Ogden Point Deep-Water Terminal

Emissions Inventory

2022

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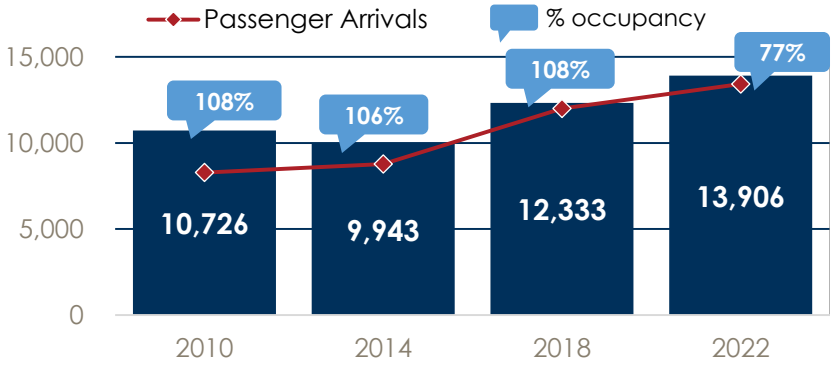
Completed	15/11/2023

GREATER VICTORIA HARBOUR AUTHORITY

synergy

Executive Summary

Annual GHG Emissions (tCO_2e)

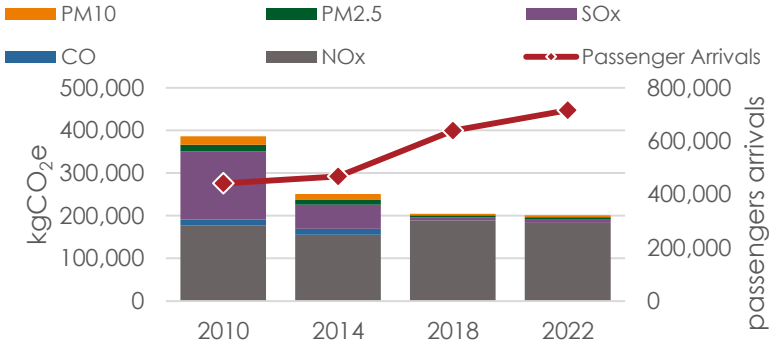


Note: 2010 & 2018 GHG emissions have been re-stated to reflect an improved estimate of emissions from whale watching vessels. See the Transportation section of this report for more details.

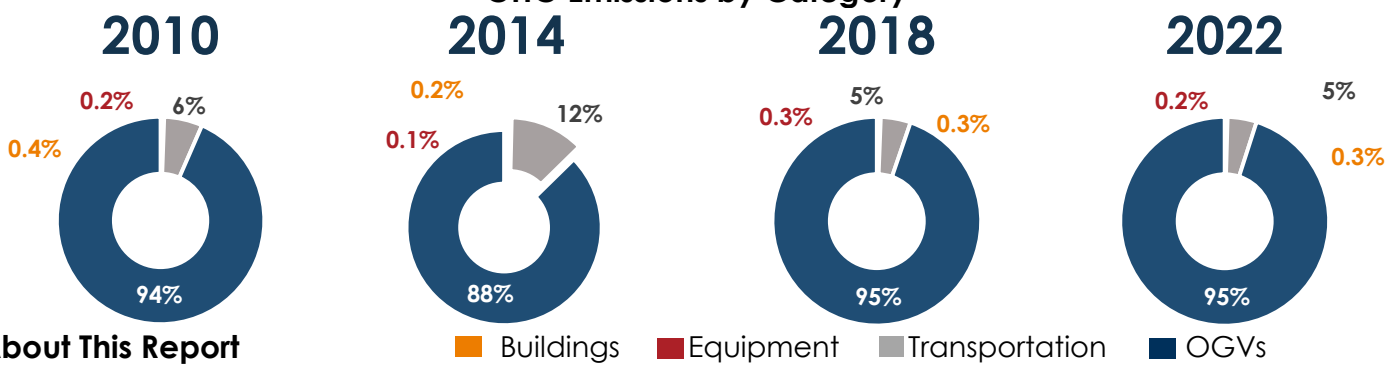
In 2022, 62% more cruise ship passengers visited Ogden Point compared to 2010, despite ships operating at reduced capacity in light of COVID-19. Over the same time period, greenhouse gas emissions from all terminal activity have only increased by 30%. The Port has further observed a significant decrease of criteria air contaminants due to increasingly stringent air emissions requirements and fuel standards.

2010	0.840 kgCACs / PAX
2014	0.513 kgCACs / PAX
2018	0.343 kgCACs / PAX
2022	0.317 kgCACs / PAX

Annual CAC Emissions



GHG Emissions by Category



About This Report

The Ogden Point terminal is owned and operated by The Greater Victoria Harbour Authority (GVHA). GVHA manages deep water, marina and upland holdings at Ogden Point. The terminal has seen a 50% increase in ship calls and a 62% increase in ship passenger arrivals since 2010. This growth resulted in a total of 715,884 passenger arrivals and 329 calls in 2022, making Ogden point the busiest cruise ship port-of-call in Canada.

This report measures 2022 GHG emissions from all buildings, onsite equipment, and transportation, as well as GHG emissions and CACs from ocean going vessels (OGVs) within the boundary of Ogden Point. GVHA continues to be a leader in reducing the environmental impact of the Port. In 2023 Ogden Point secured $9M of funding to install shore power at two berths. This project was not completed during the timeframe of this report, but it is expected that there will be emissions reductions in future years with the installation of shore power.

Total emissions are equivalent to:

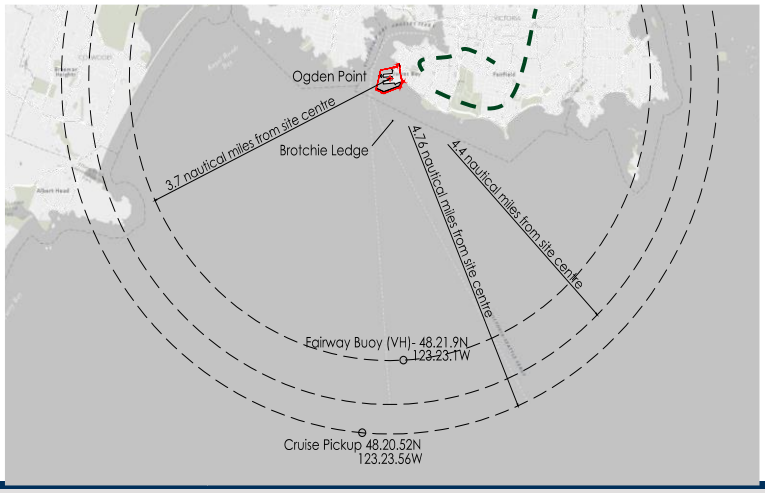
People flying round trip YYJ - YYZ	13,435 Passenger Flights
Homes' energy use for one year	1,754
kg CACs 2022	226,915
tCO_2e 2022	13,906

Geographic Boundary

All buildings and equipment located at Ogden Point have been included in the inventory.

Transportation of all passengers ashore to common tourist destinations has been estimated.

Cruise ship emissions have been measured to a point 4.4 nautical miles outside the terminal, 2 nm south of the 'VH' buoy. This is the pilot boarding location for cruise vessels.



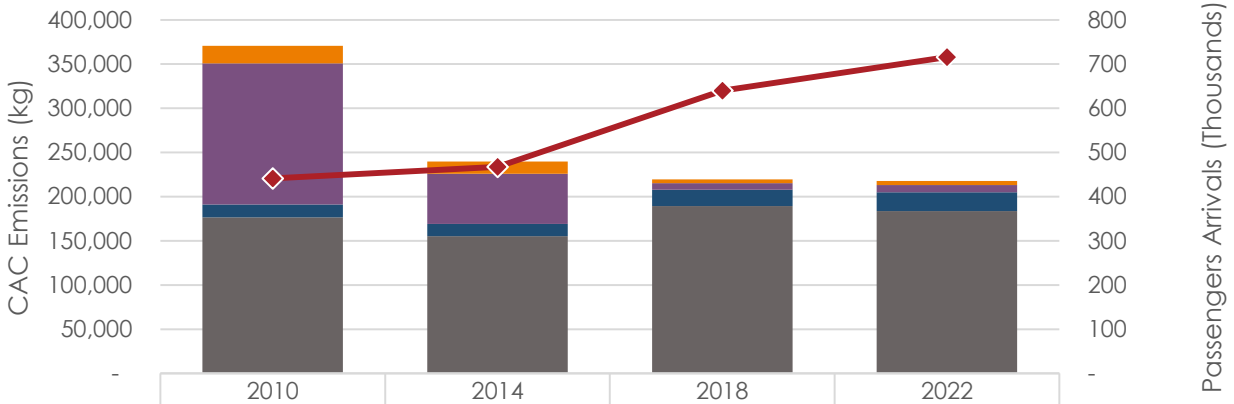
Emission Sources

In accordance with the GHG Protocol for Corporate Accounting, emissions from GVHA and Western Stevedoring have been included in Scope 1, because Western's services are contracted directly by GVHA to support cruise operations. Cruise and other Tenant emissions make up Scope 3. Within each scope, emissions have been grouped into categories including buildings, equipment, ground transportation and ocean going vessels.

	Buildings	Equipment	Transportation	OGVs	
GVHA Owns & operates Ogden Point	Maintenance Shop GVHA office	Vehicles Ground Service Equipment Propane Heaters	Leased Shuttles		Scope 1 & 2
Western Stevedoring Responsible for cruise services	Western's office Pier A Warehouse	Ground Service Equipment	CVS Tours PNWTS Buses & Shuttles		Scope 1 & 2
Cruise 20-30 ship arrivals per year				Ocean Going Vessels (OGVs)	Scope 3
Other Tenants Various tenant businesses	Helijet CVS Tours Victoria Harbour Ferries	Food Trucks Harbour Crafts (GMS Cable Innovator)	Taxis Buses Shuttles		Scope 3

Criteria Air Contaminant (CAC) Summary

Criteria Air Contaminant Emissions



	2010	2014	2018	2022
DPM	19,719	13,831	4,093	4,634
SOx	159,667	56,670	7,440	8,395
CO	14,465	13,894	18,413	21,239
NOx	176,734	155,263	189,483	183,572
Passengers	441,372	467,549	639,771	715,892

Analysis

Research has shown that CACs, in particular black carbon (a component of particulate matter) and NOx, can be significant indirect contributors to global warming. These pollutants also impact local air quality and, in high concentrations, can pose a threat to human health.

2022 saw the effects of increasingly rigorous regulations from the International Maritime Organization (IMO) causing a continual reduction of total CACs. Absolute NOx emissions increased by 4% while NOx emissions per trip decreased by nearly 31%. CO emissions increased by 32%, in line with a 33% increase in total calls. SOx and DPM emissions both decreased dramatically, an indication of the continued use of ultra low sulphur diesel and the increased use of exhaust gas aftertreatment systems on more vessels. As newer, more efficient, and cleaner vessels call at Victoria, it is anticipated that absolute and intensity-based CAC emissions will continue to decrease.

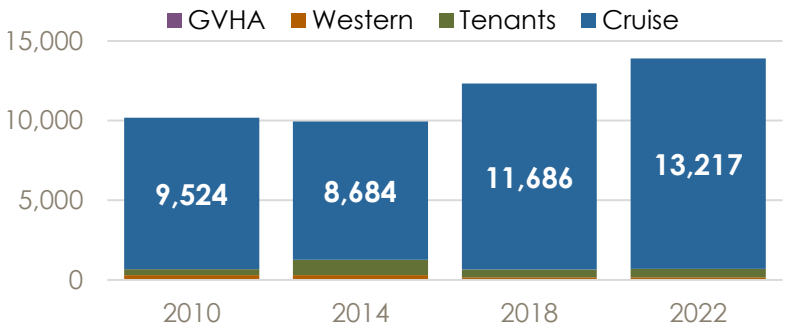
Intensity Metrics		**Kilograms of CAC emissions per cruise ship call**			
Year		2010	2014	2018	2022
NOx	Nitrogen Oxides	**807**	**761**	**780**	**558**
CO	Carbon Monoxide	**66.1**	**68.1**	**75.8**	**64.6**
SOx	Sulphur Oxides	**729**	**278**	**30.6**	**25.5**
DPM*	Diesel Particulate Matter	**90.0**	**67.8**	**16.8**	**14.1**
TOTAL CAC		**1,692**	**1,175**	**903**	**690**

**Note: PM2.5 and PM10 are not reported separately, as all particulate matter produced by diesel engines is considered diesel particulate matter (DPM).*

NO_X	**-31%** Reduction since 2010	**SO_X**	**-96%** Reduction since 2010	**PM**	**-77%** Reduction since 2010	**CACs** (Total)	**-59%** Reduction since 2010

Greenhouse Gas (GHG) Summary

Annual GHG Emissions (tCO_2e)

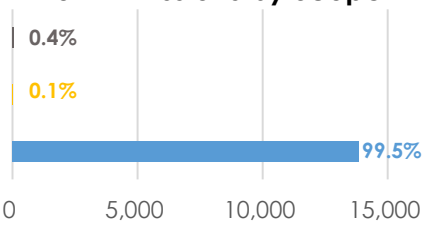


Cruise ship tenants are the largest contributor to port emissions accounting for 95% of the total. This is followed by other tenant emissions (4%), Western Stevedoring (1%), then GVHA (0.2%).

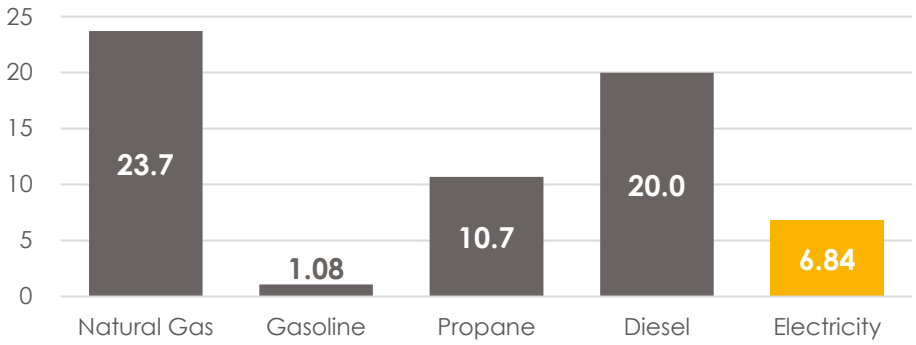
The majority of emissions from non-cruise tenants are transportation emissions from passengers travelling in taxis, whale watching trips or taking bus tours owned by local tour operators. GVHA's largest source of emissions is natural gas used for heating onsite buildings.

Inventory Results	2010	2014	2018	2022
Scope 1 (Direct)	48	30	47	55
Scope 2 (Indirect)	8	7	29	7
Scope 3 (Indirect)	10,135	9,340	12,060	13,844
TOTAL EMISSIONS	10,191	9,376	12,136	13,906

2022 Emissions by Scope



2022 Scope 1 & 2 Emissions by Source (tCO_2e)



466 GJ Nat gas

877,184 kWh of electricity

15,003 L of fuel

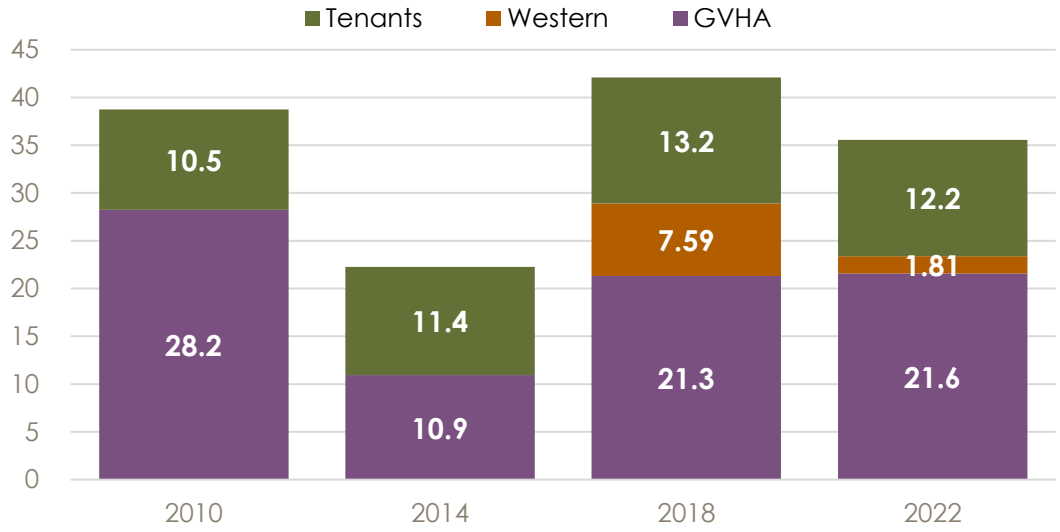
As a result of increased passenger activity and number of ship calls, total emissions has increased 13% since 2018. Total emissions per passenger arrival has also increased by 1% since 2018, due to the fact that ships were operating at reduced passenger capacity in the early part of the season in light of the COVID-19 pandemic.

Despite fluctuations in cruise ship activity, scope 1 and 2 emissions from natural gas, gasoline, propane, diesel and electricity have decreased by 18%. Electricity has the largest decrease in emissions caused by a 66% decrease in kWh consumed onsite and a reduction to the emissions intensity of electricity in BC. Emissions from both natural gas and fuel increased by 5% and 21% respectively.

Scope 1	Scope 2	Scope 3	tCO_2e 2022
55.4 tCO_2e	6.84 tCO_2e	13,844 tCO_2e	13,906

Building Emissions

Annual Building Emissions (tCO_2e)

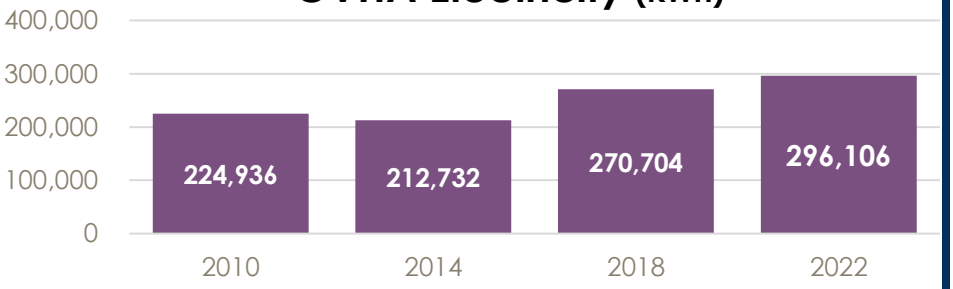


Buildings On Site
GVHA Office
Maintenance Shop
Western Office
Gift Shop & CBSA
Pier A Warehouse
Helijet
James Bay Anglers
BC Pilots House
Breakwater Bistro
Whitehall Sail

** Note: Electricity use has been attributed to Western & other tenants when GVHA bills those tenants directly for metered use. This practice has been increasing since 2010, as meter information becomes more clear. Emissions from three tenants (Whitehall Sail & Service and the Breakwater Café) were not included in the inventory as data was not available for the inventory years in question.*

GVHA Electricity (kWh)

GVHA's electricity consumption has increased 9% since 2018, with two new charging stations installed in the parking lot. However, Western saw a 66% reduction in electricity emissions resulting in a reduction of 5.8 tCO_2e in 2022 from 2018. This is due to upgrading LEDs and less winter activity compared to 2018.

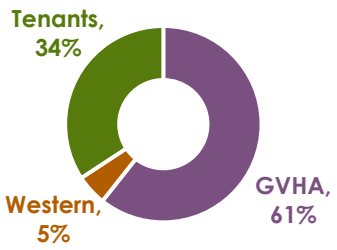


Building emissions at GVHA include heating and lighting activity. Many buildings have electric heating systems, where others are heated with natural gas and propane. In BC, electric heating systems are a great low-emission option for heating due to the low emissions intensity of hydroelectricity.

The GVHA Maintenance shop and old office at 189 Dallas Rd. are heated with natural gas. In 2022, there was a 23% increase in natural gas used at these locations compared to 2018.

With these reductions in electricity and natural gas consumption, emissions from buildings have decreased 16% since 2018. To achieve further reductions, GVHA should look to retrofit buildings with electric heating systems instead of natural gas or propane.

Building Emissions

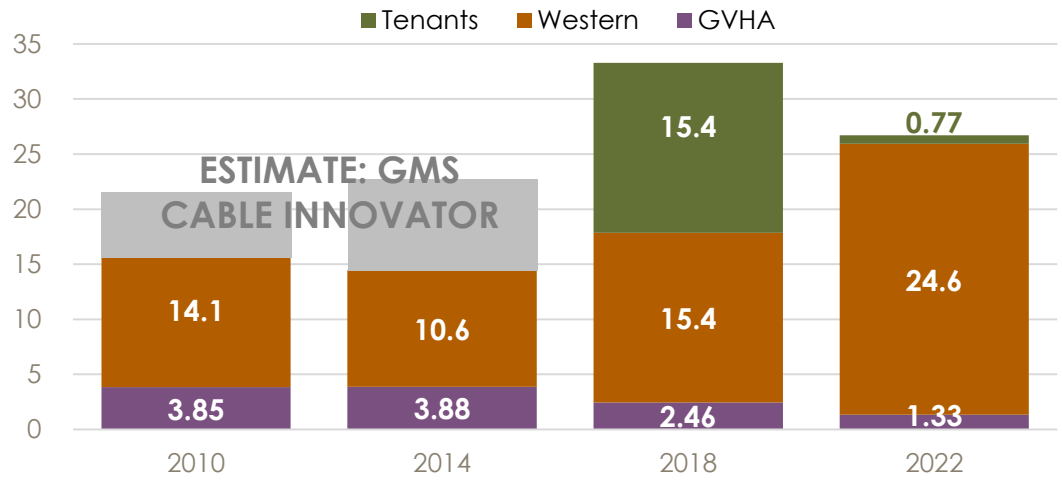


**Note: Propane consumption from Helijet was estimated to be the same as in 2018 due to no new data in 2022.*

35.6 tCO_2e	% of Total 0.3%	% Change -16% since 2018	Emissions equivalent to: People flying round trip YYJ - YYZ 34.4

Equipment Emissions

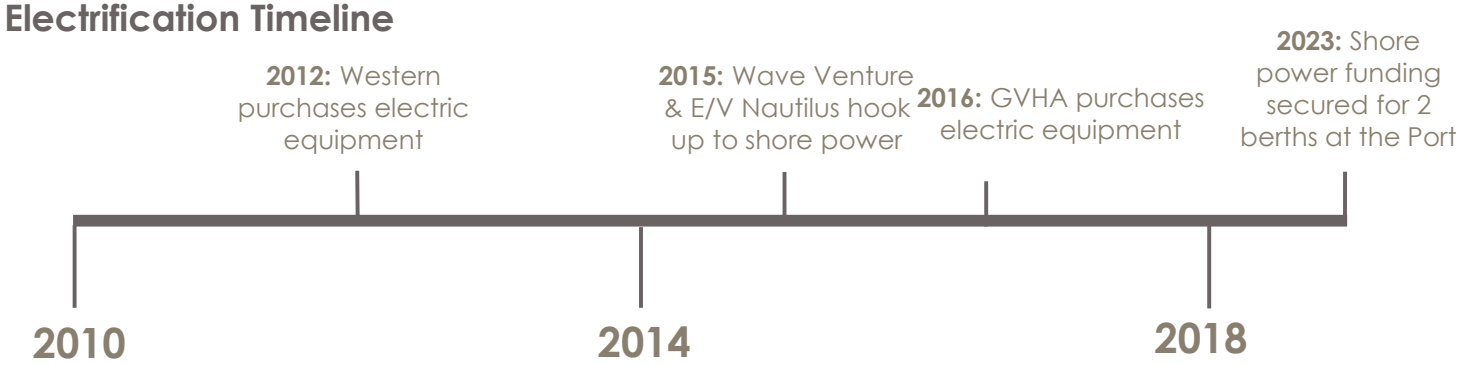
Annual Equipment Emissions (tCO_2e)



Equipment On Site
6 Vehicles
1 Electric Vehicle
1 Forklift
2 Golf Carts
1 Scooter
6 Fork Lifts
4 Electric Golf Carts
1 Backup Generator
GMS Cable Innovator
Green Bus

** Note: 8% of GVHA's total fuel purchases have been included here, to reflect the % of equipment that is used at Ogden Point. This allocation comes directly from GVHA's Maintenance Manager.*

Electrification Timeline

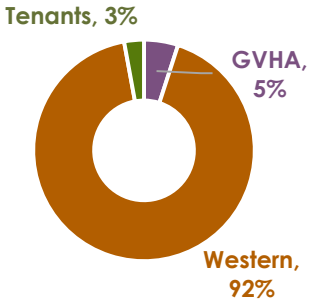


Equipment emissions result from the burning of fossil fuels like gasoline and diesel to power stationary and mobile equipment. Emissions from electrified equipment have also been included in this section.

Emissions from equipment use have decreased 20% since 2018. The proportions of emissions ownership has also changed significantly. In 2022, emissions from Western Stevedoring's equipment accounted for 92% of all equipment emissions. Equipment emissions from Western Stevedoring have increased due to propane and diesel consumption doubling since 2018.

GVHA's equipment has decreased in emissions by 46% with a 73 L reduction in diesel and 369 L reduction in gasoline consumption. This reduction in fuel consumption is due to increased electrification of the GVHA fleet. Lastly, emissions from tenant equipment have decreased 95%. This is because the GMS cable innovator stopped home porting at Ogden point and as a result does not plug into shorepower and use the port's electricity.

Equipment Emissions

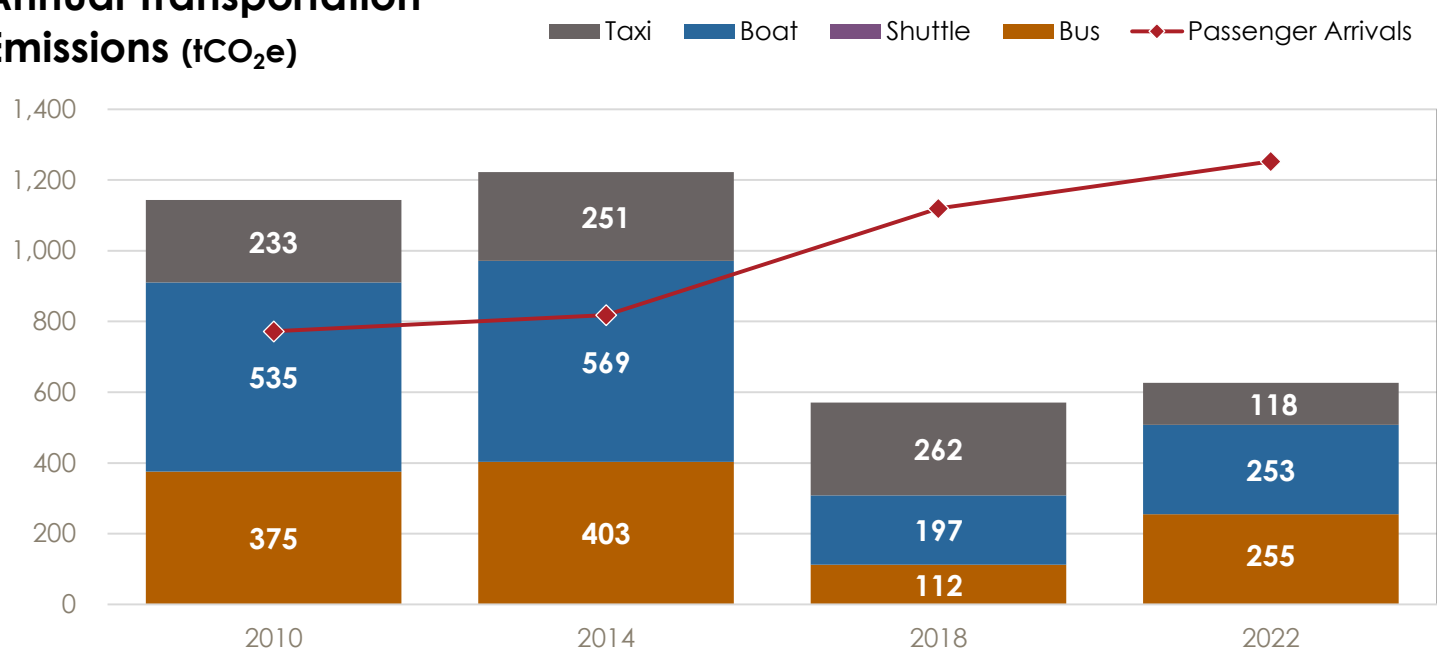


Emissions equivalent to:

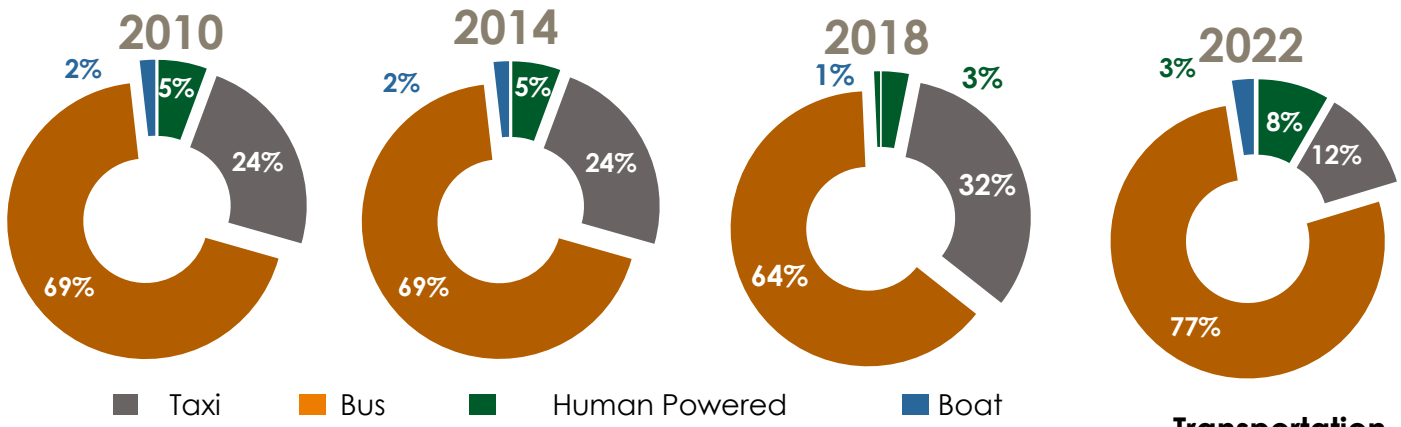
26.7 tCO_2e	% of Total	0.2%	% Change	-16% since 2018	People flying round trip YYJ - YYZ	25.8

Transportation Emissions

Annual Transportation Emissions (tCO_2e)



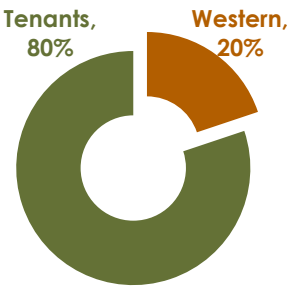
% of Passengers by Mode



Transportation emissions include trips by passengers on taxis, cars, buses, shuttles and whale watching vessels leaving from Ogden Point. Transportation emissions have increased 10% since 2018. This increase in emissions is likely the result of a 30% increase in whale watching emissions and a 47% increase in number of bus trips. 2022 further saw a 165% increase in the number of passengers taking non-motorized transportation such as horse carriages, walking, biking or rickshaws.

Transportation is an emissions source that has potential for decreasing emissions due to electrification capacity for all the vehicles. GVHA is working with transit companies to develop infrastructure and plans for vehicles with low emissions fuel in the coming years.

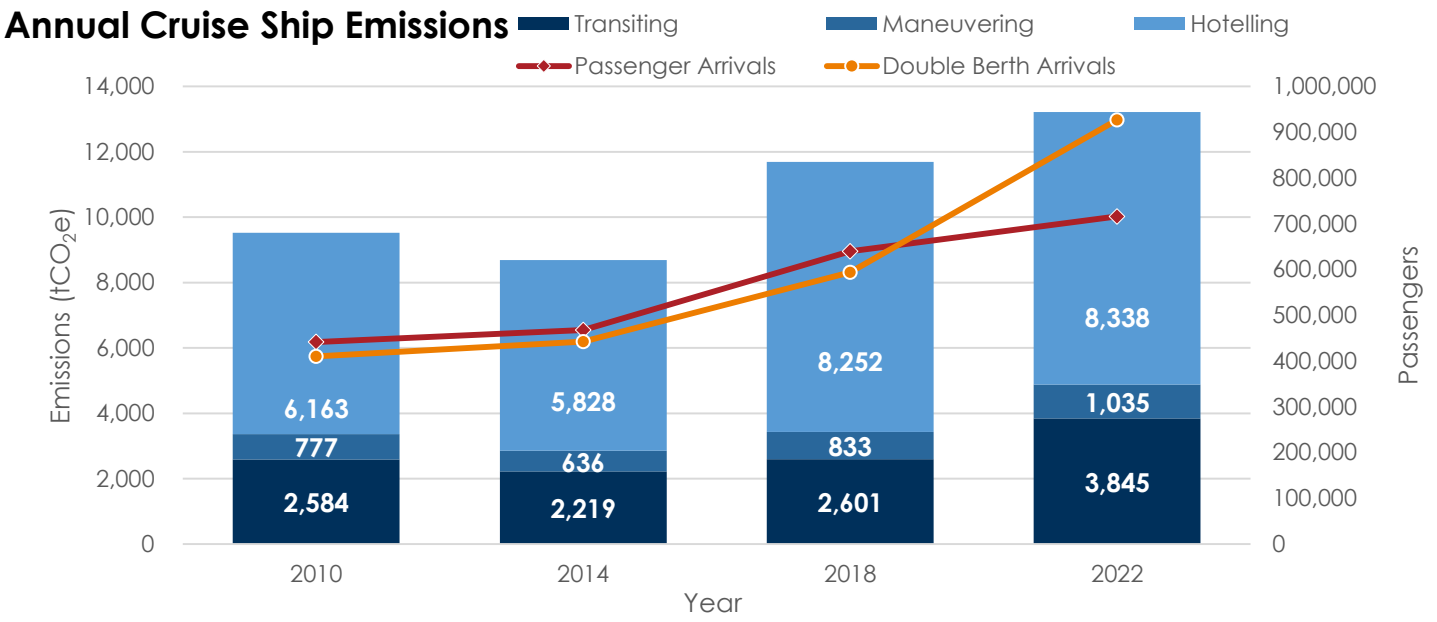
Transportation Emissions



**Note: Whale watching emissions have been restated for 2010, 2014 and 2018 with an improved methodology.*

626 tCO_2e	% of Total 4.5%	% Change 10% since 2018	*Emissions equivalent to:* People flying round trip YYJ - YYZ 605

Ocean-Going Vessel (OGV) GHG Emissions



Actual Cruise Activity KPIs

	2010	2014	2018	2022
# of calls	219	204	243	329
% Increase in Calls	-	-7%	11%	35%
Passenger Arrivals	441,372	467,549	639,771	715,884
% Change in Passengers	-	6%	45%	12%
$kgCO_2e$/Pax	21.6	18.6	18.3	18.5

100% Capacity Cruise Activity KPIs

	2010	2014	2018	2022
100% Occupancy Pax Count	410,052	442,044	593,694	926,747
$kgCO_2e$/Pax*	23.2	19.6	19.7	14.3

**These per passenger values are based on the 100% occupancy numbers for double berth occupancy at the port each year to show directly comparable values despite varying passenger loads.*

Analysis

In 2020 and 2021 the cruise industry was shut down due to COVID-19. 2022 saw a return of ships to Victoria; 329 ships called at Ogden Point, an increase of 65 ships compared to 2019, resulting in emissions of 13,217 tCO_2 The industry re-opened with caution, causing ships to sail at capacities ranging from 25% (early season) to nearly 99% for some ships (end of season). As a result, passenger numbers increased by only 11% compared to 2018, whereas ship calls increased by 22%.

In 2022 emissions per passenger arrival were slightly higher than 2018 and lower than both 2010 and 2014. Average passengers per call in 2022, however, were in line with figures in 2010 and 2014. It is suspected that this decrease is due in part to newer vessels calling at Ogden Point - average year of manufacture was 1999, 2001, 2003, and 2008 for 2010, 2014, 2018, and 2022, respectively.

tCO_2e	13,217
% of Total	95%
% Change	28% Since 2010
	2,176 PAX/Call

Inventory Information

Prepared For	Greater Victoria Harbour Authority		
Contact Information	Lindsay Gaunt	lgaunt@gvha.ca	250-383-8300
Description	Greenhouse Gas (GHG) and Criteria Air Contaminant (CAC) emissions from the Ogden Point Deep-Water Terminal in Victoria, BC.		
Reporting Period	April 1st 2022 - March 31st, 2023		
Inventory Boundary	**Scope 1 (Direct Emissions)** - Natural Gas, Gasoline, Propane, Diesel, Marine Diesel		
	Scope 2 (Indirect Emissions from Purchased Electricity) - Purchased Electricity (BC Hydro)		
	Scope 3 (Indirect Emissions from Other Sources) - Tenant Scope 1 & Scope 2, Ground Transportation, Ocean Going Vessels		
Consolidation Approach	Operational Control: Accounting for 100% of emissions from operations over which the organization has operational control.		
Primary Measurement	Carbon Dioxide Equivalent (CO_2e)		
Reporting Guidelines	Aligned with those defined in *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard, Revised Edition (The GHG Protocol, www.ghgprotocol.org)* . Landside emissions factors reviewed by Offsetters. Ocean Going Vessel methodology peer reviewed.		

Policy for Base Year Recalculation:
Base year emissions, and other previous emissions, shall be retroactively recalculated if a change in organisational structure or data quality is expected to exceed a significance threshold of 10% of base year emissions. These changes may arise from structural changes such as mergers, acquisitions, divestments, outsourcing or insourcing, changes in calculation methodology and improvements in accuracy, or discovery of significant errors.

Landside Data Limitations, Estimates & Assumptions

Fuel: Food trucks use a 7kW generator operating @ a 1/2 load. Calculated based on 4hrs operation/day, the schedule from 2018 was used for 2022 due to unavailable data for the 2022 year. GVHA fuel calculated based on $$ spent and estimating Ogden Point accounts for 8% of GVHA's total fuel use.

Ground Transportation: Main trip destinations are Butchart Gardens, Butchart & Butterfly Gardens, Craigdarroch Castle and City Tours. Avg. vehicle & bus mpg calculated based on average vehicle make/model from permits issued. No permit info available for 2022, so 2018 data was used.

Whale Watching: Emissions have been estimated using the number of whale watching trips departed from Ogden Point.

Scope 3 Tenants: Emissions from three tenants (Whitehall Sail, Mercury Sales & Service and the Breakwater Café) were not included in the inventory as data was not available for the inventory years in question.

GMS Cable Innovator Fuel: Fuel use from the GMS cable maintenance ships transiting within the geographic boundary of ogden point is not included due to data limitations.

Ocean Going Vessel Methodology

Synergy's methodology for calculating GHGs and CACs from Ocean Going Vessels (OGVs) was based heavily on the approach outlined in the World Ports Climate Initiative (WPCI) Carbon Footprinting for Port Guidance Document (2010). In particular, Synergy employed the recommended surrogate approach using a combination of GVHA data, simplified assumptions, world fleet averages and data published in the latest detailed port inventories.

According to this methodology, OGV emissions are a function of vessel power demand (energy) multiplied by an emissions factor:

Emissions (g) = Total Energy (kWh) x EF (g/kWh)

Ships will use varying amounts of energy while in transit/at sea, maneuvering, and hotelling (referred to as the 'mode' the ship is in). This is because the ship's power systems (propulsion & auxiliary) are used differently in each mode. Therefore, total energy is the sum of all energy from the ship's propulsion and auxiliary power systems in each mode*.

Total Energy = Propulsion Energy (Transit) + Auxiliary Energy (Transit) + Propulsion Energy (Maneuvering) + Auxiliary Energy (Maneuvering) + Auxiliary Energy (Hotelling)

**Note: Emissions from auxiliary boilers were not included. The 2016 Puget Sound Maritime Air Emissions Inventory suggests that large diesel-electric cruise ships use waste heat recovery to provide steam during vessel operations, and based on data from the Vessel Boarding Program (VBP), auxiliary boilers are typically off during transiting, maneuvering and hoteling unless ships are connected to shore power. Synergy was not able to access VBP data for the specific ships calling at Ogden Point, however because many of the ships also call at the Port of Seattle, it was assumed that the ships had similar characteristics to the ones in the Puget Sound inventory.*

Energy is a result of the ship's power (Maximum Continuous Rated load, or MCR), times a load factor (LF) times the length of time in a given mode.

Energy = MCR (kW) x LF (%) x Time (hrs)

Where LF = Speed (knots) / (Maximum Speed (knots)^3)
and Time = Distance (nm) / Speed (knots).

Synergy's methodology has been peer reviewed for accuracy and consistency.

Ocean Going Vessel Data, Estimates & Assumptions

Synergy's calculations are based on data from the following sources:

GVHA provided a list of cruise ship calls, including the ship name, number of calls/year, the number of passengers per call and the time at port per call.

The 4.4 nm inventory boundary was established through discussions with the Pacific Pilotage Authority Canada, and is based on the point at which cruise vessels are required to be boarded. Transit and maneuvering distances within the inventory boundary (3.4 and 1 nm respectively) were based on an estimate of typical cruise ship activity obtained from GVHA after discussions with neighbouring ports.

Ocean Going Vessel Data, Estimates & Assumptions

Ship characteristics including age (keel laid date), propulsion/auxiliary system type and deadweight tonnage were found on https://www.vesselfinder.com/vessels. Where specific propulsion and auxiliary system information was not available, a diesel-electric configuration was assumed.

Maximum Continuous Rated (MCR) power, maximum transit speed and maximum rated speed are estimates from the WPCI Guidance Document. Auxiliary engine load defaults for different ship modes are based on estimates from the Puget Sound Maritime Air Emissions Inventory 2016.

World Fleet Population MCR, Max Rated Speed & Sea-Speed			
Subtype (Cruise)	**MCR (kW)**	**Max Rated Speed**	**Sea-Speed**
< 5,000 DWT	16,613	19.5	18.3
5,000 to 9,999 DWT	40,736	21.0	19.7
> 10,000 DWT	68,890	22.3	21.0

Source: WPCI Carbon Footprinting for Ports, Guidance Document, June 30, 2010. pg. 79, Table 5.12

2016 Cruise Ship Auxiliary Engine Load Defaults, kW					
Passenger Range			**Transit**	**Maneuver**	**Hotelling**
1,499	>		5,733	6,800	3,267
1,500	<	1,999	7,000	9,000	5,613
2,000	<	2,499	11,000	11,350	6,900
2,500	<	2,999	9,781	8,309	6,089
3,000	<	3,499	8,313	10,116	8,313
3,500	<	3,999	9,934	11,764	10,600
4,000	<	4,499	12,500	14,000	12,000
4,500	<	4,999	13,000	14,500	13,000
5,000	<	5,499	13,500	15,500	13,500
5,500	<	5,999	14,000	16,000	14,000
6,000	<	6,499	14,500	16,500	14,500
6,500	+		15,000	17,000	15,000

Source: Puget Sound Maritime Air Emissions Inventory (2016), Appendix B Table B.9

Fuel types were estimated based on the IMO fuel regulation in place during the inventory year. Because Ogden Point is located in an Emission Control Area (ECA), it was assumed that all ships were complying with North American ECA rules, either by using fuels with low sulphur content or exhaust gas cleaning systems that limit sulphur emissions.

Engine tiers were assigned based on the year the ship's keel was laid, according to IMO tier regulations. If engine speeds could not be found, medium speed (>130 rpms) was assumed.

Inventory Year	Fuel Type	Engine Tiers
2010	HFO with 2.7% sulphur content	Tier 1 for all ships built 2001 - 2010
2014	MDO with 1.0% sulphur content	Tier 2 for all ships built 2011 - 2015
2018, 2022	MDO with 0.1% sulphur content	Tier 3 for all ships built 2016 - 2022

Ocean Going Vessel Emissions Factors

CAC Emissions Factors

Emission Factors for Propulsion Engines using 0.1 %S MDO, g/kW-hr							
Engine Category	**Model Year Range**	**NO_x**	**CO**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**DPM**
Slow speed (Tier 0)	< 1999	17	1.4	0.38	0.24	0.23	0.24
Slow speed (Tier 1)	2000 to 2011	16	1.4	0.38	0.24	0.23	0.24
Slow speed (Tier 2)	2011 to 2016	14.4	1.4	0.38	0.24	0.23	0.24
Slow speed (Tier 3)	2016 +	3.4	1.4	0.38	0.24	0.23	0.24
Medium speed (Tier 0)	< 1999	13.2	1.1	0.42	0.24	0.23	0.24
Medium speed (Tier 1)	2000 to 2011	12.2	1.1	0.42	0.24	0.23	0.24
Medium speed (Tier 2)	2011 to 2016	10.5	1.1	0.42	0.24	0.23	0.24
Medium speed (Tier 3)	2016 +	2.6	1.1	0.42	0.24	0.23	0.24
Gas turbine	All	5.7	0.2	0.6	0.01	0.01	0
Steam main & boiler	All	2	0.2	0.6	0.16	0.15	0
Emission Factors for Auxiliary Engines using 0.1 %S MDO, g/kW-hr							
Engine Category	**Model Year Range**	**NO_x**	**CO**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**DPM**
Medium speed (Tier 0)	< 1999	13.8	1.1	0.44	0.24	0.23	0.24
Medium speed (Tier 1)	2000 to 2011	12.2	1.1	0.44	0.24	0.23	0.24
Medium speed (Tier 2)	2011 to 2016	10.5	1.1	0.44	0.24	0.23	0.24
Medium speed (Tier 3)	2016 +	2.6	1.1	0.44	0.24	0.23	0.24
High speed (Tier 0)	< 1999	10.9	0.9	0.44	0.24	0.23	0.24
High speed (Tier 1)	2000 to 2011	9.8	0.9	0.44	0.24	0.23	0.24
High speed (Tier 2)	2011 to 2016	7.7	0.9	0.44	0.24	0.23	0.24
High speed (Tier 3)	2016 +	2	0.9	0.44	0.24	0.23	0.24

Source: Puget Sound Maritime Air Emissions Inventory (2016), Appendix B Tables B.2 & B.7

GHG Emissions Factors

Emission Factors for Propulsion Engines using 0.1 %S MDO, g/kW-hr					
Engine Category	**Model Year Range**	**CO_2**	**N_2O**	**CH_4**	**gCO_2e**
Slow speed (Tier 0)	< 1999	589	0.029	0.012	597.3
Slow speed (Tier 1)	2000 to 2011	589	0.029	0.012	597.3
Slow speed (Tier 2)	2011 to 2016	589	0.029	0.012	597.3
Slow speed (Tier 3)	2016 +	589	0.029	0.012	597.3
Medium speed (Tier 0)	< 1999	649	0.029	0.010	657.2
Medium speed (Tier 1)	2000 to 2011	649	0.029	0.010	657.2
Medium speed (Tier 2)	2011 to 2016	649	0.029	0.010	657.2
Medium speed (Tier 3)	2016 +	649	0.029	0.010	657.2
Gas turbine	All	922	0.075	0.002	942.5
Steam main & boiler	All	922	0.075	0.002	942.5
Emission Factors for Auxiliary Engines using 0.1 %S MDO, g/kW-hr					
Engine Category	**Model Year Range**	**CO_2**	**N_2O**	**CH_4**	**gCO2e**
Medium speed (Tier 0)	< 1999	686	0.029	0.008	694.1
Medium speed (Tier 1)	2000 to 2011	686	0.029	0.008	694.1
Medium speed (Tier 2)	2011 to 2016	686	0.029	0.008	694.1
Medium speed (Tier 3)	2016 +	686	0.029	0.008	694.1
High speed (Tier 0)	< 1999	656	0.029	0.008	664.1
High speed (Tier 1)	2000 to 2011	656	0.029	0.008	664.1
High speed (Tier 2)	2011 to 2016	656	0.029	0.008	664.1
High speed (Tier 3)	2016 +	656	0.029	0.008	664.1

Source: Puget Sound Maritime Air Emissions Inventory (2016), Appendix B Table B.2

Source: Puget Sound Maritime Air Emissions Inventory (2016), Appendix B Table B.7

References

1. 2020 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions
https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2018-psomethodology.Pdf

2. Environment Canada's National Inventory Report (1990-2019); Part 2 & 3.
https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html

3. Intergovernmental Panel on Climate Change (Global Warming Potentials)
http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

4. Department for Environment, Food & Rural Affairs (UK) Carbon Factors 2021
https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-

5. Port of Los Angeles Inventory of Air Emissions (2013)
https://kentico.portoflosangeles.org/getmedia/9b47cda9-e282-458e-9a80-36b17e79c47c/2013_Air_Emissions_Inventory_Full_Report

6. Puget Sound Maritime Air Emissions Inventory (2016), Revised October 2018
https://pugetsoundmaritimeairforum.files.wordpress.com/2018/10/final-2016-psei-report-19-oct-2018-scg.pdf

Glossary of Terms

GHG	Greenhouse Gas (emissions): Atmospheric gasses contributing to the greenhouse effect, including Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O).
GJ	**Gigajoule**: Unit of natural gas equal to 26.137 m^3 or 0.947 MMBtu
HVAC	**Heating, Ventilation & Air Conditioning**
kWh	**Kilowatt-Hour**: Common unit for measuring electrical consumption
psg-km	**Passenger-Kilometer**: Unit separating total emissions between passengers per km
t-km	**Tonne-Kilometer**: A unit of measurement used in shipping
tCO_2e	**Tonnes of Carbon Dioxide Equivalent**: GHGs have different warming potentials, measured collectively as CO_2 equivalent (hence "e")
CAC	**Criteria Air Contaminants:** Emissions of criteria air contaminants contribute to smog, poor air quality and acid rain.
OGV	**Ocean Going Vessel**
IMO	**International Maritime Organization**
ECA	**Emission Control Area**

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