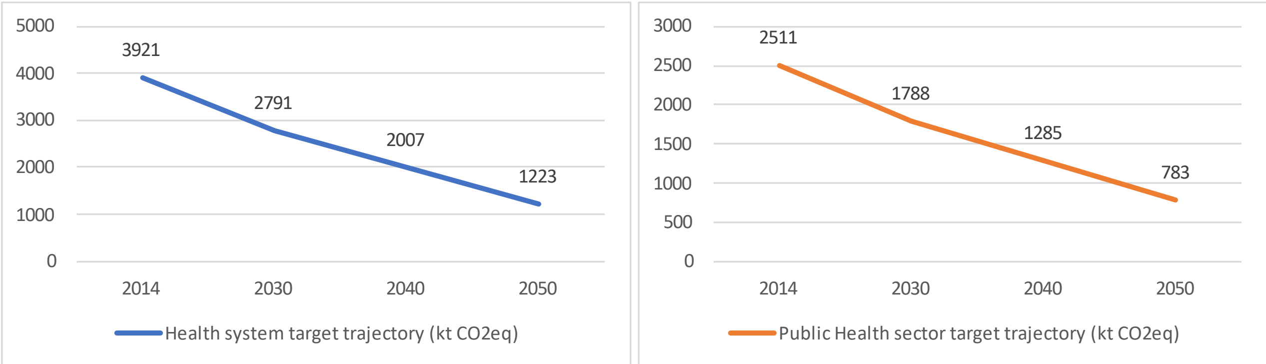


Figure 4 - Healthcare system target decarbonisation trajectory (left); Public healthcare sector target decarbonisation trajectory (right)

Ideally, GHG emissions from the Portuguese healthcare sector should respect these decarbonisation trajectories.

PROJECTIONS

OUR SCOPE, METHODS, AND DATA SOURCES

In the calculation of future emissions projections, the time interval between 2014-2050 was assumed, estimating future emissions for 2025, 2030, 2035, 2040, 2045 and 2050. The same method applied in the baseline calculation phase was used, applying top-down data, but also some bottom-up data.

In addition to the data sources initially used to calculate the emissions baseline, the following data sources were also considered:

- Energy Technology Perspectives – 2017 (ETP 2017) - International Energy Agency (IEA): The IEA data provides projections for three different decarbonization scenarios: the "Reference Technology Scenario (RTS)", the "2°C Scenario" and the "Beyond 2°C Scenario". In the projection of Scope 1, Scope 2, and Scope 3 emissions, the RTS scenario was used;
- European Commission projections for decarbonisation in the European Union: EU Reference Scenario 2020;
- Projections of the future evolution of expenditure in the health sector - Institute for Health Metrics and Evaluation (University of Washington);
- Population on 1st January by age, sex, and type of projection: Eurostat.

CALCULATIONS

For a detailed description of the calculations performed to prepare the emission projections ANNEX II-B should be consulted.

EXPLORATION OF RESULTS

Figures 5 and 6 describe the evolution of GHG emissions over the years, until 2050, for the entire health system and for the public health sector, respectively.

Taking into account the current projections for the decarbonization of the economy, and without considering any additional action taken by the health sector to mitigate GHG emissions, the results show a 42% reduction in emissions from the sector, in 2050, compared to the baseline year, 2014 (Figures 5 and 6). Thus, the total carbon footprint of the Portuguese health sector in 2050 will be around 2.29 Mt CO_2eq, with around 1.46 Mt CO_2eq (64%) being the responsibility of the public sector.

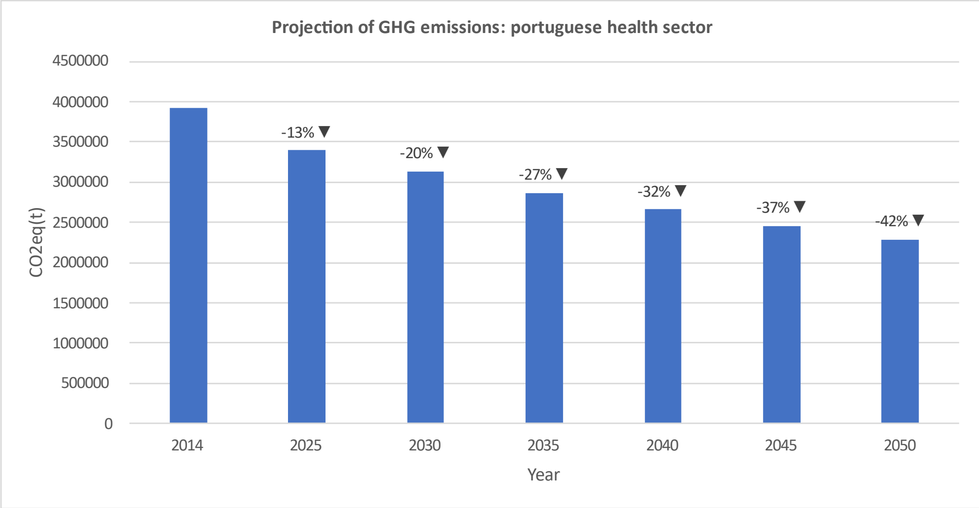


Figure 5 - Projection of GHG emissions from the portuguese health sector until 2050

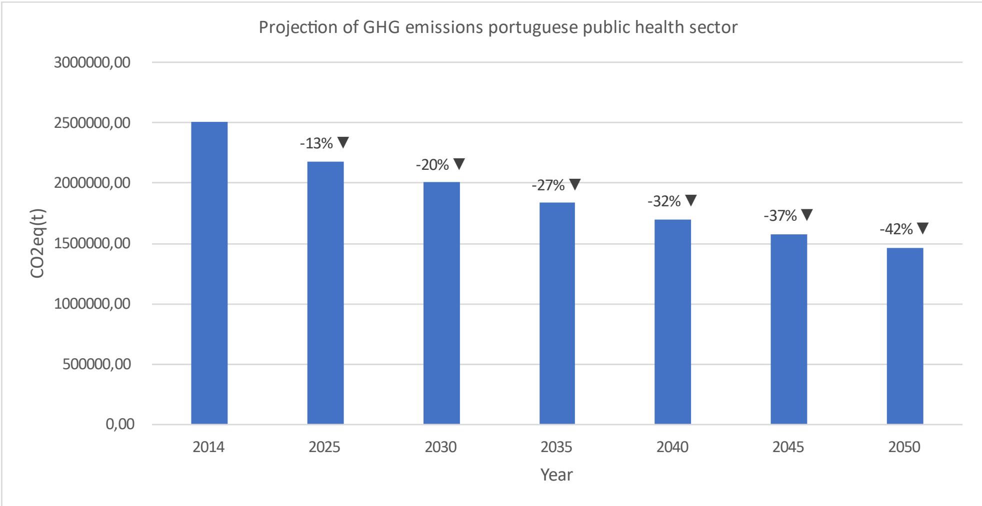


Figure 6 - Projection of GHG emissions from the Portuguese public health sector until 2050

By comparing the target emissions trajectories established in Chapter 3 of this document, which define the ideal decarbonization trajectories of the entire health system and the public health sector, with the emission projections until 2050, the following results were obtained (Figure 7).

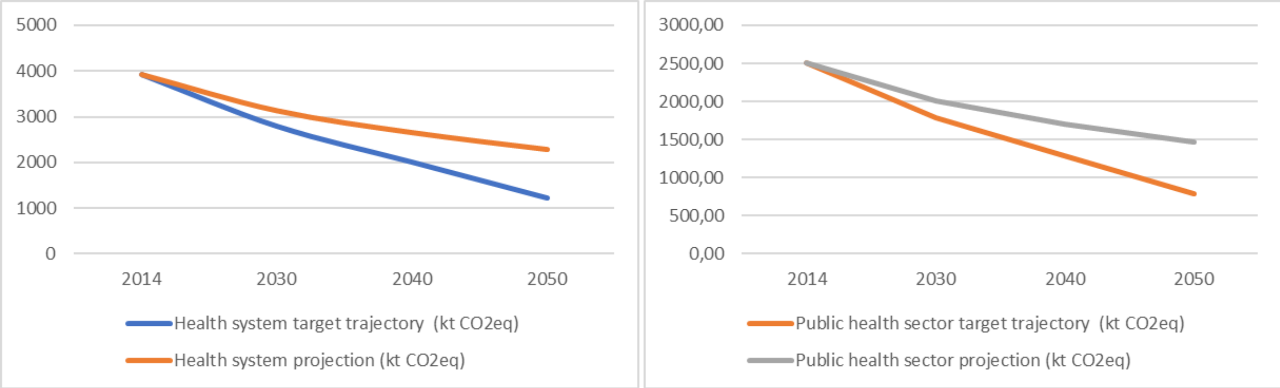


Figure 7 - Targeted decarbonisation trajectory of the healthcare system *versus* projected GHG emissions from the healthcare system (left), Targeted decarbonisation trajectory of the public healthcare sector *versus* projected GHG emissions of the public healthcare sector (right)

As can be seen in the table below, in both cases there is a significant gap between the target emissions value and the projected emissions value across the years. Considering the entire health system, to reach the target value in 2050, for example, projected emissions must undergo an additional reduction of 1068 kt CO_2eq this year. Focusing only on the public sector, to reach the target value for 2050, projected emissions must be reduced by 683 kt CO_2eq.

Table 1 - Gap between GHG emissions projections and target decarbonization trajectories

Year	2030	2040	2050
Health System (kt CO_2eq)	342	652	1068
Public Health Sector (kt CO_2eq)	218	417	683

From the analysis it is clear that in order to achieve the desired trajectories, the health sector needs to act to accelerate decarbonization. Therefore, the next chapter will be dedicated to the modeling and discussion of public health sector actions to mitigate the respective GHG emissions and obtain the necessary decarbonization levels to move towards the target decarbonization trajectory.

MODELLING ACTIONS

The study of the carbon footprint of the Portuguese health sector, presented in Chapter 2, revealed some sources of emissions with a very significant weight in the total carbon footprint, namely:

- Manufacture of chemicals and chemical products (C20);
- Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21);
- Consumption of purchased electricity (D35)
- Direct emissions (from combustion and fugitive emissions, on-site).

This chapter is dedicated to the modeling of measures to reduce the GHG footprint of the Portuguese health sector, having focused only on the public sector, as this is the universe covered by the Portuguese Ministry of Health.

ACSS

Actions to model

The Resolution of the Council of Ministers (RCM) n. º104/2020, of 24 November, establishes targets for energy consumption reduction, increasing of self-consumption through renewable sources, water consumption reduction, and materials consumption reduction, for all Portuguese public administration.

This RCM was implemented in the public healthcare sector through the publication of the Dispatch n. º 10372/2021, of 15th October, which created the ECO@SAÚDE Program (Environmental Sustainability Program at the Ministry of Health), and established the following sustainability targets, to which the Portuguese public healthcare entities are subject, considering 2019 as the reference year:

a) Energy efficiency: contribute to a 40% reduction in primary energy consumption, between the reference year and 2030;

b) Self-consumption: contribute so that 10% of energy consumption is supplied through self-consumption solutions from renewable energy sources, by 2030;

c) Water efficiency: contribute to a 20% reduction in water consumption, between the reference year and 2030;

d) Waste: contribute to a 20% reduction in waste production between the reference year and 2030;

e) Rehabilitation and improvement of buildings: contribute to achieving a 5% rate of energy and water renovation of buildings covered by ECO@SAÚDE, by 2030.

Meeting these sustainability goals has the potential to contribute not only to improving efficiency in the use of natural resources, but also to promoting the decarbonization of the public health sector. Basically, the fulfillment of ECO@SAÚDE targets can influence scope 1, scope 2 and scope 3 emissions, as they are intended to reduce water and energy consumption (gas and electricity) and waste production.

To model the effect of meeting these targets on projected emissions using the top-down method, target consumption reductions were converted into expense reductions, as explained in the following table. Although the ECO@SAÚDE targets were established considering 2019 as the reference year, since 2014 was used as the reference year in the calculation of the emissions baseline and projections, the modeling of the results of these expense reductions was carried out considering 2014 as the reference year.

Table 2 - Gap between target decarbonization trajectories and GHG emissions projections

Sector	ECO@SAÚDE targets	Expenditure reductions applied to the WIOD
Energy	-40% consumption +10% self-consumption	-50% expenditure
Water	-20% consumption	-20% expenditure
Waste	-20% production	-20% expenditure

Modeling results

The fulfillment of those sustainability targets allowed some additional reduction in the projected GHG emissions values, in relation to the emissions values of 2014 (Figure 8).

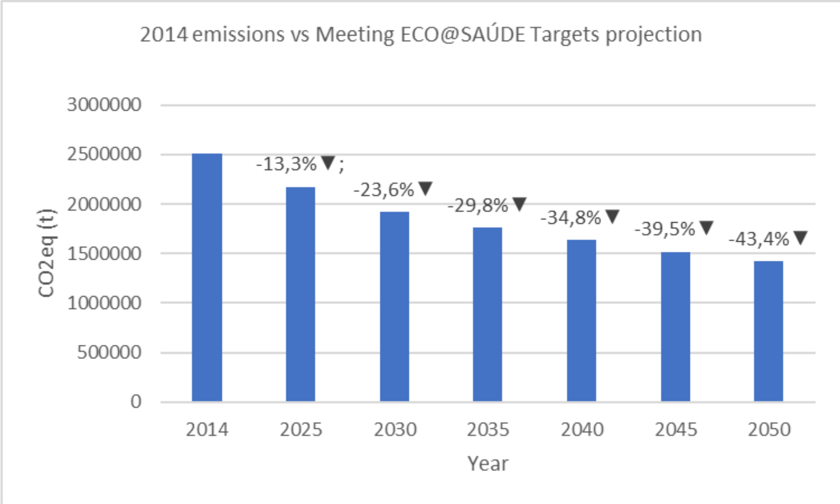


Figure 8 - Comparação entre as emissões de GEE em 2014 e as emissões projetadas, considerando o cumprimento das metas do ECO@SAÚDE

Modeling the fulfillment of ECO@SAUDE targets also contributes to the reduction of the calculated contribution of the facilities (energy and water consumption and waste production) in the expected total of GHG emissions from the public health sector, as can be seen in the figure below.

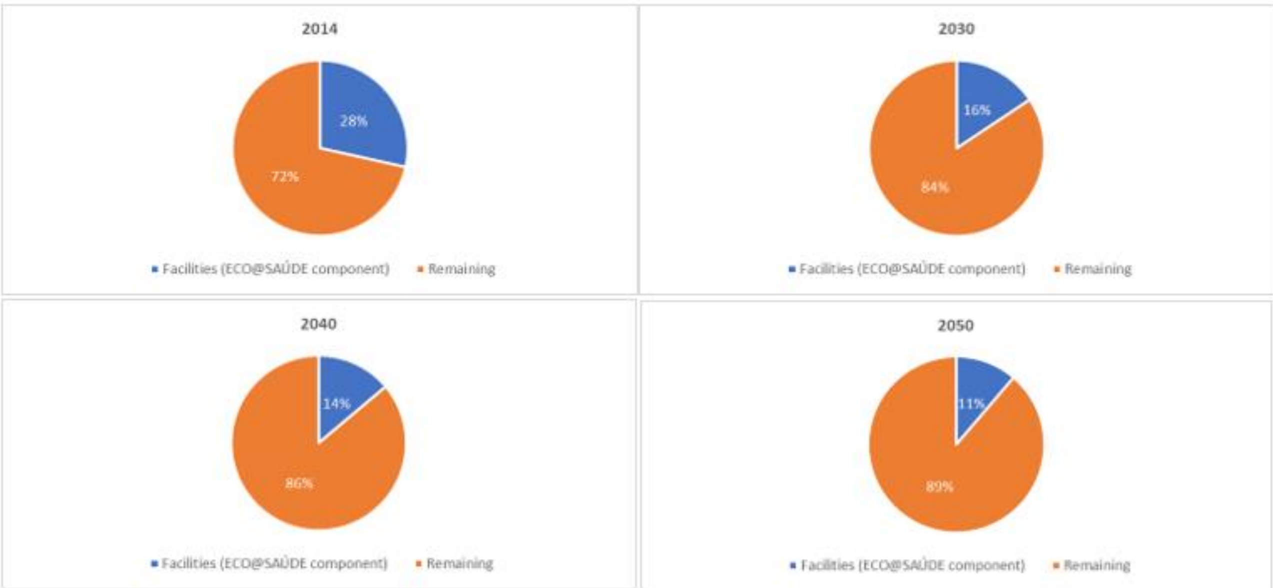


Figure 9 - Contribution of facilities to the total GHG footprint of the public health sector: (a) 2014; (b) 2030; (c) 2040 and (d) 2050

The accomplishment of the ECO@SAÚDE targets in 2030, contributes to reduce the facilities emissions projections by about 20%, regarding the first projection (Figure 10).

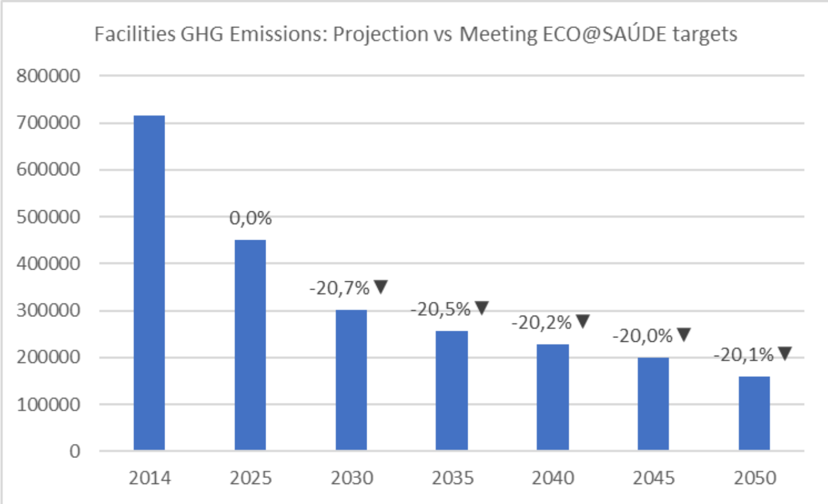


Figure 10 - Impact of meeting the ECO@SAÚDE targets in 2030 on the projection of GHG emissions from facilities (energy and water consumption and waste production) in the public health sector

The ECO@SAÚDE targets can be met by applying actions to promote energy and water efficiency and waste production reduction. Taking this into account, examples of important actions to increase the efficiency in the use of resources by entities in the health sector are identified below. The implementation of these actions and of others with the same purpose contributes, at the same time, to the reduction of GHG emissions by the health sector.

Energy efficiency

- Conducting periodic awareness-raising actions for energy efficient behavior
- Option for equipment and systems with higher categories of energy efficiency
- Implementation of Building Automation and Control Systems (SACE)
- Use design principles, at the level of the different engineering specialties, that enhance the principles of energy efficiency
- Interventions in the opaque envelope of the building (walls, windows, doors, roofs, and pavement)
- Incorporation of renewable energy sources, for self-consumption, whenever important improvements are at stake, or new constructions, thus improving the energy mix

Water efficiency

- Conducting periodic awareness-raising actions for water efficient behavior
- Option for equipment and systems more efficient regarding water consumption
- Remote and continuous monitoring of the water consumption of the different buildings/services, which make up the hospital building, to identify areas of high consumption and unjustified consumption (water leaks)
- Collect and use rainwater for watering green spaces or washing streets with the advantage of regularizing rainwater discharge into the public network
- To use design principles to improve water efficiency

Waste reduction

- Conducting periodic awareness-raising actions for waste reduction
- Efficient stock management, avoiding waste production
- Carry out regular (preventive) maintenance and repair of existing equipment in the hospital unit, in order to prolong its useful life

- Opting for multi-use medical devices, manufactured for the purpose of reuse (multiple use), rather than the respective single-use options;
- Dematerialization of procedures.

The Figure below shows the target decarbonization trajectory of the public healthcare sector emissions and the projected emissions trajectory, modeled considering the fulfillment of the ECO@SAÚDE targets.

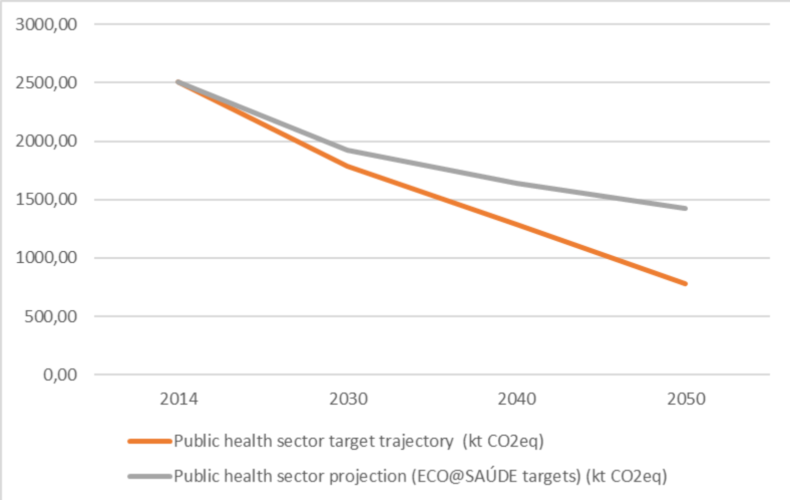


Figure 11 - Targeted emissions trajectory of the public health sector versus projected emissions trajectory considering the fulfillment of the goals of the ECO@SAÚDE program

As can be seen in the Table below, the gap between the target emission trajectory and the projection has been reduced, nonetheless, it still exists a significant difference between the target emissions and the projected emissions each year.

Table 3 - Targeted emissions trajectory of the public health sector *versus* projected emissions trajectory considering the fulfillment of the goals of the ECO@SAÚDE program

Year	2030	2040	2050
Public Sector (Kt CO_2eq)	218	417	683
Public Sector (ECO@SAÚDE targets) (Kt CO_2eq)	131	352	637

As the results of the baseline calculations showed, emissions related to the “Manufacture of chemicals and chemical products” and to the “Manufacture of basic pharmaceutical products and pharmaceutical preparations”, represent, respectively, the first and second main sources of GHG in the Portuguese Health Sector, together they represent more than 40% of the total GHG footprint of the Portuguese health system. These together -with the remaining Scope 3 emissions sources represent the great majority the footprint. Nonetheless, the sustainability targets, to which the Portuguese public healthcare entities are bound, regarding the ECO@SAÚDE Program, don’t address the supply-chain of the healthcare entities, and therefore they can’t influence the great majority of Scope 3 emissions, namely those related to the consumption of chemicals and pharmaceuticals etc.

Recognizing the limitation of the established ECO@SAÚDE targets to tackle GHG emissions regarding indirect, Scope 3, emissions, we recognize that the Portuguese public health sector needs to make a comprehensive approach to its emissions, an approach that goes beyond the ECO@SAÚDE program, and beyond the activity of ACSS facilities and equipment unit, and that needs to act on the sector's supply chain with the propose of minimizing its carbon footprint.

CONCLUSION

Following the OZ methodology ("Designing a Net Zero Road Map for Healthcare: Technical Methodology and Guidance"), we were able to calculate our baseline GHG emissions, and analyze the contribution of different direct and indirect emissions sources to that baseline. We also projected the future behavior of the health sector emissions and studied the effect of the accomplishment of ECO@SAÚDE targets on the mitigation of GHG emissions.

The results showed that the Portuguese health sector needs particularly to address its indirect emissions, related to the supply chain, and work to implement measures to minimize it, especially those related to the consumption of chemicals and pharmaceuticals. This work can be started for each healthcare entity when selecting their own purchases, opting for those with the lowest carbon footprint.

This work will be disseminated by the all the Portuguese public health entities, for the propose of spread the knowledge about the baseline and projected emissions of the Portuguese health system and reveal the need to act to reduce their carbon footprint.

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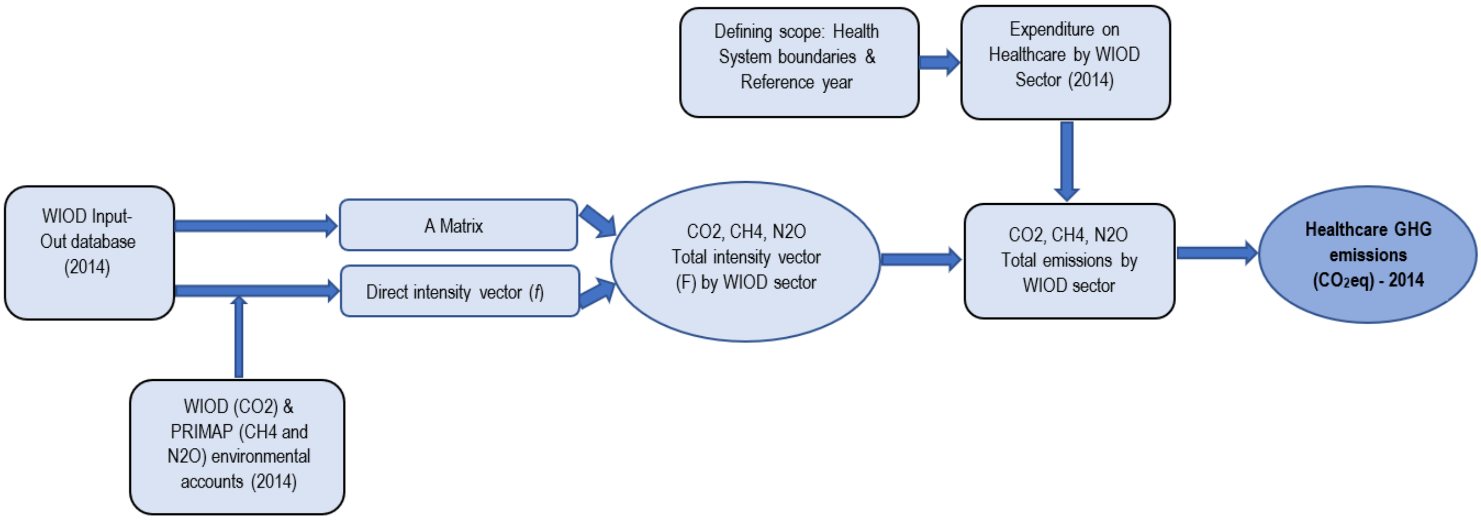
ANNEX I

Schematic explanation of the procedure we followed, which was guided by the methodology produced within the scope of the Operação Zero project.



ANNEX II-A

Calculations: Baseline

1. "TOP-DOWN" APPROACH

The "top-down" approach was applied to the calculation of CO_2 direct emissions - Scope 1 of the GHG Protocol, and to the calculation of GHG (CO_2, CH_4 and N_2O) indirect emissions - Scope 2 and 3 of the GHG Protocol.

1.1. Scope 1 emissions

To calculate the total CO_2 direct emissions from the Portuguese health system we used as emission factor the direct intensity vector calculated using the WIOD data for the Portuguese "Human health and social work activities" industry. We calculated the direct intensity vector by dividing the total CO_2 emissions of the Portuguese "Human health and social work activities" industry by the total output of that sector. After that, we multiplied this emission factor by the total value of expenditure on the health system.

1.2. Scope 2 and 3 emissions

Mapping expenditure: To apply the "top-down" methodology to the Scope 2 and 3 emissions calculation we needed first to map the expenditure data, covering the expenditure on the health sector, onto the categories used in the WIOD model. To do that we used the expenditure profile given by a SUT (Supply and Use Table), that we got from our national statistics office, that maps the expenditure of the Portuguese "Human health activities" across different supply chain activities.

Before we map the expenditure, we removed from it the amount of money spent with the payment of wages, so that we can concentrate our estimates on the portion of the expenditure that is associated with emissions and reduce the possibility of overestimating the emissions footprint of the Portuguese health system. We got the data about the expenditure with wages from the data collected by the Portuguese national statistics office for the "Human health activities" sector.

Emissions: We created the emissions factors (conversion factors) for CO_2, CH_4 and N_2O using the data from the WIOD table for 2014 and relating it with CO_2 emissions accounts from WIOD environmental accounts (2014) and with CH_4 and N_2O emissions accounts reported by the PRIMAP database (2014). In the case of CH_4 and N_2O, as the PRIMAP database reports emissions for these two gases against five aggregated categories (industries): Energy, Industrial Processes and Product Use, Agriculture, Waste, and Other, and three of them (Energy, Agriculture and Waste) directly correspond to a WIOD category, those emissions were attributed directly to those WIOD categories. PRIMAP database reports also emissions for two subcategories that align directly with WIOD categories, chemical industry, and metal industry, so we related those emissions directly with the correspondent WIOD categories

To calculate emissions factors for that three GHG we used the logic and the equation described in the Justin Kitzes (2013) article:

$$F = fL = f(I - A)^{-1}$$

Equation 1- Total intensity vector (F) (f=direct intensity vector; L=Leontief inverse matrix; I=identity matrix; A=A matrix)

To solve this equation, we first created the technical coefficient matrix, A matrix. To do that we divided each column in the central square of the WIOD input-output matrix, which gives the total dollar inputs into a sector, by the total output for that sector. After doing that, we calculated the Leontief inverse matrix (L), and then we multiplied this resulting matrix by the direct intensity vector (f) of each sector. The result of these calculations was the total intensity vector (F). This total intensity vector states the required upstream emissions for each dollar of output to final demand from a given economical sector, that is which we call, here, as the emission factor for each sector.

To make the complex calculations described above, since we needed to use big matrices (ex: 2464*2464), we used the RStudio software.

After having the emissions factors calculated for each of the WIOD categories for those three GHG, described as tons of GHG by EURO (tCO_2/EURO, tCH_4/EURO, and tN_2O/EURO), to get the total amount of emissions of each GHG, we multiplied those emission factors by the total amount of expenditure on the health system in each of the WIOD categories (industries).

We finally converted N_2O and CH_4 emissions into CO_2eq emissions, by multiplying the amount of N_2O and CH_4 emissions by the correspondent Global Warming Potential values.

1.3. Total greenhouse gases (GHG) emissions – "Top-down" approach

At last, we summed all Scope 1 and Scope 2 & 3 GHG emissions, calculated by the "top-down" approach, together. The result was of 3876655,029 tCO_2eq (3,876655029 MMtCO2eq).

2. "BOTTOM-UP" APPROACH

For the calculation of emissions produced by the use of anaesthetic gases and metered-dose inhalers consumption we used a "bottom-up" approach, as explained below.

2.1. Anaesthetic gases

About emissions from anaesthetic gases, we got information about N_2O emissions, from medical uses as anesthesia, from the Portuguese annual emissions report to the United Nations Framework Convention on Climate Change (UNFCCC) (APA, 2021). The amount of N_2O reported in 2014 was then converted in to CO_2eq using the corresponding Global Warming Potential (GWP).

2.2. Metered-Dose Inhalers (MDIs)

We received information about MDIs prescriptions numbers from the Shared Services for Ministry of Health (SPMS), an institution that manages the platform for electronic prescription of medicines used by the Portuguese health system. The data reported to us by SPMS, also regards the name of the MDIs prescribed, the corresponding composition, and the type of propellant used. Besides the MDIs prescription numbers and the type of propellant used, we also needed to know the quantities of propellant included in each type of MDIs prescribed. To get this information we did research in the literature, and we found a few documents that we used to collect information about propellant quantities. Most of the information that we used was found in the Wilkinson *et. al* (2019) article, but we also used information from Alexander and Libretto (1995). In the calculations that we made we multiplied the prescriptions quantities of each MDI by the corresponding propellant quantity, finally we converted the quantity of propellant emitted into CO_2eq emissions using the respective Global Warming Potential.

3. TOTAL GHG EMISSIONS

The sum of emissions calculated by the "top-down" and "bottom-up" approach was of 3921183,08 tCO_2eq (3,921183082 $MtCO_2$eq).

ANNEX II-B

Calculations: Projections

1. “TOP-DOWN” APPROACH

1.1. SCOPE 1 EMISSIONS PROJECTION

To calculate the projections for the direct CO_2 emissions, from the Portuguese health system, until 2050, we started with the direct intensity vector, calculated before, using the WIOD 2014 data, for the Portuguese “Human health and social work activities” sector, then we used the decarbonization trajectory for the energy sector, defined by the International Energy Agency (IEA) in the Energy Technology Perspectives (ETP) 2017 report, to model the evolution of this direct intensity vector throughout the years.

We chose to assume the decarbonization trajectory projected for the energy sector since we assumed that most part of the direct emissions from the Portuguese health system results from the use of energy. After having the direct intensity vectors (emissions factors) calculated for every year, we multiplied these emission factors by the total value of the expected expenditure on the health system, modeled by the Institute for Health Metrics and Evaluation (IHME), and finally, we obtained the value of the Scope 1 CO2 emissions for 2025, 2030, 2035, 2040, 2045 and 2050.

1.2. SCOPE 2 AND 3 EMISSIONS PROJECTION

The projections for the Scope 2 and 3 emissions were produced considering: the projected expenditure growth on the Portuguese healthcare sector, given by the IHME, and the future decarbonization trends for the different world industries until 2050 (ETP 2017).

1.2.1. Carbon dioxide (CO_2) emissions

For creating the projections of Scope 2 and Scope 3 CO_2 emissions of the Portuguese health sector across the years, until 2050, we used the CO_2 emission evolution trajectories, given by the ETP data, for different economic sectors. We started by applying the evolution trajectories to the direct intensity vectors calculated before with the 2014 WIOD data. After defining the direct intensity vectors for 2025, 2030, 2035, 2040, 2045 and 2050, we calculated the respective total intensity vector, by multiplying the direct intensity vector by the Leontief Inverse Matrix. Having the total intensity vector and the expected expenditure on the health system for a particular year in a particular industry, we then use it to calculate CO_2 emissions of the health sector for that specific year.

1.2.2. Non-Carbon dioxide (Non-CO_2) emissions

In the case of “Non-CO_2” GHG emissions (CH_4 and N_2O), when we conducted the emissions baseline calculations, we estimated emissions for these two gases starting from the PRIMAP emissions accounts. Since the PRIMAP accounts reports emissions only for five WIOD categories (Crop and animal production, hunting and related service activities; Manufacture of chemicals and chemical products; Manufacture of basic metals; Electricity, gas, steam, and air conditioning supply; Sewerage, waste collection, treatment and disposal activities, materials recovery, remediation activities and other waste management services), we investigated "NON-CO_2" GHG emissions future trajectories only for those five categories.

In the case of energy and waste-related categories, we followed the enlightenments given by the Annex A of the Global Road Map for Health Care Decarbonization (HCWH, 2021), so we considered that these two WIOD sectors will follow, for those two “Non-CO_2” GHG, the decarbonization trajectory given by de ETP data for CO_2 emissions from the energy sector. In the case of “Non-CO2” “agricultural” emissions, we used the decarbonization trajectory projected by the European Commission for the European Union until 2050 (European Union, 2020). In the specific case of chemicals and basic metals sectors, since we didn’t find data on them, we assumed no changes in “Non-CO2” GHG emissions rates until 2050.

After adopting these emissions trajectories, we applied them to the direct intensity vector of CH_4 and N_2O for 2014, and then we calculated the respective total intensity vector by multiplying the direct intensity vector by the Leontief Inverse Matrix, for every five years (i.e. 2025, 2030, 2035, 2040, 2045, 2050). Having the total intensity vector and the expected expenditure for a particular year, we calculated CH_4 and N_2O future emissions for the Portuguese health sector.

We finally converted N_2O and CH_4 emissions into CO_2eq emissions, by multiplying the amount of N_2O and CH_4 emissions by the corresponding Global Warming Potential values.

1.3. SCOPE 2 EMISSIONS PROJECTION

To break out Scope 2 emissions from the Scope 2 and 3 grouping, we used the direct CO_2, CH_4 and N_2O emission factors created for the “Electricity, gas, steam and air conditioning supply” category, multiplying it by the expenditure on this category. For the purpose of projecting CO_2,

CH_4 and N2O emissions until 2050 we adjusted the direct emissions factors according to the decarbonization trajectory given by de ETP data for CO_2 emissions from the energy sector, then we multiplied these emissions factors by the projected expenditure on that category.

2. "BOTTOM-UP" APPROACH

2.1. Anaesthetic gases emissions projection

Since we didn't find any published trajectories for the evolution of anaesthetic gases consumption (emission), we created a trajectory on that based on a projection for the evolution of population numbers in Portugal. The projected population estimates were created by the Eurostat, covering the time horizon from 2019 to 2100. Starting with the emissions reported by Portugal to the UNFCCC for 2014, specifically for N_2O, we adjusted the emissions evolution across the years, until 2050, according to the evolution expected for the population, calculating emissions of this GHG for 2025, 2030, 2035, 2040, 2045 and 2050. The results that we got applying this approach showed us that in 2050 N_2O emissions will be reduced by 10% in relation to 2014 (Figure below).

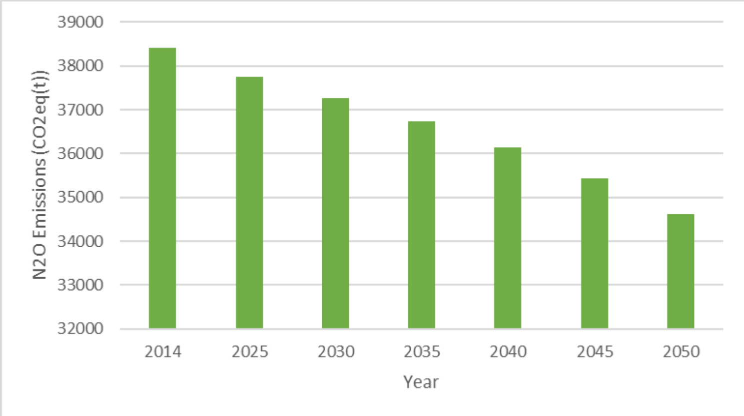


Figure 12 - N_2O emissions (CO_2eq), for medical uses as anaesthesia, evolution

We think that the decrease on the emission of this anesthetic gas can be greater that this estimate shows, since the use of this GHG as anaesthesic has been decreasing significantly over the years since the start of the report made to the UNFCCC, but unfortunately, we have no concrete data about the expected use of this anaesthetic gas across the next decades.

2.2. Metered-dose inhalers emissions projection

Also, in the metered-dose inhalers case, we didn't find any projection of the future emissions trajectories for the respective HFC gases emissions, so we proceeded as in the anaesthetic gases (N_2O) case. We created a trajectory on the MDIs emissions evolution based on the Eurostat projection for the evolution of population numbers in Portugal, calculating emissions of this GHG for 2025, 2030, 2035, 2040, 2045 and 2050. The results that we got applying this approach showed us that in 2050 MDIs emissions will be reduced in 10% in relation to 2014 (Figure below).

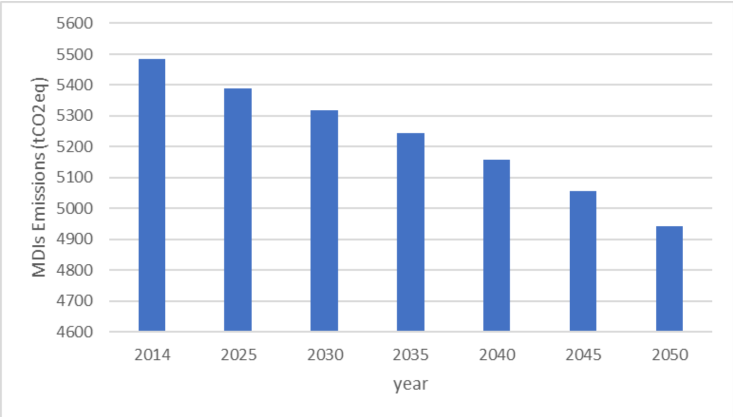


Figure 13 - Evolution of emissions from pressurized metered dose inhalers

Also, in this case, we think that the decrease of the GHG emissions due to the prescription and use of MDIs, can be greater that the estimate, due to the evolution of knowledge of health professionals in relation to the environmental impacts derived from the prescription of this type of device, and to the development of alternatives.

ANNEX III

WIOD Industries Coding

A01	Crop and animal production, hunting and related service activities
A02	Forestry and logging
A03	Fishing and aquaculture
B	Mining and quarrying
C10-C12	Manufacture of food products, beverages and tobacco products
C13-C15	Manufacture of textiles, wearing apparel and leather products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31_C32	Manufacture of furniture; other manufacturing
C33	Repair and installation of machinery and equipment
D35	Electricity, gas, steam and air conditioning supply
E36	Water collection, treatment and supply
E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
F	Construction
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
G46	Wholesale trade, except of motor vehicles and motorcycles
G47	Retail trade, except of motor vehicles and motorcycles
H49	Land transport and transport via pipelines
H50	Water transport
H51	Air transport
H52	Warehousing and support activities for transportation
H53	Postal and courier activities
I	Accommodation and food service activities
J58	Publishing activities
J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities
J61	Telecommunications
J62_J63	Computer programming, consultancy and related activities; information service activities
K64	Financial service activities, except insurance and pension funding
K65	Insurance, reinsurance and pension funding, except compulsory social security
K66	Activities auxiliary to financial services and insurance activities

L68	Real estate activities
M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities
M71	Architectural and engineering activities; technical testing and analysis
M72	Scientific research and development
M73	Advertising and market research
M74_M75	Other professional, scientific and technical activities; veterinary activities
N	Administrative and support service activities
O84	Public administration and defence; compulsory social security
P85	Education
Q	Human health and social work activities
R_S	Other service activities
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
U	Activities of extraterritorial organizations and bodies

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