

**Production Environmental Accounting Report
(PEAR) Calculator Emission
Calculation Methodology and
References
for Carbon Calculator Version 4.2.4**

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1.0 INTRODUCTION

The Production Environmental Accounting Report (PEAR) Carbon Calculator estimates CO₂e emissions for the following sources:

- Utilities (Electricity, Natural Gas & Fuel Oil)
- Vehicle & Equipment Fuel Use
- Hotels & Housing
- Commercial Travel (Flights, Train and Ferry)
- Charter Flights

The PEAR also collects information for procurement and waste practices, but emissions are not associated with these calculations. This document presents the methodology used by the PEAR to quantify emissions for each source, documents the sources of the PEAR input emission factors, and details where these factors can be referenced and updated in the PEAR.

2.0 CO₂e EMISSIONS CALCULATION METHODOLOGY

2.1 Electricity

The PEAR calculates emissions from electricity using the following formula:

$$\text{Electricity CO}_2\text{e (kg)} = \text{Electricity Used (kWh)} \times \text{Electricity Emission Factor (kg CO}_2\text{e/kWh)}$$

The PEAR converts user-entered information into electricity used by applying the following methodology based on the data entry option selected. The user-entered values are shown in bold, the embedded emission factors are shown in italics.

Table 1. Electricity used conversion methodology

Option	Methodology
Preferred (electricity use)	kWh is entered directly by the user
2 nd Option (intensity estimate)	kWh = Area (sq ft) x Days Used (days) /365 (days per year) x <i>average emission intensity by building type</i> (kWh/square foot)

2.1.1 Average Emission Intensity by Building Type

The PEAR utilizes US DOE benchmark from the Commercial Buildings Energy Consumption Survey (CBECS)¹ annual average intensity estimates based on principal building activity. The Location Types selected by the user and corresponding CBECS building activities are shown in the table below.

¹ US Department of Energy Energy Information Administration, Commercial Building Energy Consumption Survey, <http://www.eia.doe.gov/emeu/cbecs/contents.html>

Table 2. PEAR location types and corresponding CBECs building activities

PEAR Location Type	CBECs Building Activity
On Location	Office
Office	Office
Warehouse	Warehouse and Storage
Stage(s)	Warehouse and Storage

2.1.2 CO₂e Electricity Emission Factors

Because CO₂e emissions for energy consumption depend on the mix of fuel used in generation, electricity emissions factors can vary significantly across regions. The PEAR applies electricity CO₂e emission factors on a zip code or state bases for the United States, state or province basis for the United States, Canada and Australia and on a country-specific basis all other countries.

The reference for and PEAR location of all the electricity emission factors are detailed in Table 9.

2.2 Natural Gas & Heating Oil

The PEAR calculates emissions from natural gas and heating oil using the following formulas:

$$\text{Natural Gas CO}_2\text{e (kg)} = \text{Natural Gas Used (scf)} \times \text{EF (kg CO}_2\text{e/cubic foot natural gas)}$$

$$\text{Fuel Oil CO}_2\text{e (kg)} = \text{Fuel Oil Used (gal)} \times \text{EF (kg CO}_2\text{e/gal fuel oil)}$$

The PEAR converts user-entered information into natural gas or fuel oil use by applying the following methodology based on the data entry option selected. The user-entered values are shown in bold, the embedded emission factors are shown in italics.

Table 3. Natural gas and fuel oil used conversion methodology

Option	Methodology
Preferred (electricity use)	Fuel Use is entered directly by the user
2 nd Option (intensity estimate)	Fuel Use = Area (sq ft) x Days Used (days) /365 (days per year) x <i>average emission intensity by building type</i> (cubic feet or gal/square foot)

The natural gas and fuel oil emission intensities by building type are determined by applying the CBECs factors as detailed in Section 2.1.1. The reference for and PEAR location of the CBECs factors, the cost per unit values, and the CO₂e emissions factors are detailed in Table 9.

2.3 Fuel Use

The PEAR calculates emissions from fuel used from equipment and vehicles using the following formula:

$$\text{Fuel Use CO2e (kg)} = \text{Fuel Used (gal)} \times \text{Fuel Type EF (kg CO2e /gal)}$$

The PEAR converts user-entered information into fuel use by applying the following methodology based on the data entry option selected. The user-entered values are shown in bold, the embedded emission factors are shown in italics.

Table 4. Fuel use conversion methodology

Option	Methodology
Preferred (fuel use)	Fuel use is entered directly by the user
2 nd Option (distance-vehicles only)	Fuel use = Distance traveled (miles)/ <i>Vehicle efficiency</i> (mpg)
3 rd Option (cost)	Fuel use = Total Cost of Fuel(\$US) / Average \$US per Gallon

Vehicle efficiency (miles per gallon) is based on the general class of vehicle as categorized by the US Department of Transportation (US DOT). The vehicle type user options and corresponding US DOT categories are shown in the table below.

Table 5. PEAR vehicle types and corresponding US DOT classifications

PEAR Vehicle Types	DOT Vehicle Classifications
Cars	Passenger Cars
Motorcycles	Motorcycles
Buses	Buses
Vans, Pickups, SUVs	Other 2-Axel 4 Tire vehicles
Trucks (<18 wheel)	Single-Unit 2-axles 6-tire or more trucks
18 Wheelers	Combination Trucks
All Vehicles	All Motor Vehicles

The reference for and PEAR location of the fuel type CO₂e emission factors, the cost metrics and vehicle efficiency factors are detailed in Table 9.

2.4 Hotels and Housing

The PEAR calculates emissions from hotels and housing using the following formula:

$$\text{Electricity CO2e} = \text{Electricity Used (kWh)} \times \text{EF (CO2e/kWh)}$$

Unlike the previous data entry screens, the Hotels and Housing data entry tab does not include multiple data options for determining the electricity used. Instead, the electricity used is calculated based on embedded factors based on the type of location selected by the user. If the user selects a type of hotel (i.e., economy, midscale, upscale, or luxury) the electricity used is calculated based on the average room type-specific square footage and electricity emission intensity. The

PEAR categorizes hotel types based on the EPA Energy Star Hotel Database Classifications and the Residential Energy Consumption Survey classifications detailed in the table below.

Table 6. PEAR hotel types and corresponding Energy Star classifications

PEAR Housing Types	Example	Average Size in Square Feet
Economy Hotel	Motel 6, Red Roof, Days Inn	535
Midscale Hotel	Holiday Inn, Ramada, Best Western	656
Upscale Hotel	Marriot, Hilton	842
Luxury Hotel	Four Seasons, Ritz Carlton	905
Apartment/Condo		<1000 square feet
Average House		1000 - 4000 square feet
Large House		>4000 Square feet

The PEAR based House and condominium electricity use on the average electricity use of a household. The PEAR determines the regional-based CO₂e emission factor based on the selected county and/or state/province, as described in Section 2.1.3.

The reference for and PEAR location of the hotel square footage and electricity intensity factors, the housing kWh usage and the electricity CO₂e emission factors are detailed in Table 9.

2.5 Commercial Travel

The PEAR calculates emissions from commercial air travel, rail and ferries using the following formula:

$$\text{Commercial Travel CO}_2\text{e (kg)} = \text{Passenger distance traveled (mi)} \times \text{Type of Transport EF (kg CO}_2\text{e/passenger mile)}$$

The user-entered values are shown in bold, the embedded emission factors are shown in italics. The user entry screen includes one option in which the user selects the type of transport and enters the total passenger distance.

The reference for and PEAR location of the passenger air, rail and ferry travel emission factors are detailed in Table 9.

2.6 Charter and Helicopter Flights

The PEAR calculates emissions from charter and helicopter flights using the following formula:

$$\text{Charter \& Helicopter Fuel Use CO}_2\text{e (kg)} = \text{Fuel Used (gal)} \times \text{Fuel Type EF (kg CO}_2\text{e/gal)}$$

The PEAR converts user-entered information into fuel use by applying the following methodology based on the data entry option selected. The user-entered values are shown in bold, the embedded emission factors are shown in italics.

Table 7. Charter and Helicopter Flights fuel use conversion methodology

Option	Methodology
Preferred (fuel use)	Fuel use is entered directly by the user
2 nd Option (hours flown)	Fuel use= Hours Flown x <i>gallons per hour</i>
3 rd Option (distance)	Fuel use = Distance traveled (miles)/ <i>Plane efficiency</i> (mpg)

Fuel use and miles traveled per gallon can vary greatly depending on the specific equipment used, flight length and operating conditions. The PEAR uses general values for gallons per hour and miles per gallon based on the plane-type classifications. The Fuel Type CO₂e EF is based on the fuel type used by each plane type. The plane type classifications and associated fuel types are shown in the table below.

Table 8. Plane types and associated fuels

Plane Type	Fuel Type	Number of Passengers
Chartered Commercial Jet	jet fuel	>20
Large Private Jet	jet fuel	14-20
Small Private Jet	jet fuel	5-13
Helicopter	aviation gasoline	N/A

The reference for and PEAR location of the gallons per hour, miles per gallon and fuel CO₂e EFs are detailed in Table 9.

3.0 EMISSION FACTOR REFERENCES & PEAR CALCULATOR LOCATION

The following table provides details the specific references, access and PEAR location of the emission factors used in the PEAR by emission source type.

Table 9. PEAR emission factors and worksheet reference

Factor	Reference	PEAR Reference
Electricity		
kWh per Square foot by Building Activity	U.S. Energy Information Administration Independent Statistics and Analysis, Commercial Buildings Energy Consumption Survey, Table E6. Electricity Consumption (kWh) Intensities by End Use, 2018, Released Dec 2012, Total Energy Intensity (kWh/square foot) by Principal Building Activity. Accessed from: https://www.eia.gov/consumption/commercial/data/2018/ce/xls/e6.xlsx	"CBECs" worksheet Column B
US CO ₂ e emissions per kWh (Zipcode based)	United States Environmental Protection Agency "Power_profiler_zipcode_tool"; Subregion Rates (lbs-MWh) eGRID 2021 Subregion File (lbs/MWh); eGRID subregion annual CO ₂ total output emission rate (lb/MWh) United States Environmental Protection Agency. Accessed from: https://www.epa.gov/system/files/documents/2023-02/power_profiler_zipcode_tool.xlsx	"ElectricityEFs" Column D Rows 200-227 (converted from lb/MWh to kg/kWh)
US CO ₂ e emissions per kWh (State based)	United States Environmental Protection Agency "Emissions & Generation Resource Integrated Database (eGRID)". "ST21" worksheet, Column Y: State annual CO ₂ E equivalent output emission rate (lb/MWh). Accessed from: https://www.epa.gov/system/files/documents/2023-01/eGRID2021_data.xlsx	"ElectricityEFs" Column D Rows 227-279 (converted from lb/MWh to kg/kWh)
Canada CO ₂ e emissions per kWh	National Inventory Report, 1990-2020: Greenhouse Gas Sources and Sinks in Canada Part 3, 2021, Electricity GHG Consumption Intensity Tables, A13-2 through A13- 14, 2020 values for Greenhouse Gas Intensity gCO ₂ E/kWh. Accessed from: https://data.ec.gc.ca/data/substances/monitor/canada-s-official-greenhouse-gas-inventory/C-Tables-Electricity-Canada-Provinces-Territories/?lang=en :	"ElectricityEFs" Column E Rows 280-193 (divide by 1000 to convert to kg/kWh)

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Factor	Reference	PEAR Reference
Australian CO2e emissions per kWh	National Greenhouse Accounts (NGA) Factors, Australian National Greenhouse Accounts, August, 2021. Table 5: Indirect (scope 2) emission factors for consumption of purchased electricity from the grid. Accessed from: https://www.industry.gov.au/sites/default/files/August%202021/document/national-greenhouse-accounts-factors-tables-2021.xlsx ,	"ElectricityEFs" Column E Rows 294-303
International CO2e emissions per kWh	International Energy Agency Data Service, 2023, Emission Factors (https://www.iea.org/terms); CO2e emissions per kwh of electricity only, "Summary" worksheet, Product: Total, 2021 Emissions	"ElectricityEFs" Column E Rows 2-196
Natural Gas & Fuel Oil		
Natural gas per Square foot by Building Activity	U.S. Energy Information Administration Independent Statistics and Analysis, Commercial Buildings Energy Consumption Survey, Table E8. Natural Gas Consumption (cubic feet) and Energy Intensities by End Use, 2018, Released December 2022, Total Natural Gas Intensity (cubic feet/square foot) by Principal Building Activity. Accessed from: https://www.eia.gov/consumption/commercial/data/2018/ce/xls/e8.xlsx	"CBECs" worksheet Column C
Fuel Oil per square foot by Building Activity	U.S. Energy Information Administration Independent Statistics and Analysis, Commercial Buildings Energy Consumption Survey, Table E10. Fuel Oil Consumption (gallons) and Energy Intensities by End Use, 2018, Released December 2022, Total Fuel Oil Intensity (gallons/square foot) by Principal Building Activity. Accessed from: https://www.eia.gov/consumption/commercial/data/2018/ce/xls/e10.xlsx	"CBECs" worksheet Column D

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Factor	Reference	PEAR Reference
CO2e emissions of Natural Gas per cubic foot	Department for Environment, Food and Rural Affairs (2023). Greenhouse gas reporting: conversion factors 2023: full set (for advanced users), Version 1.1, Fuel Worksheet, Accessed from: https://assets.publishing.service.gov.uk/media/649c5358bb13dc0012b2e2b7/ghg-conversion-factors-2023-full-file-update.xlsx	"FuelEFs" column B
CO2e emissions of Fuel Oil per gallon	Department for Environment, Food and Rural Affairs (2023). Greenhouse gas reporting: conversion factors 2023: full set (for advanced users), Version 1.1, Fuel Worksheet, Accessed from: https://assets.publishing.service.gov.uk/media/649c5358bb13dc0012b2e2b7/ghg-conversion-factors-2023-full-file-update.xlsx	"FuelEFs" column B
Fuel Use		
CO2e emissions of non-bioenergy fuels	Department for Environment, Food and Rural Affairs (2023). Greenhouse gas reporting: conversion factors 2023: full set (for advanced users), Version 1.1, Fuel Worksheet, Accessed from: https://assets.publishing.service.gov.uk/media/649c5358bb13dc0012b2e2b7/ghg-conversion-factors-2023-full-file-update.xlsx	"FuelEFs" column B
CO2e emissions of bioenergy fuels (Scope 1) ³	Department for Environment, Food and Rural Affairs (2023). Greenhouse gas reporting: conversion factors 2023: full set (for advanced users), Version 1.1, Bioenergy Worksheet, Accessed from: https://assets.publishing.service.gov.uk/media/649c5358bb13dc0012b2e2b7/ghg-conversion-	"FuelEFs" column B
CO2e emissions of bioenergy fuels (Outside of Scopes) ⁴	Department for Environment, Food and Rural Affairs (2023). Greenhouse gas reporting: conversion factors 2023: full set (for advanced users), Version 1.1, Outside of Scopes Worksheet, Accessed from: https://assets.publishing.service.gov.uk/media/649c5358bb13dc0012b2e2b7/ghg-conversion-	"FuelEFs" column C
CO2e emissions of blended biodiesel and ethanol	Emissions factors based on a weighted average of the percent biodiesel/diesel (biodiesel blends) or ethanol/gasoline (E85). For example, the EF for B5 is (5% x biodiesel EF) + (95% x diesel EF) referenced above	"FuelEFs" column B

² Global Warming Potential Factors applied: CH4 – 28; N2O-265 based on the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report published in 2013

³ Within the Scope 1 conversion factors for biofuels, the CO2 emissions value is set as net '0' to account for the CO2 absorbed by fast-growing bioenergy sources during their growth. The Scope 1 conversion factors contain values for N2O and CH4 emissions (which are not absorbed during growth).

⁴ Outside of scopes includes biogenic CO2 factors that are used to account for the direct carbon dioxide (CO2) impact of burning biomass and biofuels.

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Factor	Reference	PEAR Reference
Fuel efficiency of non-motorcycles and buses	Davis, Stacy C., Susan W. Diegel, and Robert G. Boundy. Transportation energy data book: Edition 39. No. ORNL 5198. United States. Department of Energy, 2021. Accessed from: https://tedb.ornl.gov/wp-content/uploads/2021/02/TEDB_Ed_39.pdf	"MPG" worksheet column B
Fuel efficiency of motorcycles, buses and all vehicles	US Department of Transportation, Federal Highway Administration Office of Highway Policy Information, Highway Statistics 2016, Revised December 2018, Table VM-1, Annual Vehicle Distance Traveled in Miles and Related Data-2007, Average miles traveled per gallon of fuel consumed. Accessed from: https://www.fhwa.dot.gov/policyinformation/statistics/2016/xls/vm1.xlsx	"MPG" worksheet column B
Fuel efficiency of Hybrids	www.fueleconomy.gov , EPA Office of Energy Efficiency & Renewable Energy, Compare Hybrids side-by-side. Accessed from: https://www.fueleconomy.gov/feg/hybrids.jsp	"MPG" worksheet column B
Commercial Travel		
CO2e emission per passenger mile - air	Department for Environment, Food and Rural Affairs (2023). Greenhous gas reporting: conversion factors 2023: full set (for advanced users), Version 1.1, Business Travel-air Worksheet, Accessed from: https://assets.publishing.service.gov.uk/media/649c5358bb13dc0012b2e2b7/ghg-conversion-factors-2023-full-file-update.xlsx	"ComTravel" column B
CO2e emission per passenger mile – Ferry	Department for Environment, Food and Rural Affairs (2023). Greenhous gas reporting: conversion factors 2023: full set (for advanced users), Version 1.1, Business travel-sea Worksheet, Accessed from from spreadsheet link above.	"ComTravel" column B
CO2e emission per passenger mile – Rail	Department for Environment, Food and Rural Affairs (2023). Greenhous gas reporting: conversion factors 2023: full set (for advanced users), Version 1.1, Business travel-land Worksheet, Accessed from from spreadsheet link above.	"ComTravel" column B

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Factor	Reference	PEAR Reference
Chartered Flights		
CO2e emissions of jet fuel and aviation gasoline	Department for Environment, Food and Rural Affairs (2023). Greenhouse gas reporting: conversion factors 2023: full set (for advanced users), Version 1.1, Fuel Worksheet, Accessed from: https://assets.publishing.service.gov.uk/media/649c5358bb13dc0012b2e2b7/ghg-conversion-factors-2023-full-file-update.xlsx	“FuelEFs” column B
Plane type Gallons per hour	Values obtained from sample set of equipment types in each plane type category. PEAR averages gallons per hour by plane type)	“ComTravel” Column N and O
Miles per gallon-Commercial Jet	US EPA Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobile Combustion Sources, Table 4: Fuel Economy Values by Vehicle Type, Air Travel Domestic Carriers	“AirTravel” Column J, (Divide 1 by value to convert to miles/gal)
Miles per gallon-Large Private Jet	http://www.ehow.com/about_5665316_private-suv-jet-fuel-cost.html	“AirTravel” Column J
Miles per gallon-Small Private Jet	http://www.ehow.com/about_5665316_private-suv-jet-fuel-cost.html	“AirTravel” Column J
Miles per gallon - Helicopter	http://en.wikipedia.org/wiki/Fuel_efficiency_in_transportation	“AirTravel” Column J

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Factor	Reference	PEAR Reference
Hotels & Housing		
Square footage by hotel type	US EPA, Combined Heat and Power Partnership, CHP in the Hotel and Casino Market Sectors, December, 2005, Table 16: Average Hotel Size per Room in Square Feet, Accessed from: http://www.epa.gov/chp/documents/hotel_casino_analysis.pdf	"Hotel Factors" Column B
Electricity Intensity by Hotel Type	US EPA, Combined Heat and Power Partnership, CHP in the Hotel and Casino Market Sectors, December, 2005, Table 17: Gas and Electric Energy Usage Intensities by Climate and Chain Scale, Ave. Elec kWh/sf/yr, Accessed from: http://www.epa.gov/chp/documents/hotel_casino_analysis.pdf	"Hotel Factors" Column C
Apartment, condo and house electricity use	US Energy Information Administration, Residential Energy Consumption Survey (RECS) Table CE2.1 Household Site Fuel Consumption in the U.S., Totals and Averages, 2015 (Released May 2018). Accessed from: https://www.eia.gov/consumption/residential/data/2015/c&e/ce2.1.xlsx	"Hotel Factors" Column D
CO2e emissions per kWh	<i>See Electricity References for US, Canada, Australian and International factors</i>	