Decarbonizing Canadian Health Care

Analysis and Estimates

Prepared for:

ASPQ
ASSOCIATION POUR LA SANTÉ PUBLIQUE DU QUÉBEC

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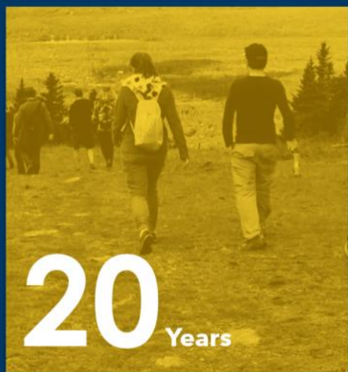
About Dunsky



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PREAMBLE

In the fall of 2023, the *Association pour la santé publique du Québec* mandated Dunsky Energy + Climate Advisors to provide high-level analyses and estimates in response to the following question:

How can Canada's health care sector achieve net-zero emissions by 2050?

To answer this question, we drew on publicly available Canadian data from sources such as Natural Resources Canada, Environment and Climate Change Canada and the Canada Energy Regulator. We then developed a roadmap for how the Canadian health care sector can achieve a net-zero building stock and vehicle fleet by 2050, identifying strategies that maximize impact and estimating the level of investment required.

The analysis also built on our December 2023 study on decarbonizing Quebec's health care sector, *Décarbonation du secteur de la santé – Diagnostic, trajectoires et stratégies* [Decarbonizing health care: Diagnosis, pathways and strategies] (in French only).[1]

The projections in this roadmap are not meant to predict what the Canadian health care sector will look like in the future. They simply present a scenario in which net-zero emissions can be efficiently achieved by 2050, to the best of our knowledge and based on the state of technology and available data when this report was prepared.

Our analysis focused mainly on emissions from energy use, but changes to health care delivery models and new medical practices will also play an important role in reducing the health care sector's carbon footprint. Any action that can be taken in those areas will make it easier to achieve the roadmap's end goal.

We acknowledge that there are barriers to achieving net-zero in the health care sector, with multiple ways to achieve this goal, particularly for buildings. This roadmap is not meant to downplay the difficulty and complexity involved in decarbonizing health care or to impose a single vision of how this should be done, rather, establish a solid baseline for proposing initiatives and actions that can make a difference.

[1] Dunsky Energy + Climate Advisors. 2023. "Décarbonation du secteur de la santé – Diagnostic, trajectoires et stratégies." https://aspq.org/une-nouvelle-feuille-de-route-au-service-de-la-decarbonation-du-systeme-de-sante-quebecois/ (French only)

Acronyms, abbreviations and units of measure

ACH	Air exchanges per hour
ASPQ	Association pour la santé publique du Québec [Québec public health association]
CIHI	Canadian Institute for Health Information
CISSS	Centre intégré de santé et de services sociaux [Integrated health and social services centre]
CIUSSS	Centre intégré universitaire de santé et de services sociaux [Integrated university health and social services centre]
COP	Coefficient of performance
EV	Electric vehicle
FCV	Fuel cell vehicle
GHG	Greenhouse gas
GJ	Gigajoule
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-emitting diode
MSSS	Ministère de la Santé et des Services sociaux [Quebec department of health and social services]
MURB	Multi-unit residential building
NRCan	Natural Resources Canada
NHS	National Health Service (England)
PJ	Petajoule
RNG	Renewable natural gas
SCC	Social cost of carbon
TJ	Terajoule
W	Watt
ZEV	Zero-emission vehicle

Executive Summary

The World Health Organization has identified climate change as one of the biggest threats to our health. The activities of health care systems contribute to climate change, with Canada's health care sector currently accounting for nearly 5% of the country's total greenhouse gas (GHG) emissions.[2] In May 2022, Canada's Minister of Health pledged to achieve net-zero emissions in the country's health care sector by no later than 2050.

Dunsky Energy + Climate Advisors was commissioned to provide high-level analyses and estimates of the work required to achieve this goal. As such, we have developed a roadmap for how the Canadian health care sector can lower its direct emissions, including identifying strategies that maximize impact.

Most direct (scope 1) emissions in the health care sector are from fossil fuel use in buildings, particularly space and service water heating. Medical gases and emissions from emergency patient transport and other health care service vehicles account for the rest.

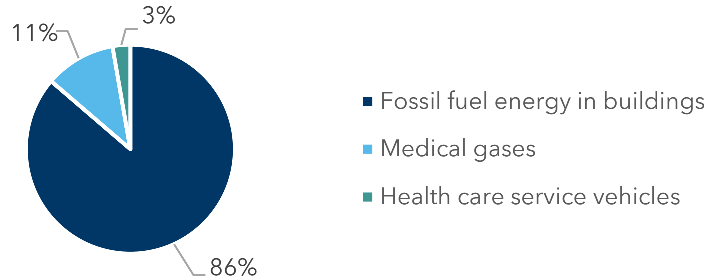

Figure E1. Direct (scope 1) GHG emissions from the Canadian health care sector

Scope 2 emissions are from fossil fuel-based electricity production. Scope 2 emissions vary from province to province but taken together, are equivalent to about one third of the sector's direct emissions.

The decarbonization roadmap

The first key to efficient decarbonization is to reduce energy use in buildings by **40%** through energy-saving measures such as **LED lighting and controls, heat recovery technology and higher-efficiency heating systems**. Measures like these prevent unnecessary stress on the electrical grid and reduce the need to produce extra renewable energy to meet decarbonization goals.

Heat recovery is key, as health care facilities experience higher rates of heat loss than other kinds of buildings due to health safety standards mandating higher air exchange rates per hour. Advancements in heat distribution networks and ventilation systems have made it possible to capture surplus heat from internal heat loads and exhaust air, reducing the demand for heating.

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[2] Eckelman MJ, Sherman JD, MacNeill AJ. 2018. Life cycle environmental emissions and health damages from the Canadian healthcare system. PLOS Med. Jul 31;15(7).

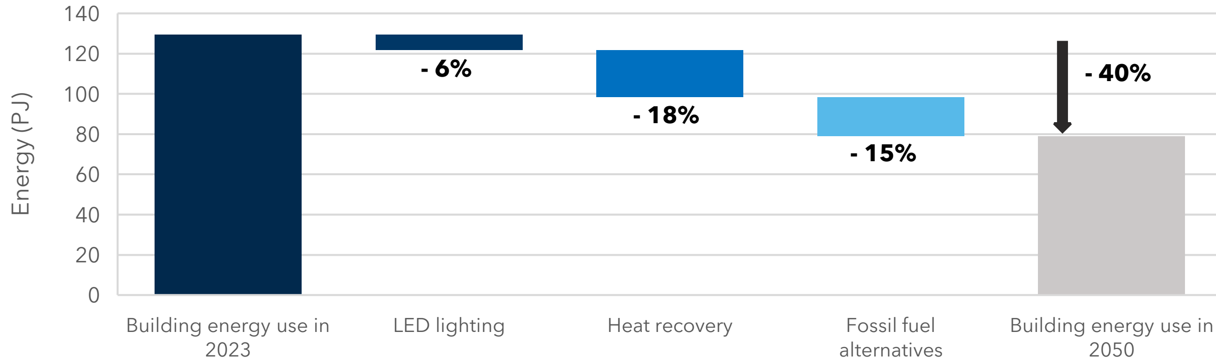

Figure E2. Key measures for reducing energy use in buildings

The next step after implementing energy efficiency measures is to **reduce the use of electricity produced from fossil fuels**. High-efficiency technologies such as geothermal systems and, to a lesser extent, aerothermal systems should be used whenever possible for heating air and preheating service water. The energy needed for processes that are more challenging to electrify, such as steam production, sterilization and cleaning, plus heating water to the right temperature, should be supplied by a mix of biomass, electricity, and renewable natural gas (RNG).

As for vehicles, **gradually transitioning to all-electric ambulances and health care road vehicles by 2050** would eliminate GHG emissions associated with emergency patient transport. Emissions from medical gases can also be eliminated by switching out high-carbon-footprint gases, such as inhaler gases and anaesthetic gases like desflurane, for lower-impact medical practices such as intravenous anaesthesia.

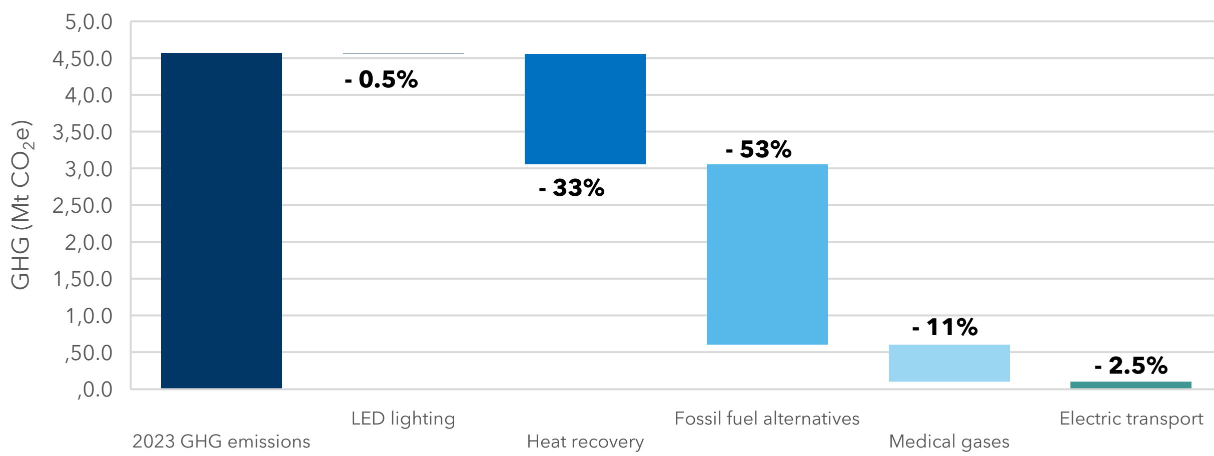

Figure E3. Direct (scope 1) emissions reduced as a result of roadmap interventions – 2050 projection[3]

Decarbonizing Canadian health care will require an investment of **$8 billion** over the next five years and a total investment of $34 to $45 billion between now and 2050.[4]

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[3] The 2023 GHG emissions in Figure E3 do not include emissions from electricity (scope 2 emissions).
[4] This number includes additional investment costs but does not account for energy savings, avoided power costs or the social cost of carbon.

Table E4. Summary of costs and total GHG reductions from decarbonizing health care

Area	Total GHGs avoided, 2024–2050[5]	5-year investment	Total investment
Buildings	75 Mtonnes	$7.8B	$32B – $42B
Vehicles	2 Mtonnes	$0.2B	$1.6B – $2.6B
Total	**77 Mtonnes**	**$8B**	**$34B – $45B**

All other things being equal, a decarbonized electrical grid alone would reduce GHG emissions by 24% by 2050.[6] Changes in grid carbon intensity are projected to play a large part in reducing GHG emissions by 2030.

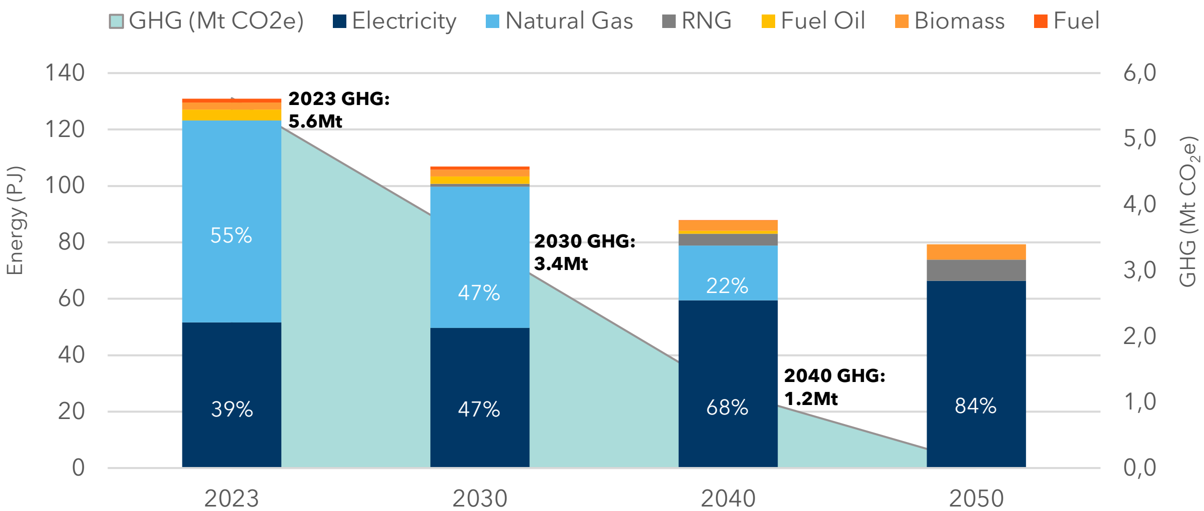

Figure E5. Change in health care energy profile and GHG reductions[7]

Pursuing decarbonization would bring the goal of achieving net-zero emissions by 2050 within reach and yield **$26 billion in savings between now and 2050**. Once all the measures in the roadmap are in place, annual savings of $2 billion are anticipated starting in 2050. The sector will double the share of electricity in its energy profile, eliminate fossil fuel energy, and fully harness the power of a decarbonized electrical grid. Apart from achieving the goal of net-zero health care, the roadmap will also lead to 1) dramatically reduced energy use and energy costs for buildings, 2) lower energy and maintenance costs for vehicles and 3) health benefits due to reduced emissions. However, if we want to meet this target by 2050, we need to start making the necessary investments now.

The roadmap assumes that all energy-saving measures will be in place by 2035 at the latest. Delays in taking action will only amplify the amount of work it will take to meet the target by 2050. Making health care a net-zero sector requires a resolute commitment to achieving this goal and funds specifically earmarked for decarbonization efforts.

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[5] Includes avoided GHGs from medical gases and decarbonized electrical grids.
[6] Government of Canada. 2023. Canada's Greenhouse Gas and Air Pollutant Emissions Projections. https://publications.gc.ca/collections/collection_2023/eccc/En1-78-2023-eng.pdf
[7] GHGs include scope 2 emissions but do not include medical (non-energy) gases.

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1. Introduction

1.1. Background

The World Health Organization has identified climate change as one of the biggest threats to health, however, the activities of health care systems also contribute to climate change. In Canada, the health care sector currently accounts for nearly 5% of the country's total greenhouse gas (GHG) emissions.[8] At a May 2022 meeting of the G7 in Germany, Canada's Minister of Health pledged to achieve net-zero emissions in the country's health care sector by no later than 2050.[9]

Health care buildings typically have a higher energy use intensity than other public sector buildings. This is in addition to emissions from emergency vehicles and indirect emissions such as those associated with waste, equipment (both medical and non-medical), the supply chain, food, and patient and staff travel.

Given the health care sector's relative significance in Canada's public sector, it must be considered a key priority and given particular emphasis if we are to achieve our 2050 climate goals. There are opportunities that can be seized and **concrete actions** that can be taken in the areas of energy efficiency, electrification, renewable energy, and effective energy management.

The **benefits** of low-carbon health care extend far beyond environmental gains, from improved air quality and more predictable energy costs, to lower operating costs and optimized health care services. Decarbonizing health care offers Canada the opportunity to lead by example on the world stage, while simultaneously meeting its climate goals and delivering broader health benefits.

1.2. Overview of our mandate

Dunsky Energy + Climate Advisors was commissioned to provide advanced analysis and estimates of the work required to make the country's health care sector achieve net-zero by 2050. To carry out this mandate, we estimated the health care sector's current emission levels and identified maximum-impact strategies for lowering these emissions. The analysis was built on our 2023 study on decarbonizing Quebec's health care sector.[10]

Based on our analysis, we have created a **decarbonization roadmap** for Canadian health care as a whole. We estimated the level of investment required to achieve a net-zero health

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[8] Eckelman MJ, Sherman JD, MacNeill AJ. 2018. Life cycle environmental emissions and health damages from the Canadian healthcare system. PLOS Med. Jul 31;15(7).
[9] G7 Germany. May 20, 2022, Berlin. https://www.g7germany.de/resource/blob/974430/2042058/5651daa321517b089cdccfaffd1e37a1/2022-05-20-g7-health-ministers-communique-data.pdf?download=1
[10] Dunsky Energy + Climate Advisors. 2023. Décarbonation du secteur de la santé. https://aspq.org/app/uploads/2024/01/dunsky_decarbonation-sante_rapport-final_18dec2023.pdf (French only)

care building stock and vehicle fleet by 2050 using an efficient decarbonization approach focused first and foremost on reducing energy use.

The primary constraint we imposed on our simulated decarbonization efforts was that the goal of achieving net-zero emissions must be met. Given the current energy landscape, we also wanted to ensure that the approach set out in the roadmap minimized any undue stress on electric power systems. Essentially, we did not impose limitations on electricity generation capacity in our analysis, but the principles of efficient decarbonization guided our choice of actions.

We acknowledge that there are significant barriers to achieving net-zero in health care and that there is multiple ways to achieve that goal, particularly for buildings. This roadmap is not meant to downplay these barriers or to impose a single vision of how this should be done, rather, establish a **solid baseline** for determining the key actions that should be taken.

The analysis also drew on our energy expertise and did not involve changes to health care delivery models or new medical practices that could help reduce GHG emissions. However, any action that can be taken in those areas will make it easier to achieve the roadmap's end goal.

Lastly, it should be noted that uncertainties and inaccuracies are inevitable in any high-level analysis spanning the whole of Canada. More focused studies at the provincial/territorial and health care facility levels are required; this report simply provides a starting point for further exploration.

2. GHG emissions overview

Canada's health care sector generates **4.6% of the country's GHG emissions** (approximately 33 million tonnes) when including indirect (scope 2 and 3) emissions.[11] A general breakdown of the sector's primary emission sources is provided in Figure 1. .

GHG emissions from buildings were determined primarily using data from Natural Resources Canada (NRCan).[12] Since there is a lack of aggregate data on vehicle emissions at the national level, we extrapolated data from our Quebec health care study. Indirect emissions data were drawn from a variety of North American and European sources. While there is some inherent uncertainty when using data from other countries, these were the best sources of information at our disposal at the time of our analysis. Details about the data used can be found in

Appendix A.

[11] Eckelman MJ, Sherman JD, MacNeill AJ. 2018. Life cycle environmental emissions and health damages from the Canadian healthcare system. PLOS Med. Jul 31;15(7).
[12] NRCan. 2020. Table 15. Health Care and Social Assistance Secondary Energy Use and GHG Emissions by Energy Source.
https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=com&juris=ca&rn=25&year=2020&page=3.

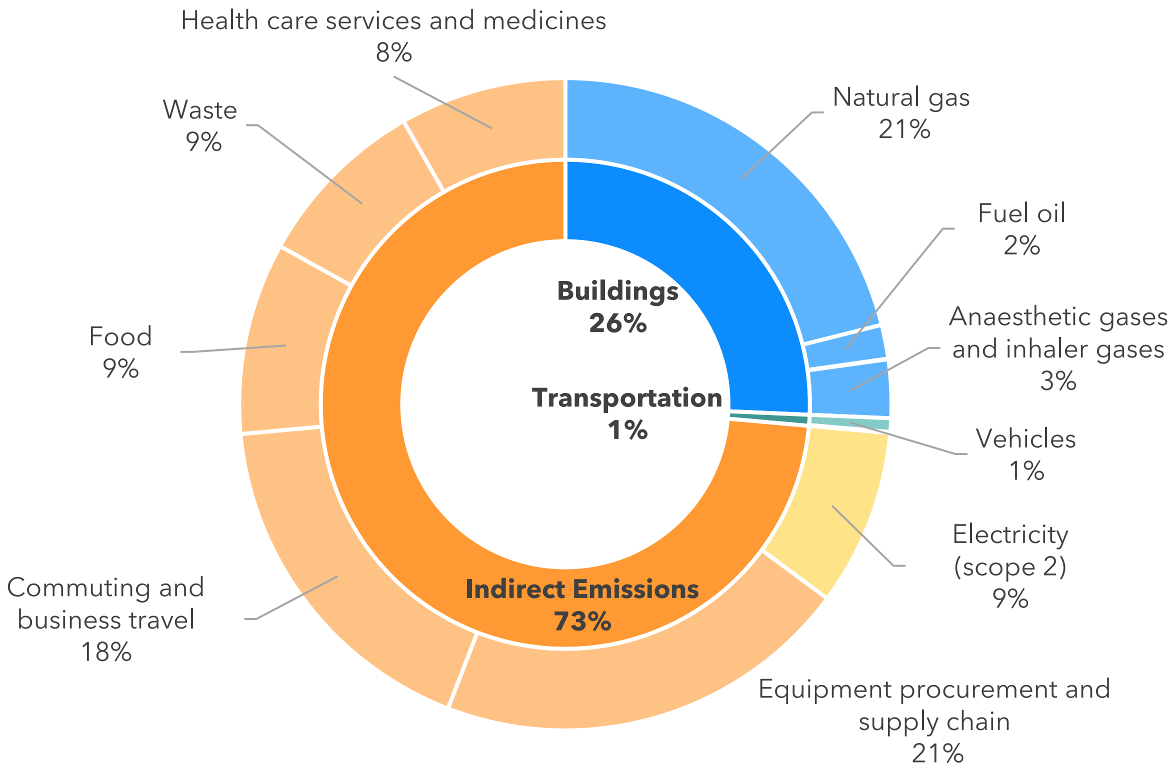


Figure 1. Overview of GHG emissions in Canada's health care sector[13]

2.1. Buildings

Buildings are responsible for just over a quarter of all emissions. According to NRCan, Canada boasts 67.85 million square metres of health and social services space,[14] housing a total of approximately 328,500 beds across the country (all facility types combined).[15]

In general, health care facilities, especially hospitals, differ from regular buildings in that they not only see high volumes of activity, but critically, must also be very well ventilated in order to comply with health and safety standards. This directly impacts the facilities' heating and ventilation needs, and their overall energy use profile. Hospitals are also 40% more energy-intensive than other health care buildings on average. Energy use intensities for health care buildings are provided in

Appendix A.

[13] Emissions from patient, visitor and supplier travel are excluded.
[14] 2020 floor space linearly extrapolated to 2023: NRCan. 2020. Table 15. Health Care and Social Assistance Secondary Energy Use and GHG Emissions by Energy Source. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=com&juris=ca&rn=25&year=2020&page=3.
[15] Canadian Institute for Health Information (CIHI). 2021–2022. Canadian MIS Database (CMDB).

Fossil fuels, i.e., natural gas and fuel oil, are the main source of direct building emissions. The primary uses for these fuels are shown in Figure 2. .

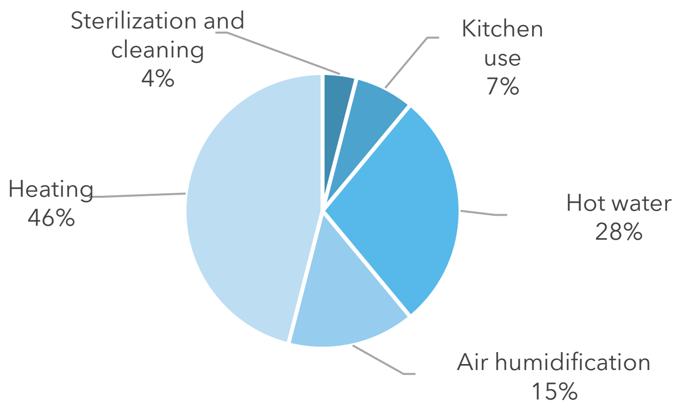


Figure 2. GHG emissions from fossil fuels, by use[16]

2.2. Transportation

GHGs from vehicles account for 1% of all health care emissions. This includes emergency patient transport by ambulance, airplane and van, as well as employee travel using corporate vehicles (Figure 3.). The assumptions used to calculate emissions in each patient transport category are provided in

Appendix A.

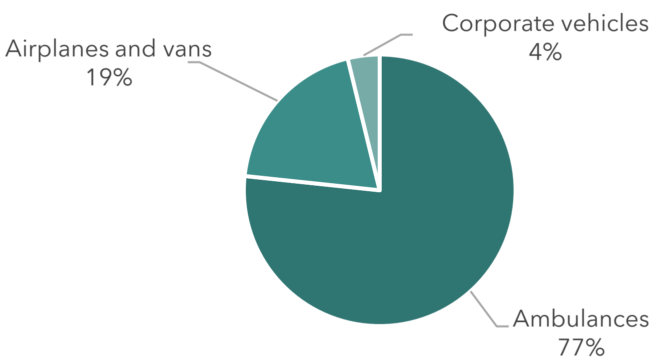


Figure 3. Sources of GHG emissions from vehicles

3. The decarbonization roadmap

Our roadmap for achieving net-zero emissions in the health care sector lists the key actions and estimated investments required to transition Canadian health care buildings and vehicles away from carbon by 2050. We have chosen to present options that 1) are aligned with the target of net-zero emissions, 2) leverage proven technologies and 3) result in lower costs whenever possible.

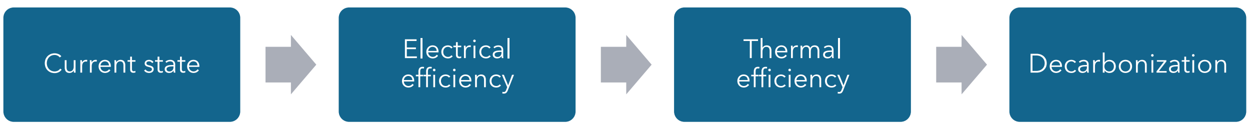
[16] The GHG breakdown was determined based on our knowledge of the sector.

Our analysis encompasses both the existing building stock and vehicle fleet however, does not account for potential growth in the health care sector. We assumed an average inflation rate of 2% each year until 2050.

3.1. Buildings

Transitioning Canada's health care facilities to net-zero emissions by 2050 will require significant changes to both the equipment and sources of the energy they use. We expect the health care sector's consumption of electricity to approximately double over this period of time.

We've identified **reducing energy use** from both electrical and thermal sources as the top priority to minimize the stress on electrical infrastructure caused by decarbonization. For this reason, some of the measures in the roadmap focus on energy efficiency to lessen the need for decarbonization measures. The phases of the roadmap can be summarized as follows:



For each phase, we have determined a set of actions, evaluated the scope of their impact sector-wide, and quantified the resulting change in energy use, costs, and GHG emissions through 2050. Actions have been chosen based on the **highest potential for impact**.

Health care facilities have a specific operational context that make them distinct from other kinds of buildings, providing unique opportunities for heat recovery. Under health safety standards, fresh air must be brought into health care facilities at a rate equivalent to two air exchanges per hour (ACH); in other words, the volume of air in a facility must be replaced at least every 30 minutes, sometimes much more frequently in clinical and technical facilities. With that in mind, some actions were not considered to have a sector-wide impact, although they are still relevant and applicable to the decarbonization process for certain buildings. For example, measures to recover heat from exhaust air are much more impactful than upgrading a building's envelope, even though both require substantial investments. However, if major renovations on a building are already in the works, the opportunity could be taken to upgrade the envelope.

We conducted a "top-down" analysis drawing on energy use data from the Canadian health care sector as a whole. The impact of the proposed measures was determined using energy modelling for four climate zones (see the climate zone map in Appendix C). A Canadian average was calculated using a weighted average based on the population distribution for the four zones. Average values and assumptions were then established for the health care sector as a whole, such as energy use distribution and system efficiency. Details of the parameters, climate zones, and assumptions used for calculations are provided in Appendix C. All in all, our analysis was very high-level, and more detailed analyses are needed to account for specific provincial and territorial differences.

For the purpose of our analysis, the total cost of new equipment acquired to drive decarbonization is considered an additional expense, since fossil fuel-based equipment will be kept on hand as a resiliency strategy. The assumption is that this backup equipment will remain available as a redundant power supply in the event of a power outage. By 2050, it may be feasible to run this backup equipment on renewable fuels. This roadmap will therefore focus on decarbonizing primary heating systems.

3.1.1. Pathways to decarbonization

LED lighting

New LED light bulbs in facilities that have not already upgraded to LEDs[17] would use 15% less energy, **reducing overall energy use by 6%**. Lighting is the second-largest end use of electricity after auxiliary equipment, which is more limited in its energy-saving potential. Switching to LEDs would both save power and lower indirect emissions from energy generation (scope 2 emissions).

Heat recovery

Heat recovery systems has the potential to **reduce overall energy use by 18%**.[18] In many health care facilities, heat recovery is not possible with the systems currently in place. Major changes or complete overhauls of their mechanical systems are needed, particularly for heat distribution and ventilation. Recovered heat can handle a large part of a facility's air heating load (43% to 82%, depending on the climate zone) and hot service water heating load[19] (27% to 64%). Heat recovery systems can meet the lion's share of the heating needs of health care buildings in southern Canada (climate zone 4).

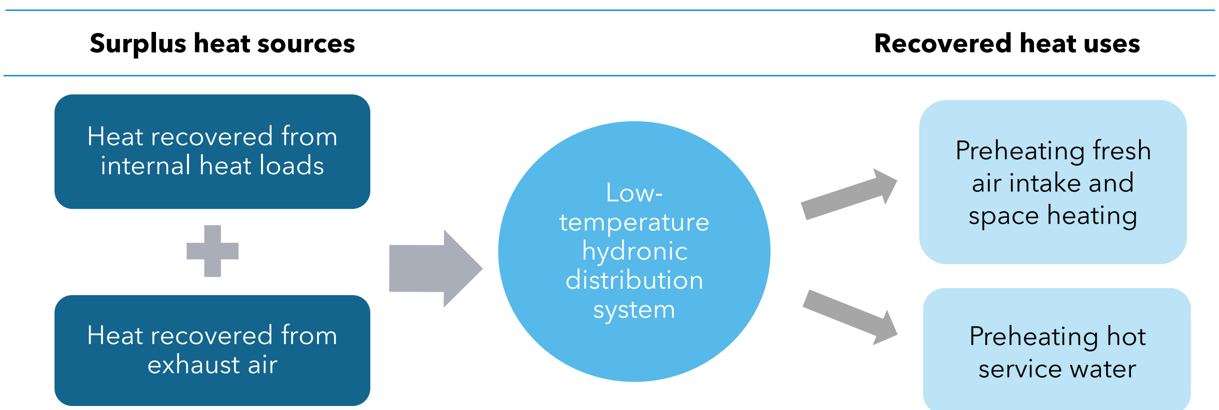


Figure 4. Recovered heat sources and uses

Fossil fuel alternatives

Alternative energies and technologies

Once the energy required is reduced using heat recovery systems, the remaining fossil fuel energy is replaced with renewable energy sources. For more easily electrifiable use cases such as kitchen appliances, air heating and some water heating, existing equipment is replaced with high-efficiency electric units. Biomass and renewable natural gas (RNG[20]) are

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[17] Our assumption is that approximately 40% of lighting has already been upgraded to LEDs.
[18] The calculated energy savings from heat recovery systems factor in the increase in electricity used to run the additional pumps and coolers.
[19] A heat recovery system can preheat the service water to 45°C.
[20] RNG is defined as a natural gas produced from non-fossil organic materials degraded by means of biological processes (anaerobic digestion) or thermochemical processes (gasification).

used as alternatives for higher-temperature use cases, such as remaining water heating needs,[21] steam generation for air humidification, and cleaning and sterilization. Decarbonization options are summarized in the figure below.

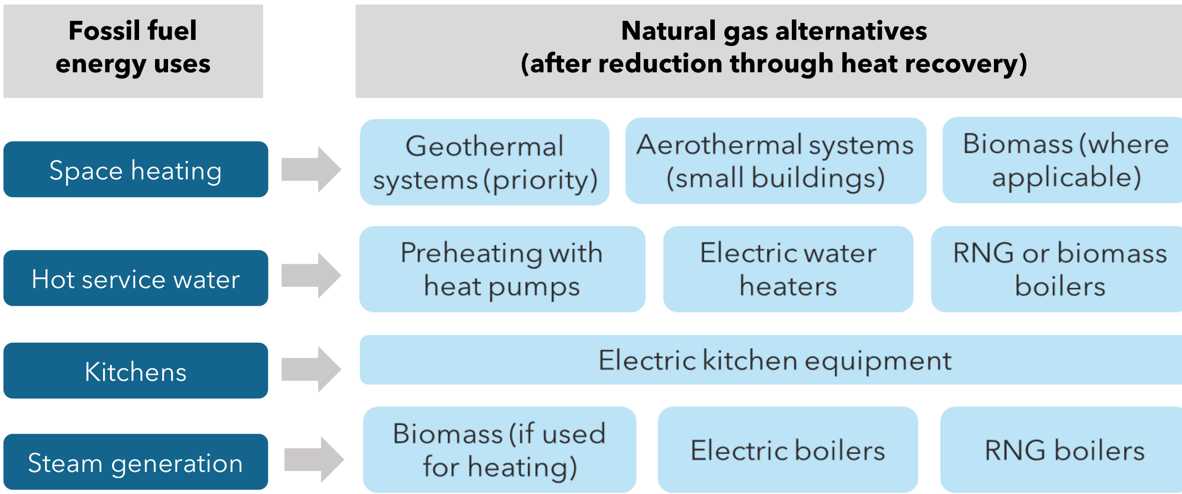

Figure 5. Decarbonization of remaining fossil fuel use cases after energy efficiency is maximized

The use of high-efficiency electric heating equipment would **reduce overall energy use by 15%**, due to the relative higher efficiencies of electric equipment, especially heat pumps, compared to natural gas furnaces.[22]

The figure below illustrates how the energy mix is projected to change from now until 2050 if the decarbonization options set out above are pursued.

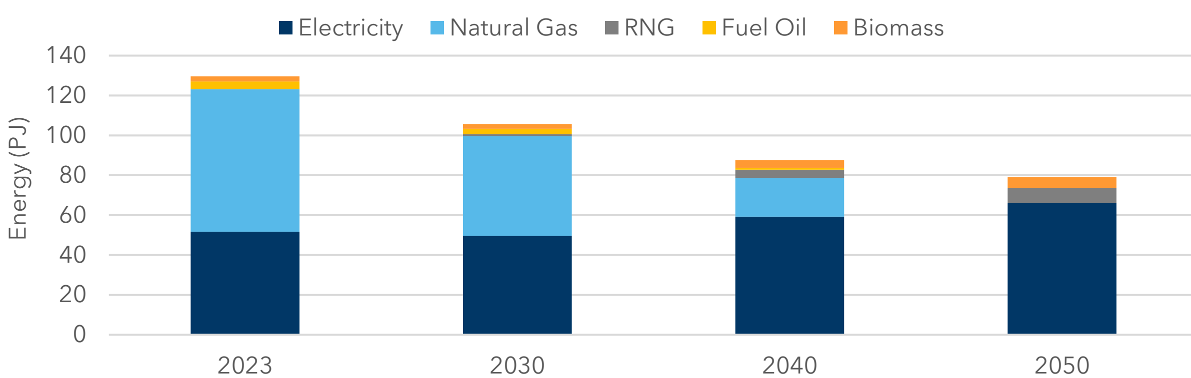

Figure 6. Change in energy profile for health care buildings, 2023-2050

The limits of RNG

Just as we should strive to reduce stress on the electrical grid, the use of RNG needs to be carefully planned. Demand for RNG is expected to grow, but any increase in production is limited by resource availability. According to our analysis, RNG could meet 5% to 10% of the health care sector's overall energy demand.

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[21] Additional heating is required to heat water past 45°C.
[22] Geothermal systems are 300% efficient on average, compared to 90% for natural gas systems.

In our roadmap, the share of RNG in the energy mix varies from one climate zone to another, based on the current natural gas network. On average, RNG is expected to meet approximately half of the difficult to electrify energy use cases, namely steam generation and remaining hot service water needs after preheating with heat recovery and heat pump systems. However, if there is a shift toward broader societal decarbonization, the share of RNG should be reduced in favour of other alternatives so as not to unduly add to RNG demand.

The use of RNG we are proposing only applies to health care buildings. These projections are not representative of other kinds of buildings beyond the health care sector. The proposed use of RNG is therefore limited to health care use cases that are difficult to decarbonize.

Reliable energy and peak demand management

Control systems are key to any reliable energy management strategy, as they help optimize energy savings and system functionality, as well as manage peaks in electricity demand.

Peak demand management eases the strain on the electrical grid in times of high demand. Fossil fuel-powered equipment will remain in place as backups and can run on RNG or other renewable fuels at critical times when the grid is at peak demand. Alternative peak demand management technologies are available (such as thermal energy and battery storage systems), although they represent a small share of the market. Because of their cost, we did not include these technologies in the roadmap. However, they are expected to become more affordable in the years ahead and viable options for health care facilities by 2050.

Technological advancements

Anticipated technological advancements may make it possible to achieve greater energy use savings by 2050 than projected using the measures we have proposed. One example is atomization, or adiabatic humidification, in which water is atomized into tiny droplets and released into the air instead of generating steam. On this, we have kept the roadmap conservative and drawn on recognized, evidence-backed strategies.

3.1.2. Energy and investment costs

If the health care sector achieves net-zero direct emissions by 2050, the sector's annual energy costs will come to an estimated $3 billion—approximately **$1.8 billion less per year** than if business as usual is maintained. Total building energy savings of **$24 billion are expected from 2024 to 2050** (see

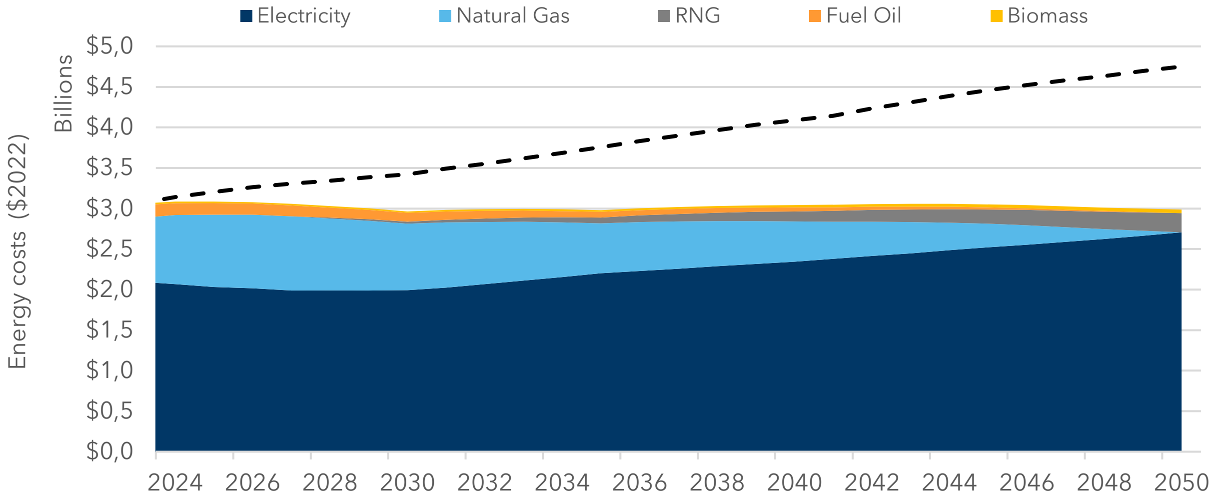

Figure 7.).

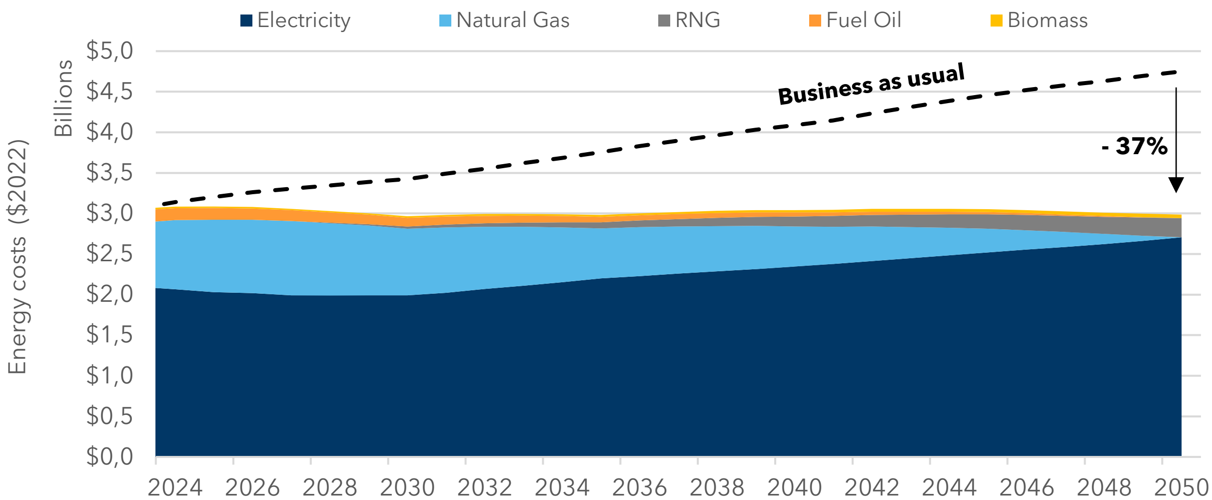

Figure 7. Change in building energy costs through 2050

From now through 2050, a **$32 to $42 billion** investment will be required to make all of Canada's health and social services buildings net-zero.[23] A wide range is given as we cannot know for certain what the total building stock space will be, what the average energy intensity of health care buildings will be, or what percentage of buildings have already electrified their space and water heating systems. The initial investment needed is estimated at **$8 billion over the next five years**. In the short-term, this investment will enable the sector to begin implementing many energy-saving measures and kick-start its decarbonization efforts.

[23] This includes the cost of acquiring, installing and commissioning equipment, prerequisite energy audits, overhead costs and taxes. See Appendix C for details.

Table 1. GHG reduction and energy savings from building decarbonization and required investment

Intervention	Avoided GHGs 2024–2050[24]	Energy savings as of 2050	Savings, 2024–2050	5-year investment	Total investment
LED lighting	0.9 Mtonnes	6%	$7.5B	$0.7B	$0.8B – $1.2B
Heat recovery	32 Mtonnes	18%	$11B	$5.8B	$11B – $13B
Fossil fuel alternatives	29 Mtonnes	15%	$5.6B	$1.3B	$20B – $28B
Total	**62 Mtonnes**	**40%**	**$24B**	**$7.8B**	**$32B – $42B**

3.1.3. Medical gases

Anaesthetic gases and inhaler gases are potent GHGs that are up to 2,540 times worse for the environment than carbon dioxide (CO_2). The gases most commonly used in operating rooms are sevoflurane, desflurane and nitrous oxide. After these gases are inhaled by patients, they are exhaled and released into the atmosphere. Sevoflurane lasts in the atmosphere for one year, while desflurane persists for 14 years. The global warming potential of each gas is provided in Table 2.

Table 2. Global warming potential for most common gases

Anaesthetic gas	Global warming potential[25]
Desflurane	2,540
Nitrous oxide (N_2O)	273
Sevoflurane	130

Sevoflurane and desflurane are two gases with similar uses and effects, including similar patient recovery times. The table below presents the main options for significantly scaling back the use of high-carbon-footprint anaesthetic gases.

Table 3. Options for eliminating emissions from anaesthetic gases and inhaler gases

Actions
Switching from desflurane to sevoflurane
Eliminating the use of nitrous oxide gas and pipelines
Reducing gas waste
Using anaesthetic gas capture and reuse/destruction systems
Adopting intravenous anaesthesia techniques using appropriate dosing and monitoring systems
Switching to low-carbon inhalers

[24] Lowered GHG emissions include emissions resulting from the decarbonization of electrical systems.
[25] Global warming potential over a 100-year time frame.

Switching from desflurane to sevoflurane can eliminate 98% of the GHG emissions associated with the use of desflurane.[26] Sevoflurane is also more efficient, as three times less gas is needed for a single anaesthesia procedure compared to desflurane—which means that using desflurane is also three times less expensive, given that bottles of the two gases are comparable in cost. Emissions from medical gases can also be eliminated by switching to intravenous anaesthesia techniques, which could prevent approximately **13 million tonnes of GHGs from being released** between 2024 and 2050. Reducing GHG emissions from medical gases mainly involves operating costs, which represent a minor investment compared to other building decarbonization measures.

Table 4. GHG reduction from decarbonizing medical gases and required investment

Action	Avoided GHGs, 2024-2050	Total investment
Medical gases	13 Mtonnes	N/A

3.2. Vehicles

The transition to a fully electric vehicle fleet by 2050 will require advancements in vehicle technology and charging infrastructure for light-duty vehicles, vans and ambulances. Our roadmap revolves around one main area of action, which is **electrifying the fleet of road vehicles** (ambulances, light-duty vehicles and vans). Air ambulance services have been excluded due to the lack of alternative zero-emission technology currently available.

Because data on the number of emergency vehicles and how they are used (distance travelled, usage rates, operating costs) have not been aggregated at a Canada-wide level, we extrapolated data from our study on Quebec's health care sector based on the country's population. This extrapolation may slightly underestimate the size of the Canadian health care sector's vehicle fleet and how these vehicles are used. However, since patient transport accounts for a much smaller portion of health care emissions compared to buildings, we have determined that the extrapolated data provide valid high-level estimates for the purpose of our analysis. Assumptions and data sources are provided in Appendix D.

We also recognize that there are challenges involved in electrifying ambulance fleets. The circumstances governing this effort are complex and vary not only from region to region, but also within regions themselves. Charging station locations, ambulance usage rates, travel distances and charging speeds are all factors that must be taken into consideration when rolling out electric ambulances and charging infrastructure so that the population can continue to receive an appropriate level of service. Our analysis is very high-level; and more detailed analyses are needed to account for specific provincial and territorial differences.

[26] Dr. S.R. Williams, Université de Montréal, "Crise climatique et agents inhalés". https://anesthesiologie.umontreal.ca/wp-content/uploads/sites/33/2021/12/2021-cours-crise-climatique.pdf (French only)

3.2.1. Cost of electrification

Vehicle cost

Electric ambulances cost approximately three times as much as combustion engine ambulances.[27] We expect the cost of electric vehicle battery components to gradually decrease over the next few years,[28] though electric ambulance purchase prices will not reach cost parity with combustion engine ambulances. However, electric ambulances also have a three- to five-year longer lifespan than regular ambulances.[29]

At present, electric models of light-duty vehicles and vans cost 30% and 40% (respectively) more than their conventional counterparts, but that gap is expected to close completely by 2027 for light-duty vehicles and 2030 for vans.[30]

Availability of heavy-duty vehicle technology

The supply of electric ambulances will need to increase significantly in the coming years to support decarbonization goals. Zero-emission ambulance technologies include electric vehicles (EVs) and fuel cell vehicles (FCVs). Electric ambulances are an emerging solution and already available on the market.[31] The range of electric ambulances available will grow rapidly in the coming years, but FCV options are still limited. FCVs are hybrid vehicles that can travel longer distances than is possible with electric batteries. For the purpose of our analysis, only electric ambulances were considered.

As for vans, there are a wide range of electric options on the market that could meet the health care sector's needs.

Cost of charging stations

Given the various purposes that different vehicles are used for in health care, we suggest having two types of charging stations. For the purpose of our analysis, we assumed a ratio of one Level 2 charger per EV for light-duty vehicles and vans. A smaller ratio of chargers may be deemed optimal when the specific needs of each building are analyzed. Level 2 chargers are well suited for these vehicles as they are typically parked for long periods of time.[32]

Fast charging stations are suggested for ambulances, as they have larger batteries and make shorter stops. We have assumed a ratio of one 40 kW charging station to three ambulances. Fast charging stations require careful planning as they are 15 to 20 times more expensive to purchase and install than Level 2 charging stations.

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[27] Based on discussions with manufacturers that specialize in these types of vehicles.
[28] Assumption based on the trend of declining EV prices over the past 10 years. Even though the price of basic ambulance components such as chassis frames and paramedic equipment is expected to remain stable, a decline in battery prices could mean electric ambulances will cost 35% less by 2040.
[29] Based on discussions with manufacturers that specialize in these types of vehicles.
[30] The change in EV prices is illustrated in Appendix D.
[31] Lightning eMotors sells one such model, and Lion Electric and Demers launched a prototype.
[32] Level 2 charging stations with a 7-kW power output on a 240-volt circuit. 7-kW charging stations with a load management system keep electricity needs low.

Electrical services may also need to be upgraded, and standby generators installed for ambulance charging stations. Like redundancy for buildings, generators will help ensure uninterrupted service in the event of a power outage from now through 2050.

Backup diesel engines

Ambulances spend much of their shifts idling. Then, electric ambulances in the coldest parts of the country should have fuel combustion engines to keep medical equipment and patients at an appropriate temperature in winter.[33] Cold weather can also affect the availability of ambulances as they need to be charged more frequently. We assume that backup engines will not be necessary past 2030 as battery density and capacity improves.[34]

Operating costs: Energy and maintenance

EVs may cost more to buy, however, they cost much less to operate. Their higher efficiency, combined with the low cost of electricity, saves money in the long run: **charging an EV is approximately 80% cheaper** than filling up a tank of gasoline or diesel.[35]

Electric motors are also easier and cheaper to maintain because they have fewer moving parts, **cutting maintenance costs by nearly half**.[36]

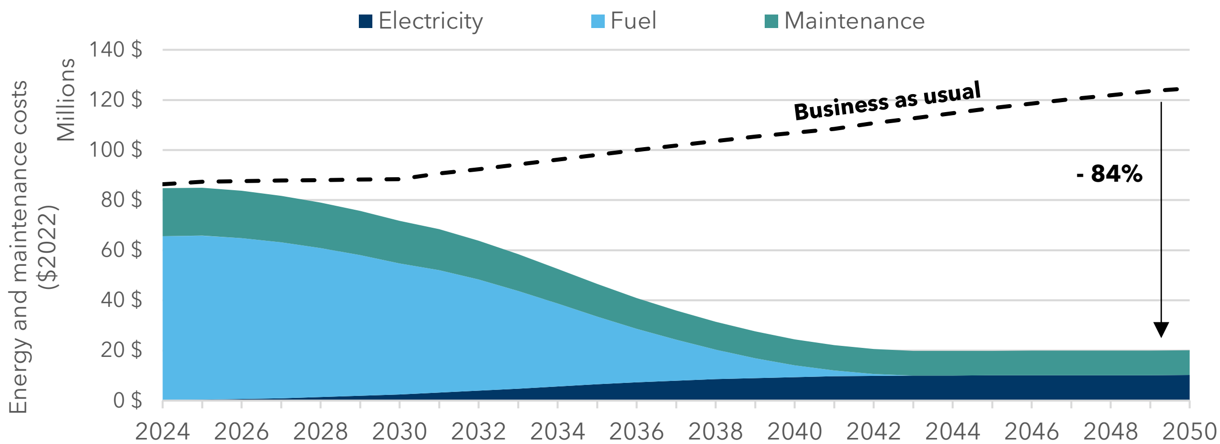

Figure 8. Change in vehicle operating costs through 2050

These lower costs yield a total of $105 million in annual energy and maintenance savings through 2050, **for a total of $1.6 billion in savings from 2024 to 2050**.

Investment cost

Between now and 2050, **a total of $1.6 to $2.6 billion** is needed to fully electrify Canada's

[33] A 15-kW engine with an average fuel consumption of 0.9 L/h, equivalent to 50% of the fuel consumption of a typical M50 engine. To be used 12 h per day from October to April only. https://www.tomahawkind.ca/wp-content/uploads/2016/12/M-series.pdf

[34] BloombergNEF's *Electric Vehicle Outlook 2020* report predicts that batteries will be 50% denser in 2030. Also, wireless and public charging stations could also be used once they are available in sufficient numbers. Internal combustion engines could still be used with biofuels as a last resort.

[35] Electricity, gas and diesel prices through 2050 are provided in Appendix B.

[36] Consumer Reports. 2020. 2. https://advocacy.consumerreports.org/wp-content/uploads/2020/09/Maintenance-Cost-White-Paper-9.24.20-1.pdf

health care vehicle fleet, with a margin of error of approximately 25%.[37] The initial investment needed is estimated at **$0.2 billion over the next five years**, which will cover the initial installation of charging infrastructure prior to the rollout of the first electric ambulances. Adoption of electric ambulances will accelerate over time as more models enter the market. Under the Government of Canada's zero-emission vehicle (ZEV) standard, as of 2035, all new vehicles sold must be electric.

Table 5. GHG reduction and energy savings from vehicle electrification and required investment

Vehicle type	Avoided GHGs 2024-2050	Savings 2024-2050	5-year investment	Total investment
Ambulances	1.5 Mtonnes	$1.3B	$0.15B	$1.5B – $2.5B
Vans and light-duty vehicles	0.5 Mtonnes	$0.3B	$0.05B	$0.07B – $0.1B
Total	**2 Mtonnes**	**$1.6B**	**$0.2B**	**$1.6B – $2.6B**

3.3. Indirect emissions

We have not thoroughly calculated the Canadian health care sector's indirect emissions, even though they account for the majority of the sector's emissions. Since indirect emission sources vary widely and there are no specific Canada-wide datasets, we have kept the focus of the roadmap on direct emissions. However, in Appendix E we provide a comprehensive list of strategies for working towards reducing indirect emissions to net-zero by 2050 as well.

Once comprehensive data on indirect emissions are available from health care facilities across the country, carbon accounting can provide a structured approach to identifying, optimizing, and tracking progress on actions for reducing these emissions. In the interim, we have decided to provide a foundation to inform **decision making** on the actions to be taken.

Support from **broader government initiatives** will be essential to the success of some climate actions. For example, to reduce emissions from employee commuting, alternative transportation infrastructure must be robust, accessible, and safe to be widely adopted.

The list of actions in Appendix E is based on a review of the literature and existing initiatives. Some of the interventions target medical practices and will require the involvement of health care professionals and experts in the field.

4. Conclusion

To achieve net-zero in the health care sector by 2050, key **energy-saving measures** for buildings must be prioritized, both for electrical energy (by installing LED lighting) and thermal energy (through heat recovery). In the roadmap, energy-saving measures are rolled

[37] Investments include the additional costs compared to what it would currently cost to replace standard combustion engine vehicles.

out immediately and continue through 2035, whereas decarbonization measures begin in 2028 at the latest. Any delays will only amplify the amount of work required later.

In addition to these measures, action must be taken to **switch from equipment that runs on fossil fuel energy** to energy-efficient equipment that runs primarily on electricity, and to a lesser extent, biomass and RNG. As it pertains to transportation, vehicles that run on traditional fuels (diesel and gasoline) must be replaced with EVs. High-carbon-footprint medical gases must also be phased out.

Our analysis found that net-zero emissions by 2050 is an achievable goal for Canada's health care sector. **Beyond achieving this climate goal**, pursuing the roadmap will provide **three key additional benefits:** 1) dramatically reduced energy use and costs for buildings, 2) lower energy and maintenance costs for vehicles and 3) better health benefits (see callout box below). However, if we want to meet this target by 2050, we need to start making the necessary investments immediately.

The social benefits of reduced GHG emissions

The impact of taking action toward net-zero health care goes far beyond saving energy; it also yields social benefits, starting with direct health benefits from improved air quality due to avoided emissions from burning fossil fuels. Better air quality is associated with a decrease in symptoms of asthma and respiratory problems.[38]

There is also the broader social cost of carbon (SCC), which estimates the total cost of the impact of GHGs on society, including physical climate risks and impacts on human health and infrastructure. If our study had used SCC as a measure, the savings generated by decarbonization would have been even greater. SCC estimates vary from study to study, but the Government of Canada placed the number at $261 per tonne of CO_2e in 2023.[39]

Technology alone will not help us hit our climate targets. Effective **governance** must be in place to support the transition to net-zero. Achieving net-zero in the health care sector requires a resolute commitment to decarbonization efforts and funding specifically earmarked for this purpose, and it needs to begin immediately.

What's more, asset transformation is only one part of the solution. Members of the Canadian health care community have a broader vision for the sector that includes patients and employees in the transition. This vision emphasizes the importance of prevention and health promotion, but also the need to **modernize health care delivery models and reimagine medical practices** to deliver health care that is more aligned with the population's actual needs, more environmentally responsible, and more readily available in local communities, to name a few examples. In essence, the goal to achieve net-zero emissions in Canadian health care will require an **all-encompassing transformation** of the sector.

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[38] Government of Canada, Health Impacts of Air Pollution in Canada. 2021. https://www.canada.ca/en/health-canada/services/publications/healthy-living/health-impacts-air-pollution-2021.html#a4
[39] Government of Canada, Social cost of greenhouse gas emissions. https://www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/social-cost-ghg.html

Appendix A

Data sources for the overview of GHG emissions in the health care sector

The overview of GHG emissions from buildings was mainly based on data from NRCan, summarized in the tables below. The overview of GHG emissions from vehicles was largely based on data for Quebec scaled to the national level and some secondary data from other Canadian jurisdictions.

The emissions from medical gases are an aggregate of emissions from anaesthetic gases and inhaler gases. Emissions were calculated based on an average emission factor for anaesthetic gases of 1.54 tonnes of CO_2e per hospital bed from Quebec's inventory of hospital GHG emissions, and the ratio of emissions from inhalers to emissions from anaesthetic gases came from a study of the National Health Service (NHS) in England.[40]

Our analysis of indirect emissions was based on Quebec's inventory of GHG emissions from CISSSs and CIUSSSs and the NHS's GHG inventory, normalized for the number of beds, total building space across Canada, and the country's population.[41] Our analysis provides a high-level overview, with the understanding that more specific data are needed. At present, there is a lack of data that can be used to estimate emissions from patient, visitor and supplier travel. Additionally, the overview of indirect GHG emissions does not include emissions calculated through a full life-cycle assessment of energy sources. The calculated GHGs from energy use are therefore for direct emissions only.

Table 6. Health care building space and energy use intensity

Building type	Floor space (m^2)[42]	Energy use intensity (GJ/m^2)[43]
Rehabilitation centres	12,351,000	1.11
Long-term care centres	21,615,000	1.76
Hospitals	25,397,000	2.62
Clinics	8,492,000	1.33
Total/Weighted average	**67,855,000**	**1.91**

The total building floor space was linearly extrapolated from 2020 NRCan data to 2023. Due to the lack of aggregate data at the pan-Canadian level, the floor space for each building type was calculated proportionally based on data from Quebec.

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[40] Tennison et al. A carbon footprint assessment of the NHS in England. Lancet Planet Health 2021; 5: e84–92. https://www.thelancet.com/pdfs/journals/lanplh/PIIS2542-5196(20)30271-0.pdf
[41] Idem.
[42] NRCan. Health Care and Social Assistance Secondary Energy Use and GHG Emissions by Energy Source. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=com&juris=ca&rn=25&year=2020&page=3.
[43] NRCan. Health Care and Social Assistance Secondary Energy Use and GHG Emissions by End Use. Table 26. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=com&juris=ca&year=2020&rn=26&page=0.

The energy use intensity data for hospitals came from NRCan. Since energy use intensity was not reported for other building types, it was extrapolated from data that the Ministère de la Santé et des Services sociaux (MSSS) [Quebec department of health and social services] obtained for our study of Quebec's health care sector.

Table 7. Breakdown of the health care sector's energy sources

Energy	Electricity	Natural gas	Fuel oil	Biomass	Fuel
Share (%)[44]	39%	55%	3%	2%	1%

The breakdown of energy sources came from NRCan and was adjusted to include the estimated share of biomass based on our knowledge of Canada's energy sector.

Table 8. Building energy use, by end use

End use	Share[45]	Calculated energy (PJ)
Space heating	50%	64.5
Water heating	10%	12.3
Auxiliary equipment	21%	26.6
Auxiliary motors	3%	3.9
Lighting	13%	17.1
Space cooling	4%	5.2
Total		**129.6**

The tables below show data for vehicle emissions, extrapolated to the population of Canada using Quebec-level data from an analysis of expenditures by the MSSS.

Table 9. Patient transportation data for Quebec[46,47]

Vehicle type	Average mileage (km/year)	Efficiency (L/km)
Ambulances	35,200	0.385
Airplanes	780	1.57
Vans	7,300	0.1375
Light-duty vehicles	9,000	0.11

44 NRCan. Health Care and Social Assistance Secondary Energy Use and GHG Emissions by End Use. Table 26. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=com&juris=ca&year=2020&rn=26&page=0.

45 Idem.

46 Ministère de la Santé et des Services sociaux. Rapports financiers annuels des établissements 2021-2022: https://publications.msss.gouv.qc.ca/msss/document-003433/ (French only)

47 Ministère de la Santé et des Services sociaux. Comptes de la santé 2020-2023. Table 20. https://cdn-contenu.quebec.ca/cdn-contenu/adm/min/sante-services-sociaux/publications-adm/rapport/RA_22-614-01W_MSSS.pdf (French only)

Table 10. Reference metrics for calculating indirect GHG emissions

GHG emission category	Reference metric	Source
Anaesthetic gases and inhaler gases	Capacity/beds (hospitals), NHS	CIUSSS/CISSS data, S.R. Williams (CHUM),[48] NHS[49]
Ambulance transport	Number of trips, MSSS expenditures	Ambulance transport funding (2021–2022),[50] Canadian ambulance studies[51,52]
Employee commuting and business travel	Distance, number of employees, means of transportation	CIUSSS/CISSS data, MSSS human resources
Waste	Building floor space	CIUSSS/CISSS data
Food	Number of meals, capacity/beds	CIUSSS/CISSS data
Medicine	Capacity/beds (hospitals)	CIUSSS/CISSS data
Equipment procurement and supply chain	Normalization for Canada	NHS (England)

Table 11. Employee travel data sources

Data type	Assumption	Source
Number of health care workers	1,327,000	Calculated proportionally from MSSS data[53]
Emissions intensity – Urban centres (tonnes of CO_2e/employee)	0.16	CIUSSS/CISSS data
Emissions intensity – Non-urban centres (tonnes of CO_2e/employee)	0.08	CIUSSS/CISSS data

[48] Dr. S.R. Williams, Université de Montréal, "Crise climatique et agents inhalés". https://anesthesiologie.umontreal.ca/wp-content/uploads/sites/33/2021/12/2021-cours-crise-climatique.pdf (French only)
[49] Tennison et al. A carbon footprint assessment of the NHS in England. Lancet Planet Health 2021; 5: e84–92. https://www.thelancet.com/pdfs/journals/lanplh/PIIS2542-5196(20)30271-0.pdf
[50] Ministère de la Santé et des Services sociaux. Comptes de la santé 2020-2023. Table 20. https://cdn-contenu.quebec.ca/cdn-contenu/adm/min/sante-services-sociaux/publications-adm/rapport/RA_22-614-01W_MSSS.pdf (French only)
[51] Edwards, S. 2021. Western University. Financial and Environmental Viability of Municipally Operated Hybrid Ambulance Fleets in Ontario. https://ir.lib.uwo.ca/cgi/viewcontent.cgi?article=1202&context=lgp-mrps
[52] Niagara Region. 2019. Ambulance Chassis Review. p. 48. https://pub-niagararegion.escribemeetings
[53] Ministère de la Santé et des Services sociaux. Ressources humaines. https://www.msss.gouv.qc.ca/professionnels/statistiques-donnees-services-sante-services-sociaux/ressources-humaines/ (French only)

Appendix B

Assumptions for calculations: Costs

All costs in the report are given in 2022 dollars and assume **2%** long-term inflation. With that in mind, the annual increases set out below refer to **real increases**, as demonstrated by the following equation:

$$Real\ increase\ (\%) = Nominal\ increase\ (\%) - Inflation\ (\%)$$

The energy costs used for 2024 to 2050 are summarized in Table 12, *Cost of economic inputs*. All costs include taxes associated with energy use.

Cost of electricity

The *Canada's Energy Future 2023* report from the Canada Energy Regulator includes assumptions about demand and costs for energy sources according to different scenarios.[54] These costs include the cost of carbon and were referenced for the use of electricity in the commercial sector in the Canada Net-zero Scenario.

Cost of carbon

The cost of carbon is based on the minimum national carbon pollution price that will apply through 2030.[55] After 2030, the cost of carbon will increase by **5%** per year. This rate of increase represents the cost of carbon between 2030 and 2050 as modelled by the Canada Energy Regulator in the *Canada's Energy Future 2023* report.

Cost of renewable natural gas (RNG)

The cost of RNG is based on Énergir's total delivery charges (rate D1) and the cost of the RNG itself. The gas delivery rate increases with inflation (0% real increase) while the cost of the RNG increases by **1%** per year. Increases in the cost of RNG are based on Énergir's projections (approximate nominal increase of 3% per year between 2024 and 2030).[56]

Cost of fossil-based natural gas, fuel oil, gasoline, and diesel

The *Canada's Energy Future 2023* report from the Canada Energy Regulator includes assumptions about demand and costs for energy, according to various scenarios.[57] These costs include the cost of carbon and were referenced for the use of fuel oil, gasoline and diesel in the commercial sector in the Canada Net-zero Scenario. Real increases in cost vary by energy source; fossil-based natural gas is projected to increase by **less than 4%**, while the cost of fuel oil, gasoline and diesel is projected to increase by **less than 2% for each**.

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[54] Canada Energy Regulator. Canada's Energy Future 2023: Energy Supply and Demand Projections to 2050. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2023/

[55] Government of Canada. Pan-Canadian Approach to Carbon Pollution Pricing 2023-30. https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/carbon-pollution-pricing-federal-benchmark-information/federal-benchmark-2023-2030.html

[56] Énergir. Price of renewable natural gas (RNG). https://energir.com/en/major-industries/bulletin-bleu-express-mai-2023

[57] Canada Energy Regulator. Canada's Energy Future 2023: Energy Supply and Demand Projections to 2050. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2023/

Cost of biomass

The estimated cost of biomass is $7.85/GJ, increasing in line with inflation (real increase of **0%**). This cost is based on an average price of $100 per oven-dry tonne as reported by the Fédération québécoise des coopératives forestières [Quebec Federation of Forestry Cooperatives].[58] The type of biomass assumed for our purposes is wood chip biomass derived from logging residue with a moisture content of 40% and an average delivery distance of 100 km.

Table 12. Cost of economic inputs[59]

Economic input	2024 (2022 $)	2050 (2022 $)
Electricity ($/kWh)	0.15	0.15
Carbon ($/tonne of CO_2e)	77	259
Fossil-based natural gas ($/m^3)	0.47	1.28
Renewable natural gas ($/m^3)	0.96	1.20
Fuel oil ($/L)	1.44	1.95
Gasoline – Regular ($/L)	1.61	2.65
Diesel ($/L)	1.62	2.02
Biomass ($/GJ)	7.85	7.85

Assumptions for calculations: GHG emission coefficients

The sources of emissions used in the report are listed in the table below. Carbon intensity for each source is calculated based on the Intergovernmental Panel on Climate Change (IPCC)'s Fifth Assessment Report on global warming potentials.[60]

[58] Fédération québécoise des coopératives forestières. Chaînes d'approvisionnement en biomasse forestière résiduelle innovantes et adaptées aux besoins de chaufferies institutionnelles, commerciales et industrielles. (French only)
[59] Costs include taxes and delivery charges.
[60] Government of Canada. Global warming potentials. https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/quantification-guidance/global-warming-potentials.html

Table 13. Carbon intensity, by energy source

Product (unit)	Carbon intensity (g of CO_2e/unit)	Source
Electricity (kWh) – 2021	110	2023 NIR, Part 3, Table A13-1[61]
Electricity (kWh) – 2050	3.4	Government of Canada: GHG emissions projections[62]
Fossil-based natural gas (m^3)	1,936	2023 NIR, Part 2, Tables A6.1-1 and A6.1-3[63]
Fuel oil (L)	2,762	
Gasoline – Regular (L)	2,315	
Diesel (L)	2,689	
Kerosene (L)[64]	2,568	
Renewable natural gas (m^3)	11	Énergir[65]
Biomass (GJ)	1,923	Transition Énergétique Québec: emission factors[66]

[61] United Nations Climate Change. 2023. National Inventory Report: Greenhouse Gas Sources and Sinks in Canada. https://unfccc.int/documents/627833
[62] Government of Canada. 2023. Canada's Greenhouse Gas and Air Pollutant Emissions Projections. https://publications.gc.ca/collections/collection_2023/eccc/En1-78-2023-eng.pdf
[63] United Nations Climate Change. 2023. National Inventory Report: Greenhouse Gas Sources and Sinks in Canada. https://unfccc.int/documents/627833
[64] Kerosene is used to calculate emissions from airplane transport.
[65] Énergir. https://energir.com/en/about/our-energies/natural-gas/renewable-natural-gas
[66] Transition energétique Québec. Facteurs d'émission et de conversion: https://transitionenergetique.gouv.qc.ca/fileadmin/medias/pdf/FacteursEmission.pdf (French only)

Appendix C

Baseline assumption for building stock decarbonization modelling

Energy modelling was run for four climate zones based on the National Energy Code of Canada for Buildings. Given the low number of health care facilities in northern Canada, the two zones with average heating degree day values of 6000 and 7000 were merged for the purpose of our analysis.

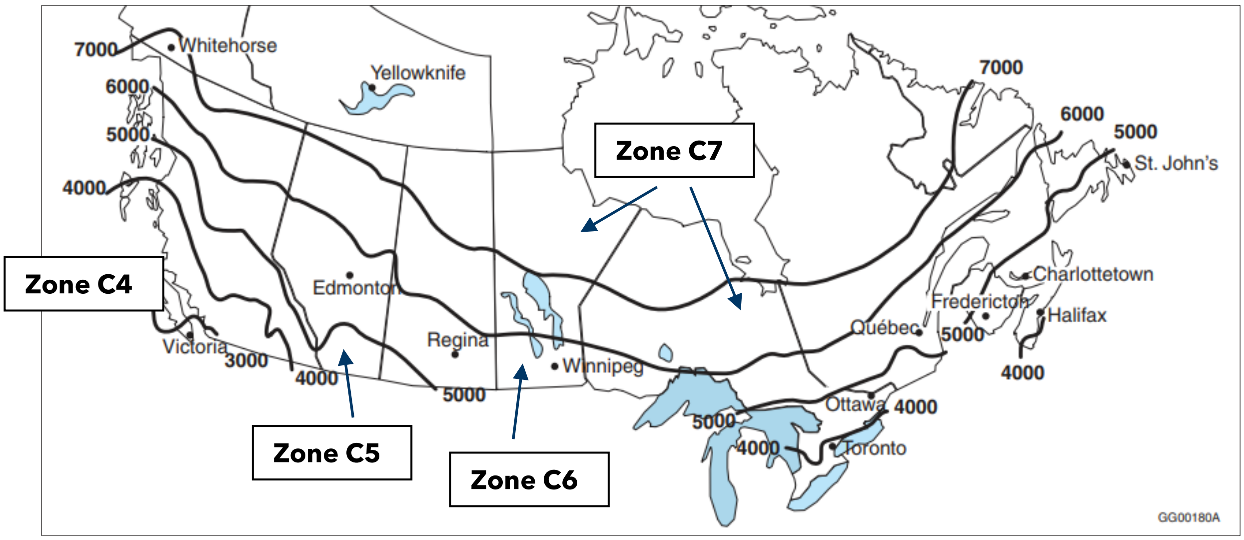

Figure 9. Map of Canada's climate zones[67]

The tables below show the parameters used for our building decarbonization calculations.

Table 14. Representative internal loads by building type[68]

Building type	Occupant load (m²/occupant)	Receptacles (W/m²)	Lighting[69] (W/m²)	Service water heating (W/occupant)
Clinic	20	7.5	9.4	90
MURB (long-term care centre)	25	5	6.5	500
Hospital	20	7.5	13	90
Office (rehabilitation centre)	25	7.5	9.7	90
Weighted average	**22**	**7**	**10**	**206**

[67] NRCan. 2017. National Energy Code of Canada for Buildings. Division B. Section A-1.1.4.1.(1).
[68] Canadian Commission on Building and Fire Codes. National Energy Code of Canada for Buildings 2020. https://nrc-publications.canada.ca/eng/view/object/?id=af36747e-3eee-4024-a1b4-73833555c7fa
[69] Government of Canada. National Energy Code of Canada for Buildings 2011. https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-canada-publications/national-energy-code-canada-buildings-2011

Table 15. Building occupant loads[70]

Occupant load	Sensible	Latent
Load (Watt/occupant)	63	54

Table 16. Variables for calculations and sensitivity assumptions for buildings

Variable	Assumed value	Notes
Recoverable internal heat loads	0.9	70% recirculated in the air, the rest exhausted
Average COP (130°F condensing temperature)	4	Conservative assumption
Average COP (125–115°F condensing temperature, 32–27°F evaporating temperature)	3	Conservative assumption
LED conversion factor	0.4	
Receptacle load factor	0.9	
Occupant load factor	0.9	
Hospital renovation factor	0.75	Used for expansions of hospitals only
Gas heating system efficiency	0.9	
Biomass system efficiency	0.8	
Induction heater efficiency	0.8	
Total air changes (ACH)	6	
Fresh air changes (ACH)	2	
Fresh air changes in technical facilities (ACH)	20	

Table 17. Intervention lifespan

Intervention	Years
LED light bulbs	20[71]
Heat recovery	25[72]
Decarbonization measures	25[73]

[70] The Engineering ToolBox. Human Heat Gain. https://www.engineeringtoolbox.com/persons-heat-gain-d_242.html
[71] Assuming a 100,000 hr lifespan with 12 hrs of controlled use per day.
[72] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Service Life Data Query. http://weblegacy.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=2
[73] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Service Life and Maintenance Cost Database. http://weblegacy.ashrae.org/publicdatabase/

Appendix D

Baseline assumption for vehicle fleet decarbonization

We drew on our consultations and inputs from our report on decarbonizing Quebec's health care sector and assumed the averages set out below to characterize the Canadian health care sector's vehicle fleet.[74]

We acknowledge that these characteristics vary significantly between urban, suburban and rural areas. The assumptions selected represent a middle ground for high-level estimates.

Table 18. Baseline assumptions for vehicle fleet

Vehicle type	Number of vehicles	Lifespan (years)	Annual mileage (km)	Fuel type (baseline)
Ambulance	2,550	Combustion: 7 Electric: 10	35,200	80% gasoline 20% diesel
Light-duty vehicle	4,508	10	9,000	100% gasoline
Van	2,454	10	7,300	100% gasoline
Source	Calculated proportionally from Quebec vehicle data	Niagara Region, external consultations[75]	Quebec MSSS data	Quebec MSSS data

We roughly estimate that the sector will need charging stations in the following ratios:

Table 19. Assumptions for vehicle fleet charging

Vehicle type	Ratio (vehicle to charging station)	Charging station type (power output)	Notes
Ambulance	2:1	Fast charging 40 kW	We estimate that ambulances will spend 16 to 18 hours in service and undergoing maintenance and 4 to 6 hours charging.
	3:1	Fast charging 60 kW	We recommend having at least one 60 kW fast charging station for emergencies.
Light-duty vehicle	1:1	Level 2 < 6.7 kW	Instead of purchasing fewer charging stations to save money, install lower-power charging stations and use a load management system.
Van	1:1	Level 2 < 6.7 kW	

[74] Dunsky Energy + Climate Advisors. 2023. Décarbonation du secteur de la santé. https://aspq.org/app/uploads/2024/01/dunsky_decarbonation-sante_rapport-final_18dec2023.pdf (French only)

[75] Niagara Region. 2019. Ambulance Chassis Review. p. 48. https://pub-niagararegion.escribemeetings.com/filestream.ashx?DocumentId=6417

The cost of purchasing, installing, and upgrading each type of charging station to a higher power output are provided in the table below:

Table 20. Information about vehicle fleet charging stations

Level	Power output	Purchasing and installation cost
Level 2	6.7 kW of energy split between two ports	$12,300
	16.6 kW	$35,200
Fast charging[76]	40 kW	$175,000
	60 kW	$215,000

Purchasing, maintenance, and energy costs for each vehicle type are provided in the table below:

Table 21. Annual ownership, maintenance and energy costs, by vehicle type[77]

Vehicle type	Technology	Annual ownership cost (2024–2025 average)	Maintenance cost[78] ($/km)	Energy cost ($/km) (2024)
Ambulances	Electric	$74,700	$0.07	$0.09
	Combustion	$66,600	$0.14	$0.63
Light-duty vehicles	Electric	$5,700	$0.06	$0.05
	Combustion	$7,400	$0.11	$0.22
Vans	Electric	$6,000	$0.07	$0.04
	Combustion	$7,700	$0.14	$0.18

[76] The cost of charging stations for electric ambulances also includes the cost of purchasing a standby generator.
[77] Costs include taxes.
[78] Maintenance costs are consistent with inflation (0% real increase).

Appendix E

Table 22. Initiatives to track and reduce indirect emissions from the health care sector

Initiative	Overview	Information needed to inform decision making
Commuting and business travel		
Amenities that encourage the use of active transportation	Showers, secure change rooms and lockers for employees.	• Number of potential users • Condition of existing amenities
Subsidized public transit pass		• Number of potential users • Cost of pass
EV charging infrastructure for employees	Level 2 charging stations with free or lower-cost charging.	• EV uptake projections • Projected access to home charging
Carpooling platform or car-/bike-sharing service	In-house platform or subsidized car-/bike-sharing service membership.	• Number of potential users
Bike parking and electric bike charging	Dedicated bike parking that is secure (indoor, locked), convenient and accessible (free or affordable). Secure, dedicated charging stations near parking.	• Number of cyclists • Number and location of bike parking spaces • Condition of existing amenities (security, location, accessibility, etc.)
Telework and telehealth services	For administrative and research staff. Virtual care services for initial assessments, follow-up appointments and other suitable consultations.	• Best practices for appropriate use of virtual care and telehealth for health care services
Guaranteed ride home program	Providing a safety net in case of unforeseen or exceptional circumstances (agreements with local taxi companies and/or emergency public transit passes).	
Active transportation benefit	Flexible allowance to spend on equipment (bikes, running shoes, bike trailers for kids, headlamps, etc.), services (yearly bike tune-ups or repairs, bike-sharing memberships, etc.), and/or active transportation-related classes (bike safety classes, running classes, etc.).	
Parking cash-out	A financial incentive for employees to opt out of employer-provided parking.	• Number of potential users • Amount of compensation
Park-and-ride incentive	A financial incentive for employees to leave their cars at public transit stations.	
Employee assignment optimization	Assigning employees to locations close to home.	• Commuting distances
Equipment procurement and supply chain		
Limiting unused kits and purchases	Improving synergy between clinicians making purchase requests and procurement teams.	• Purchasing and inventory levels • Survey of medical staff
Washable and reusable supplies	Limiting single-use items. Developing a knowledge base to establish and promote	• Research on available products

Initiative	Overview	Information needed to inform decision making
	net-zero infection prevention and control practices, including returning materials for reuse.	
Low-impact products	A responsible procurement policy with criteria prioritizing products with the lowest carbon footprint. Requiring suppliers to conduct life-cycle assessments. Working with other health care systems to align procurement requirements and encourage suppliers to take action.	
Prioritizing procurement from sustainability-minded suppliers	Calls for tenders that include pre-established sustainability criteria.	
Health care services and medicine		
Prevention and health promotion	Emphasizing prevention.	
Education and prescriptions for low-GHG inhalers	Carrying out a communications campaign and limiting high-carbon-footprint inhalers.	• Number of prescriptions for each inhaler type
Reducing medication waste	Reducing purchases of unused or rarely used medication.	
Low-carbon-footprint medication	Incorporating sustainability clauses into calls for tenders.	
Reducing the use of medication	Where possible, having committees dedicated to evaluating the appropriateness of medication and care. Promoting deprescribing.	
Reducing unnecessary care		
Waste		
Limiting disposable, single-use items	R&D on reusable protective equipment for frontline workers.	
Recycling programs/procedures	For single-use items.	
Medical device reprocessing programs		
Streamlining the contents of preassembled procedure kits	Creating different "levels" of kits based on actual needs to avoid wasting unused items.	• Number of procedure kits for each type/category • Type and number of each item
Composting	For organic waste.	
Food recovery and donation system	Preventing food waste through a program for recovering surplus and unneeded food (ideally in close proximity to the health care facility).	
Food		
Fewer animal-based products and more vegetarian meals	For patient meals and food services (for employees and visitors).	• Number of meals served per day

Initiative	Overview	Information needed to inform decision making
		• Alternative providers
On-demand food service for hospital patients, with customized portions	Accommodating older adults, children and patients experiencing low appetite.	• Dietary information in patient charts for meal orders
Reusable cutlery	Reusable cutlery with on-site or outsourced dishwashing.	• Available space • Potential external partners
Partnerships with local farmers	Cutting food miles	• Local farms
Reducing food waste	Preventing overbuying, food purchases that go unused, and the preparation of food that goes uneaten.	• Tracking inventory, purchases and meals served
Patient transport		
Community-based health care	Reducing hospital visits by improving access to community-based health care.	
Virtual health care and telehealth	Especially for remote, rural, northern and Indigenous areas/communities.	• Types and number of health care services adapted for remote delivery
High-speed internet access in non-urban areas	Especially for remote, rural, northern and Indigenous areas/communities.	
Active and public transportation infrastructure	All-season bike parking, electric bike charging stations and inviting bus stops.	
Charging stations for patients and visitors	Level 2 chargers available for patients and visitors.	

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