Blue Zone Technologies: Prevented Emissions LCA Project

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Executive Summary

A comparative life cycle analysis (LCA) was conducted to determine total prevented emissions associated with using a Deltasorb® canister compared to a conventional anesthetic practice.

Total Prevented Emissions

The total prevented emissions relates to the avoided emissions from capturing anesthetic gases in an operating room using the Deltasorb® canister compared to the conventional anesthetic practices where the gases are released. The total prevented emissions is equal to the avoided emissions minus impacts due to Deltasorb® canister processing and transportation.

Table 1: Total Prevented Emissions by Institution

		Total Impacts (Deltasorb® Processing + Transportation)	Avoided GWP Anesthetics	Total Prevented Emissions
		(kg CO_2-eq/Deltasorb® canister cycle)		
Eastern Health	St. John, NFL	7.36	437.17	429.81
Montreal Heart Institute	Montreal, QC	2.32	437.17	434.85
CHUM	Montreal, QC	2.32	437.17	434.85
CHEO	Ottawa, ON	1.9	437.17	435.27
Peterborough Regional	Peterborough, ON	1.48	437.17	435.69
UHN	Toronto, ON	1.32	437.17	435.85
Sunnybrook	Toronto, ON	1.28	437.17	435.89
Interior Health	Kelowna, BC	9.32	437.17	427.85
Jesse Brown VA	Chicago, IL	2.88	437.17	434.29
Jamaica Plains VA	Boston, MA	3.02	437.17	434.15
West Roxbury VA	Boston, MA	3.02	437.17	434.15
Kaiser Permanente	San Leandro, CA	9.82	437.17	427.35

Based on the GWP values for anesthetic gases, the avoided emissions from capturing instead of releasing the anesthetic gases is 437.17 kg CO_2-eq./Deltasorb® canister cycle. Meanwhile, the total impacts vary by location from 1.28-9.82 kg CO_2-eq/Deltasorb® canister cycle, which leads to a total prevented emissions ranging from 427.35-435.89 kg CO_2-eq/Deltasorb® canister cycle (prevented emissions from capturing the anesthetic gases generated in an operating room per week).

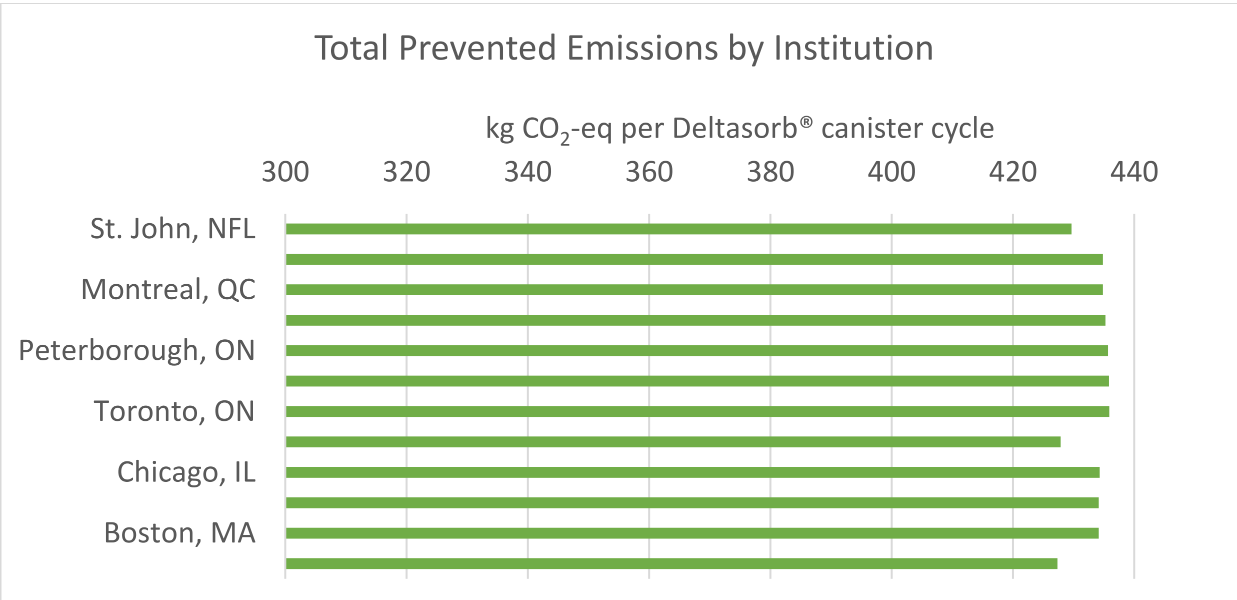

Figure 1: Total Prevented Emissions by Institution

Even though the total impacts vary based on Institution location, the total prevented emissions is still 97.75% - 99.71% of the avoided emissions, which means the Deltasorb® canister would reduce the impacts from the anesthetic gases by approximately 99%.

The Deltasorb® processing system would prevent approximately 427 – 435 kg CO_2-eq per Deltasorb® canister cycle. The Deltasorb® canister would capture 70% of the total anesthetic gases used in an operating room, and the total GWP of the anesthetic gases released would be reduced from 625 kg CO_2-eq to 190-198 kg CO_2-eq.

Increasing the number of cycles for the Deltazite® material would improve the total prevented emissions due to the contribution from Deltazite® manufacturing. It is also recommended to include the potential value of the generic anesthetic.

Table of Contents

List of Tables

List of Figures

List of Units

kg – kilogram
km – kilometer
kgkm – kilogram-kilometer
kWh – kilowatt hours
MJ – mega joules
kg CO_2 eq. – kilogram carbon dioxide equivalent

Introduction

A comparative life cycle analysis (LCA) was conducted to determine total prevented emissions associated with using a Deltasorb® canister compared to a conventional anesthetic practice. The ISO standard for Carbon Footprint (ISO 14067) outlines the methodology to quantify the Carbon Footprint of Products (CFP), in conformity to the ISO standard for Life Cycle Analysis (ISO 14040/44) and was utilized for this project. GaBi LCA Software was used to model the products' life cycle and calculate the carbon footprint results and avoided emissions.

Product Description and Primary Function for Deltasorb®

Blue Zone Technologies Deltasorb® canisters capture anesthetic gases currently released during surgery for recovery. Anesthetic gases represent significant climate impacts. The primary function for a Deltasorb® canister is to capture and recover anesthetic gases.

Functional Unit and Reference Flow

The functional unit is one Deltasorb® canister cycle, which represents the capture of 0.525 kg of anesthetic gas, which is approximately the amount of anesthetic gases generated in an operating room per week.

System Boundaries

The system boundaries for the LCA include manufacturing of consumables, transportation, and anesthetic gas recovery.

LCA Limitations

Parameter uncertainty, scenario uncertainty, and model uncertainty contribute to the limitations in using LCA. Assumptions and secondary data are required when information and primary data are not available. The LCA limitations are discussed in the data quality discussion section.

LCA Software

GaBi is an LCA software used to conduct a life cycle analysis with information gathered from specific industry and regional databases. The system is first visually constructed indicating each life-stage with material and energy flows. The inputs and outputs for the system are defined using arrows to indicate flow direction. Each block is then customized with respect to the process. Once the system is complete, the software will then generate values with respect to the environmental metrics such as global warming potential (GWP), acidification, eutrophication, and photochemical oxidation [1].

Environmental Performance and Impact Categories

Environmental performance and impact categories include carbon footprint. The carbon footprint is calculated using the CML-2016 methodology for global warming potential (GWP), 100 years.

LCIA Methodology

The processes within the LCA for the Deltasorb® canisters include manufacturing of consumables, transportation, and anesthetic gas recovery. The use phase is passive without a significant pressure differential, and it is assumed to not contribute to the environmental impacts.

LCIA Methodology: Manufacturing of Consumables

Major Unit Processes

Consumables are from suppliers located in Central Asia and Canada. Transportation of raw materials to suppliers, and treatment of waste generated are also included. Extraction and refining of raw materials are included in the manufacturing process for each component in GaBi. Transportation to Blue Zone Technologies is also included in the manufacturing of consumables.

Table 2: Consumable Manufacturing Locations

Parts	Location
Deltazite®	Central Asia
4" EPDM Gasket	Mississauga, Ontario
Screws, Washers, and Nuts	Concord, Ontario
Screens	Hamilton, Ontario

Assumptions and Interpretation

Deltasorb® canisters are assumed to be rebuilt after 8 cycles where the following consumables are replaced: Deltazite®, screws, gaskets, and screens. Deltazite® is the absorbent material used for anesthetic gas recovery inside the canister. Data for Deltazite® manufacturing was supplied for the manufacturer in Central Asia and modelled separately. Screws, washers, nuts, and screens are assumed to be stainless steel. All of the Deltazite®, 50% of the screws, 50% of the screens, and 10% of the gaskets are assumed to be replaced at the 8-week rebuild. The canister is made from stainless steel and can be used for up to 10+ years, and the manufacture and disposal of the canister is assumed to not significantly contribute to the environmental impacts.

The Deltazite® is assumed to be transported to Blue Zone Technologies by ocean freighter, train, and truck transport. Other consumables are assumed to be transported to Blue Zone Technologies by truck transport.

LCIA Methodology: Transportation

Major Unit Processes

Transportation to Blue Zone Technologies' facility and back to the institution is included in the analysis.

Table 3: Institution Locations

Institution(s)	Location
Eastern Health	St. John, NFL
Montreal Heart Institute	Montreal, QC
CHUM	Montreal, QC
CHEO	Ottawa, ON
Peterborough Regional	Peterborough, ON
UHN	Toronto, ON
Sunnybrook	Toronto, ON
Interior Health	Kelowna, BC
Jesse Brown VA	Chicago, IL
Jamaica Plains VA	Boston, MA
West Roxbury VA	Boston, MA
Kaiser Permanente	San Leandro, CA

Assumptions and Interpretation

Transportation is assumed to be by truck transport. The distance between Blue Zone Technologies and the Institutions are assumed to be the fastest route as identified by Google Maps. The distance is doubled to include impacts from transporting the canisters to the processing facility for anesthetic gas recovery and back to the institution to be reused. The canister is assumed to weigh 5kg. The carbon footprint results are presented by location.

Major Unit Processes

The Anesthetic gas recovery and production consists of desorption and distillation processes at Blue Zone Technologies' facility located at 13-84 Citation Drive, Concord, Ontario, Canada.

Assumptions and Interpretation

The use phase at the institution is assumed to not contribute to the environmental burden. It is assumed 70% of the anesthetic gas used in an operating room is captured. It is assumed the patient consumes 5%, and the remaining is lost during exhalation, and mask removal. Assume anesthesia gases is composed of 29% Desflurane, 70% Sevoflurane, and 1% Isoflurane. Desorption and distillation process assumed to be near closed loop systems with <1% loss.

Desorption Process

Desorption is used to recover anesthetics captured on the adsorbent and liquify them as raw material for further processing. Each desorption run processes 100 canisters and requires 6300 gallons of water and the nitrogen bulk tank decreases by 8 cm H_2O.

Distillation Process

Distillation is used to separate the cocktail of recovered anesthetics back into pure generic drug products. Inputs are assumed to include the raw material and electrical usage only. It is assumed no waste is generated as intermediates and leftover material is re-used in future production batches. It is assumed Desflurane takes 3-5 days and Sevoflurane takes 5-8 days for distillation.

Calculation Procedures

Manufacturing of Consumables

Component transportation to Blue Zone Technologies from Supplier in kgkm/Deltasorb® (separated in GaBi):

Component Transportation (kgkm/Deltasorb® canister cycle) =Component(kg/Deltasorb®) *Distance(km)/ 8 cycles

Consumable CF = Consumable CF (kg CO_2-eq/kg Consumable) * Consumable weight (kg) / 8 cycles

Transportation

Product Transportation=5 (kg)*Distance to Institution(km)*2

Anesthetic Production

Distillation Electricity

Distillation – Desflurane = Electricity (kWh/day) * 5 days

Distillation – Sevoflurane = Electricity (kWh/day) * 8 days

Study Data for Deltasorb®

Anesthetic Gas Global Warming Potential

Andersen, M.P, et al. (2012). Assessing the impact on global climate from general anesthetic gases. *Anesthesia & Analgesia*. 114(5):p 1081-1085, May 2012. DOI: 10.1213/ANE.0b013e31824d6150 [2]

Table 4: Anesthetic Gas Global Warming Potential

Inhaled anesthetic agent	Global Warming Potential, 100 years (kg CO_2-eq/kg anesthetic agent)
Desflurane	2540
Isoflurane	510
Sevoflurane	1 30

Consumables Data

The following data represents the quantity consumed per 8 cycle-rebuild:

Table 5: Consumables Data

Component Name	Material	Form of Material	Weight (kg)	Supplier Location
Deltazite®	SiO_2 98.95% Al2O3 1.05%	Spherical Beads	2	Central Asia
Screws	Stainless steel		0.0128	Concord, Ontario
Gasket	EPDM		0.0018	Mississauga, Ontario
Screens	Stainless steel		0.175	Hamilton, Ontario

Deltazite® Manufacturing Data

The following data is used to produce 1kg of Deltazite®:

Table 6: Deltazite® Manufacturing Data

Input Data	
Sodium silicates	2.98 kg
Sulfuric acid	0.57 kg
Natural gas	18-32 MJ
Water	45 kg
Output Data	
Deltazite®	1 kg
Sodium sulfate	0.89 kg
Air particulates	0.00124 kg
Wastewater	34 kg
Carbon dioxide	0.00018%
Steam	0.0052

Institution Transportation Data

The following data shows the one-way distance between Blue Zone Technologies and the listed Institution:

Table 7: Institution Transportation Data

Institution(s)	Location	Distance
Eastern Health	St. John, NFL	3070
Montreal Heart Institute	Montreal, QC	550
CHUM	Montreal, QC	550
CHEO	Ottawa, ON	340
Peterborough Regional	Peterborough, ON	130
UHN	Toronto, ON	50
Sunnybrook	Toronto, ON	30
Interior Health	Kelowna, BC	4050
Jesse Brown VA	Chicago, IL	830
Jamaica Plains VA	Boston, MA	900
West Roxbury VA	Boston, MA	900
Kaiser Permanente	San Leandro, CA	4300

Anesthetic Recovery Process Data

The following data represents the anesthetic recovery process per canister cycle:

Table 8: Anesthetic Recovery Process Data

Desorption Process	
Electricity	2.3 kWh
Nitrogen	0.42 kg
Process Water	286 kg
Distillation Process	
Electricity	0.52 kWh per day

Data Sources

The following table provides information relating to the data sources used within GaBi.

Table 9: Data Sources

Component	Material Description	Material Dataset	Data Source	Publication Date
		Manufacturing of Consumables		
Screws	Stainless Steel	Stainless steel parts	Worldsteel	2022
Gasket	EPDM	Ethylene Propylene Diene Elastomer (EPDM)	Sphera	2020
Screens	Stainless Steel	Stainless steel parts	Worldsteel	2022
Deltazite®	Sodium silicates	Journal Article [3] 0.91 kg CO_2-eq/kg sodium silicates		
Deltazite®	Sulfuric acid	Sulphuric acid aq. Mix (96%)	Sphera	2020
		Transportation		
Truck	Diesel	Transport, single-unit truck, diesel powered	US LCI Database	2020
Ocean Freighter	Average fuel mix	Transport, ocean freighter, average fuel mix	US LCI Database	2020
Train	Average fuel mix	Transport, train, average fuel mix	US LCI Database	2020
		Energy/Processing		
Electricity – Ontario, Canada	Ontario electricity mix	Emission Factors and Reference Values [4] Ontario electricity consumption intensity value: 28 g CO_2-eq/kWh electricity consumed		
Natural Gas	Natural gas	IN: Natural gas mix	Sphera	2022
Process water	Water	Process water from ground water	Sphera	2022
Nitrogen	Nitrogen	Nitrogen (gaseous)	Sphera	2020
		Waste Processing		
Wastewater	Wastewater	Processed water to lake, output	Sphera	2022
Landfill	Waste	Landfilling of waste	Sphera	2022

Data Quality Discussion

Table 10: Data Quality Discussion

Data Quality Parameter	Data Quality Discussion
Geographical Coverage: **Geographical area from which data for unit processes is collected to satisfy the goal of the study**	Suppliers located in Canada and Central Asia. Blue Zone Technologies located in Concord, Ontario, Canada. Institutions located in Canada and United States.
Technology Coverage: **Specific technology or technology mix**	Electricity grid mix is based on the manufacturing facility location, and the appropriate electricity grid mix is used within the LCA model in GaBi.
Precision: **Measure of the variability of the data values for each data expressed**	The electricity values vary based on weather conditions, demands of production and time of day by electricity provider. The Deltasorb® canister consumables weight varies by cycle. The transportation values are based on fastest routes and may vary by delays, detours, and weather.
Representativeness: **Qualitative assessment of the degree to which the data set reflects the true population of interest**	The Deltasorb® canister consist of all major consumables. The electricity for processing at Blue Zone Technologies is based on average run.
Consistency: **Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis**	Each component was separately represented within the model based on manufacturing location, material, and manufacturing process.
Sources of the Data: **Description of all primary and secondary data sources**	Primary data sources collected and provided by Blue Zone Technologies. Secondary sources from a journal article, Canada Government website, Sphera database, worldsteel database, and US LCI database.
Reproducibility: **Qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study**	The results could be reproduced using the information provided within the LCA report.
Uncertainty of the Information: **Uncertainty related to data, models, and assumptions**	The assumptions for manufacturing technology, material data availability, and transportation from suppliers contributes to the uncertainty of the information.
Environmental Relevance:	The environmental relevance of the LCIA results is decreased due to the system wide averaging, aggregation, and allocation.

Results and Discussion

The following section will discuss the carbon footprint for the Deltasorb® canister processing, and the total prevented emissions compared to the conventional anesthetic practices. The carbon footprint results are shown separately for the Deltasorb® processing and by institution.

Carbon Footprint - Deltasorb® Canister Processing

The Deltasorb® Canister processing carbon footprint includes the consumables impacts (manufacturing and supplier transportation) and Desorption and Distillation process impacts. The transportation to and from Blue Zone Technologies will be presented separately.

Table 11: Carbon Footprint for Deltasorb® Canister Processing

	kg CO_2-eq per Deltasorb® canister cycle
Consumables - Deltazite®	0.814
Consumables – screws, gaskets, and screens	0.047
Supplier transportation	0.145
Desorption Process	0.105
Distillation Process – Desflurane	0.022
Distillation Process – Sevoflurane	0.082
Total	**1.22**

The carbon footprint for 1 kg of Deltazite® is determined to be 3.26 kg CO_2-eq. Although the canister uses 2 kg of Deltazite®, the Deltazite® can be reused for 8 cycles before disposal. Therefore, the contribution to the total carbon footprint from the Deltazite® is ¼ of 3.26 which is 0.814 kg CO_2-eq./Deltasorb® canister cycle. The total carbon footprint for processing the Deltasorb® canister, including consumables impacts and processing at Blue Zone Technologies is 1.22 kg CO_2-eq./Deltasorb® canister cycle.

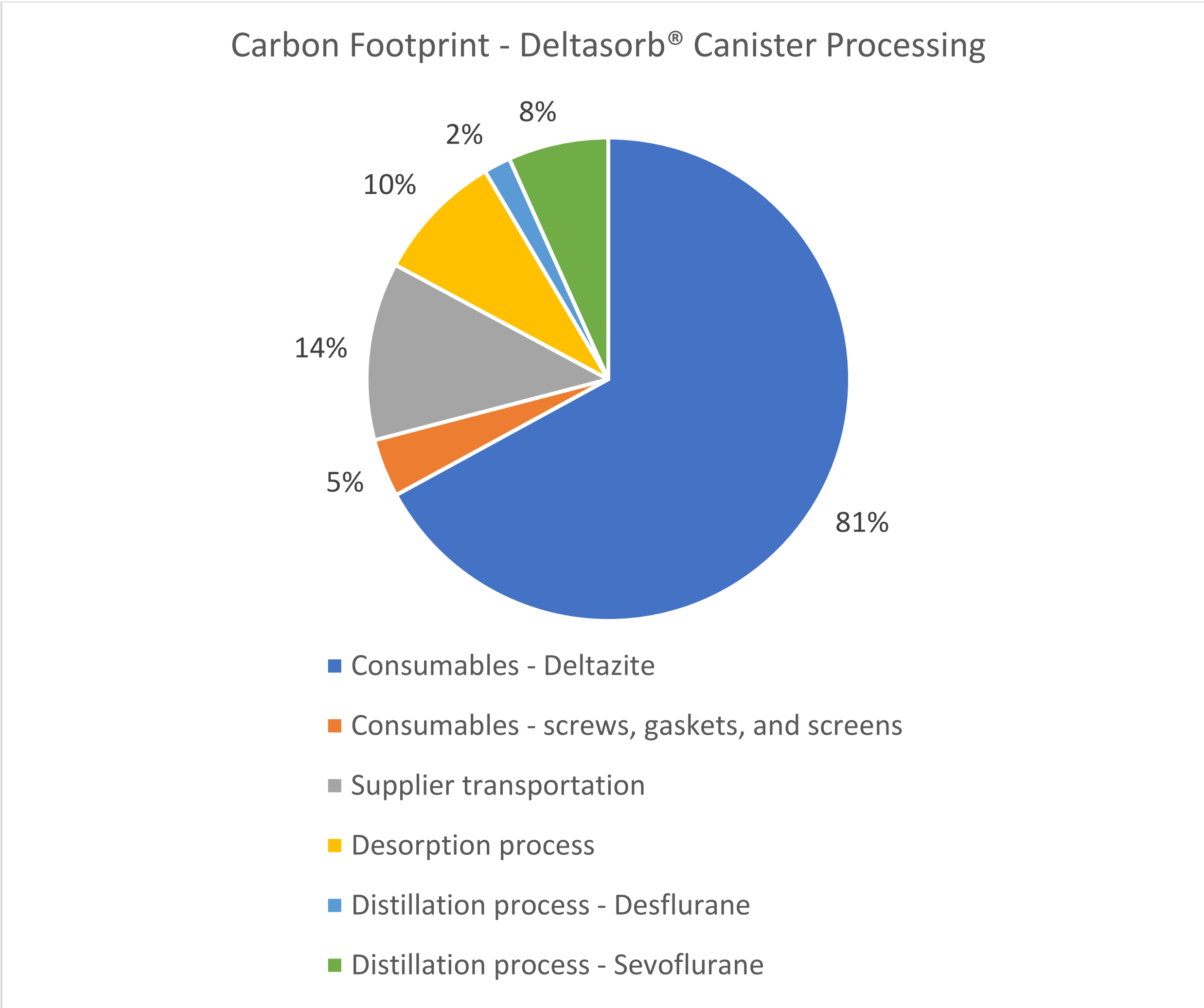

Figure 2: Carbon Footprint - Deltasorb® Canister Processing

The Deltazite® manufacturing significantly contributes to the total carbon footprint for the Deltasorb® canister processing at 81%, followed by supplier transportation at 14%. The Desorption and Distillation processes combined contribute 20% to the total carbon footprint.

Total Prevented Emissions

The total prevented emissions relates to the avoided emissions from capturing anesthetic gases in an operating room using the Deltasorb® canister compared to the conventional anesthetic practices where the gases are released. The total prevented emissions is equal to the avoided emissions minus impacts due to Deltasorb® canister processing and transportation.

Table 12: Total Prevented Emissions by Institution

		Total Impacts (Deltasorb® Processing + Transportation)	Avoided GWP Anesthetics	Total Prevented Emissions
		(kg CO_2-eq/Deltasorb® canister cycle)		
Eastern Health	St. John, NFL	7.36	437.17	429.81
Montreal Heart Institute	Montreal, QC	2.32	437.17	434.85
CHUM	Montreal, QC	2.32	437.17	434.85
CHEO	Ottawa, ON	1.9	437.17	435.27
Peterborough Regional	Peterborough, ON	1.48	437.17	435.69
UHN	Toronto, ON	1.32	437.17	435.85
Sunnybrook	Toronto, ON	1.28	437.17	435.89
Interior Health	Kelowna, BC	9.32	437.17	427.85
Jesse Brown VA	Chicago, IL	2.88	437.17	434.29
Jamaica Plains VA	Boston, MA	3.02	437.17	434.15
West Roxbury VA	Boston, MA	3.02	437.17	434.15
Kaiser Permanente	San Leandro, CA	9.82	437.17	427.35

Based on the GWP values for anesthetic gases, the avoided emissions from capturing instead of releasing the anesthetic gases is 437.17 kg CO_2-eq./Deltasorb® canister cycle. Meanwhile, the total impacts vary by location from 1.28-9.82 kg CO_2-eq/Deltasorb® canister cycle, which leads to a total prevented emissions ranging from 427.35-435.89 kg CO2-eq/Deltasorb® canister cycle (prevented emissions from capturing the anesthetic gases generated in an operating room per week).

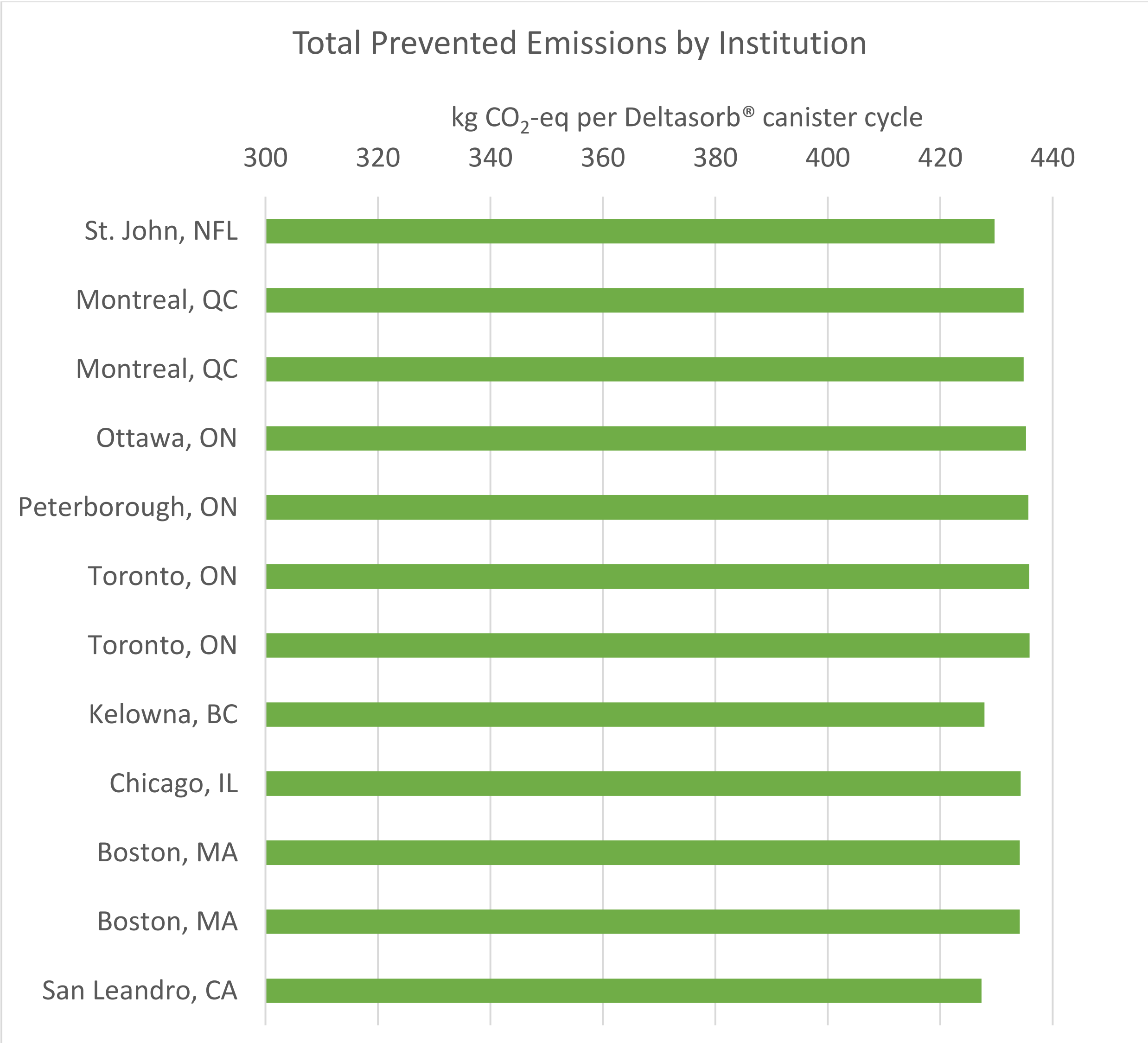

Figure 3: Total Prevented Emissions by Institution

Even though the total impacts vary based on Institution location, the total prevented emissions are 97.75% - 99.71% of the avoided emissions, which means the Deltasorb® canister would reduce the impacts from the anesthetic gases by approximately 99%.

Sensitivity Analysis

A sensitivity analysis is used to test the robustness and uncertainties of the data and results in an LCA study due to choices made within the LCIA methodology. A sensitivity analysis was conducted for two different scenarios for the Deltasorb® canister cycle in relation to the LCIA assumptions. The two scenarios are described below.

Scenario 1: Canister rebuilt after 6 cycles

- Canisters rebuilt after 6 cycles instead of 8 cycles

Scenario 2: 100% Sevoflurane

- Composition of anesthetic gases 100% Sevoflurane instead of 29% Desflurane

Table 13: Sensitivity Analysis

		Baseline	Scenario 1	Scenario 2
Eastern Health	St. John, NFL	429.81	429.31	60.89
Montreal Heart Institute	Montreal, QC	434.85	434.52	65.93
CHUM	Montreal, QC	434.85	434.52	65.93
CHEO	Ottawa, ON	435.27	434.94	66.35
Peterborough Regional	Peterborough, ON	435.69	435.36	66.77
UHN	Toronto, ON	435.85	435.52	66.93
Sunnybrook	Toronto, ON	435.89	435.56	66.97
Interior Health	Kelowna, BC	427.85	427.52	58.93
Jesse Brown VA	Chicago, IL	434.29	433.96	65.37
Jamaica Plains VA	Boston, MA	434.15	433.82	65.23
West Roxbury VA	Boston, MA	434.15	433.82	65.23
Kaiser Permanente	San Leandro, CA	427.35	427.02	58.43

Sensitivity Analysis Discussion

The sensitivity analysis conducted for the Deltasorb® concerns two assumptions inducing uncertainty for the LCA results – cycles before canister is rebuilt and anesthetic gas composition.

For the first scenario, canisters were set to be rebuilt after 6 cycles instead of 8 cycles. The Deltasorb® processing impacts increased from 1.21 to 1.55 kg CO_2-eq./Deltasorb® canister cycle, while the prevented emissions were decreased by <1%.

For the second scenario, 100% of the anesthetic gases would be Sevoflurane instead of including 29% of Desflurane, which has a significantly higher GWP. The avoided emissions decreased from 437 to 69 kg CO_2-eq/ Deltasorb® canister cycle, which led to a significant reduction in prevented emissions. However, total prevented emissions would still be between 86-98% of the avoided emissions, taking into consideration the Deltasorb® processing impacts.

Due to the limited changes in results from the sensitivity analysis, the LCIA assumptions are shown to be reasonable.

Impacts from Capture Efficiency

The capture efficiency in an operating room impacts the total emissions from the Deltasorb canister and total prevented emissions, considering the released emissions would vary by capture efficiency. Two scenarios for Deltasorb utilization are presented below:

Scenario #1: Canister in use until 0.525 kg of anesthetic gas is captured

- Assume if the capture efficiency were to decrease, the canister would continue in use until 0.525 kg of anesthetic gas is captured

Scenario #2: One week canister cycle

- Assume canister is returned after 1 week, regardless of capture efficiency

The scenarios are analyzed for capture efficiency and anesthetic gas composition. The capture efficiency varies from 20% to 70% and the current anesthetic gas composition and 100% Sevoflurane anesthetic gas composition are assessed for each scenario.

Scenario #1: Canister in Use Until 0.525 kg of anesthetic gas is captured

The canister is in use until 0.525 kg of anesthetic gas is captured, which means the impacts from the Deltasorb processing and transportation will remain the same, assuming the use phase does not contribute to the environmental burden.

Current Anesthetic Gas Composition (Scenario #1)

For the current anesthetic gas composition, the total prevented emissions for one Detasorb canister is 433 kg CO_2-eq/Deltasorb canister.

Table 14: Impacts from Capture Efficiency: Current Anesthetic Gas Composition (Scenario #1)

Capture Efficiency	Total Potential GWP of Anesthetic Gases Released (without Deltasorb)	Total GWP of Anesthetic Gases Released (with Deltasorb)	Percent Reduction of Gases Released	Total Prevented Emissions	Percent Reduction in Avoided Emissions
20%	2185.84	1752.84	20%	433	99%
30%	1457.23	1024.23	30%	433	99%
40%	1092.92	659.92	40%	433	99%
50%	874.34	441.34	50%	433	99%
60%	728.61	295.61	59%	433	99%
70%	624.53	191.53	69%	433	99%

If the Deltasorb canister were to remain in use until it reaches capacity, 99% of the captured emissions would be avoided, meaning that the reduction would be directly related to the capture efficiency. For instance, if the capture efficiency is 30%, then the percent reduction of gases released would be 30%. No additional emissions would be created or released from the processing or transport of the Deltasorb canister since it remains in use.

100% Sevoflurane Anesthetic Gas Composition (Scenario #1)

For the 100% Sevoflurane anesthetic gas composition, the total prevented emissions for one Detasorb canister is 64.41 kg CO_2-eq/Deltasorb canister.

Table 15: Impacts from Capture Efficiency: 100% Sevoflurane Anesthetic Gas Composition (Scenario #1)

Capture Efficiency	Total Potential GWP of Anesthetic Gases Released (without Deltasorb)	Total GWP of Anesthetic Gases Released (with Deltasorb)	Percent Reduction of Gases Released	Total Prevented Emissions	Percent Reduction in Avoided Emissions
20%	341.25	276.84	19%	64.41	94%
30%	227.50	163.09	28%	64.41	94%
40%	170.63	106.22	38%	64.41	94%
50%	136.50	72.09	47%	64.41	94%
60%	113.75	49.34	57%	64.41	94%
70%	97.50	33.09	66%	64.41	94%

If the anesthetic gas composition were to be 100% Sevoflurane and the Deltasorb canister were to remain in use until it reaches capacity, 94% of the captured emissions would be avoided. The precent reduction of gases released would be 1-4% lower than the capture efficiency due to the lower total prevented emissions for the 100% Sevoflurane anesthetic gas composition.

Scenario #2: One week canister cycle

The canister is returned and replaced after one week canister cycle, irrespective of the capture efficiency. The total potential GWP of the anesthetic gases released in an operating room per week and the Deltasorb emissions for processing and transportation would remain the same, while the total prevented emissions would be correlated with the capture efficiency.

Current Anesthetic Gas Composition (Scenario #2)

For the current anesthetic gas composition, the total potential GWP of the anesthetic gases in an operating room per week is 624.53 kg CO_2 eq, while the Deltasorb processing and transportation emissions per week is 3.84 kg CO_2-eq/Deltasorb canister.

Table 16: Impacts from Capture Efficiency: Current Anesthetic Gas Composition (Scenario #2)

Capture Efficiency	Total Potential GWP of Anesthetic Gases Released (without Deltasorb)	Total GWP of Anesthetic Gases Released (with Deltasorb)	Percent Reduction of Gases Released	Total Prevented Emissions	Percent Reduction in Avoided Emissions
20%	624.53	503.46	19%	121.07	97%
30%	624.53	441.01	29%	183.52	98%
40%	624.53	378.56	39%	245.97	98%
50%	624.53	316.10	49%	308.42	99%
60%	624.53	253.65	59%	370.88	99%
70%	624.53	191.20	69%	433.33	99%

If the Deltasorb canister were to be replaced and processed weekly, a lower capture efficiency would result in the canister containing less anesthetic gases for processing, compared to a higher capture efficiency, and lower weekly prevented emissions. For the current anesthetic gas composition, the percent reduction of gases released would be 1% lower than the capture efficiency, and the percent reduction in avoided emissions ranges from 97-99%.

100% Sevoflurane Anesthetic Gas Composition (Scenario #2)

For the 100% Sevoflurane anesthetic gas composition, the total potential GWP of the anesthetic gases in an operating room per week is 97.50 kg CO_2 eq, while the Deltasorb processing and transportation emissions per week is 3.84 kg CO_2-eq/Deltasorb canister.

Table 17: Impacts from Capture Efficiency: 100% Sevoflurane Anesthetic Gas Composition (Scenario #2)

Capture Efficiency	Total Potential GWP of Anesthetic Gases Released (without Deltasorb)	Total GWP of Anesthetic Gases Released (with Deltasorb)	Percent Reduction of Gases Released	Total Prevented Emissions	Percent Reduction in Avoided Emissions
20%	97.50	81.84	16%	15.66	80%
30%	97.50	72.09	26%	25.41	87%
40%	97.50	62.34	36%	35.16	90%
50%	97.50	52.59	46%	44.91	92%
60%	97.50	42.84	56%	54.66	93%
70%	97.50	33.09	66%	64.41	94%

If the anesthetic gas composition were to be 100% Sevoflurane and the Deltasorb canister were to be replaced and processed weekly, the percent reduction of gases released would be 4% lower than the capture efficiency. The percent reduction in avoided emissions would be sensitive to the capture efficiency due to the lower total prevented emissions relative to the processing and transportation emissions, which remains the same for each capture efficiency at 3.84 kg CO_2-eq/Deltasorb canister.

100% Sevoflurane Anesthetic Gas Composition (Scenario #2-San Leandro,CA)

For the 100% Sevoflurane anesthetic gas composition, the total potential GWP of the anesthetic gases in an operating room per week is 97.50 kg CO_2 eq, while the Deltasorb processing and transportation emissions per week for the health care facility located furthest from the processing facility (San Leandro, CA) is 9.82 kg CO_2-eq/Deltasorb canister.

Table 18: Impacts from Capture Efficiency: 100% Sevoflurane Anesthetic Gas Composition (Scenario #2-San Leandro,CA)

Capture Efficiency	Total Potential GWP of Anesthetic Gases Released (without Deltasorb)	Total GWP of Anesthetic Gases Released (with Deltasorb)	Percent Reduction of Gases Released	Total Prevented Emissions	Percent Reduction in Avoided Emissions
20%	97.50	87.82	10%	9.68	50%
30%	97.50	78.07	20%	19.43	66%
40%	97.50	68.32	30%	29.18	75%
50%	97.50	58.57	40%	38.93	80%
60%	97.50	48.82	50%	48.68	83%
70%	97.50	39.07	60%	58.43	86%

Considering the sensitivity to processing and transportation emissions for the Deltasorb canister and 100% Sevoflurane anesthetic gas composition, the impacts from capture efficiencies were also assessed for the health care facility located furthest from the processing facility. In this case, the weekly processing and transportation emissions for the Deltasorb canister is 9.82 kg CO2-eq/Deltasorb canister, which is 2.6 times higher than the average emissions used in the previous scenarios. The percent reduction of gases released would be 10% lower than the capture efficiency, where the percent reduction in avoided emissions ranges from 50% - 86%.

Conclusions and Recommendations

The LCA report outlined the process and methodology to determine the carbon footprint for the Deltasorb® canister, and total prevented emissions from its use in operating rooms.

The Deltasorb® processing system would prevent approximately 427 – 435 kg CO_2-eq per Deltasorb® canister cycle. The Deltasorb® canister would capture 70% of the total anesthetic gases used in an operating room, and the total GWP of the anesthetic gases released would be reduced from 625 kg CO_2-eq to 190-198 kg CO_2-eq.

Increasing the number of cycles for the Deltazite® material would improve the total prevented emissions due to the contribution from Deltazite® manufacturing. It is also recommended to include the potential value of the produced generic anesthetic in the analysis.

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