CARBON FOOTPRINT w9thw¢

(Scope 1, Scope 2 and avoidance)

To

From

Earthonomic Engineers Private Limited

Contents

Introduction

IIT Madras is one of the premier technical institutes in India, located in the city of Chennai. The campus is famous for its lush forest cover and the various life forms that have made the campus its natural habitat. The campus is spread over an area of 611 acres and is known for its lush green landscape and serene atmosphere. Additionally, the institute has taken several initiatives to promote sustainability and has implemented several eco-friendly measures beyond green building standards primarily considering the fragile ecosystem that it houses.

They have introduced sustainable transportation systems such as electric vehicles and bicycles, which are available for use by students and faculty.

The campus is home to several green spaces, including parks, gardens, and tree plantations, which help to maintain a healthy ecological balance.

About Carbon Footprint

Carbon footprint refers to the total amount of greenhouse gases (carbon dioxide) Emitted directly or indirectly by an individual, organization, product, or event. It is a measure of the impact of human activities on the environment in terms of carbon emission.

The activity provides a detailed account of an organization's carbon footprint to identify emission hotspots and propose alternatives to reduce its impact.

- **Environmental Awareness:** Carbon footprints help raise awareness about the impact of human activities on the environment, specifically in terms of climate change.
- **Mitigating Climate Change:** Carbon footprints provides a framework for identifying and prioritizing actions to reduce greenhouse gas emissions. By measuring the carbon footprint of various activities, strategies can be developed to mitigate climate change, transition to low-carbon alternatives, and promote sustainable practices.
- **Setting Targets and Monitoring Progress:** Carbon footprints allow individuals and organizations to set emission reduction targets and track their progress over time.

Summary of findings:

Emissions

Carboon footprint			
Scope 1	Vehicle emission	90987.2	6259576.418
	Natural Gass	235560	
	Energy	46373.25	
	Refrigerant	5886655.968	
Scope 2	Energy	3,02,73,251.31	30273251.31
		TOTAL (Kg co2e)	**36532827.73**

Avoidance:

Overall Annual Solar Energy generation (KWh)	36,25,745

Purpose:

A carbon footprint analysis will provide an estimate of the total greenhouse gas emissions produced by an individual, household, or organization over a given period, usually measured in metric tons of carbon dioxide equivalent (CO2e).

- **Emissions breakdown**: A breakdown of emissions by different categories, such as energy, transportation, food, and waste.
- **Comparison and benchmarking:** A comparison of the user's carbon footprint to regional or national averages, or to specific benchmarks allows users to understand how their emissions compare to others and serve as a motivator for reducing their carbon footprint.
- **Recommendations and Mitigation:** Recommendations on how to reduce carbon emissions based on the user's input on energy-saving practices, transportation alternatives, sustainable lifestyle choices, and other measures to mitigate emissions.

Scope definitions:

Scope 1 Emissions:

- **On-Site Combustion:** Emissions from the combustion of fossil fuels for heating, cooling, and power generation within the college's buildings. This includes emissions from boilers, generators, or other on-site equipment that burn fuels like natural gas, diesel, or fuel oil.
- **College-Owned Vehicles:** Emissions from vehicles owned or controlled by the college, such as maintenance vehicles, transportation services, or campus shuttle buses.

Scope 2 Emissions:

- **Purchased Electricity:** Emissions resulting from the generation of electricity that the college purchases from the grid. This includes both on-campus facilities and off-campus facilities owned or controlled by the college.

Scope 3 Emissions:

- **Employee Commuting:** Emissions from the transportation of faculty, staff, and students to and from the college, whether by private vehicles or public transportation.
- **Business Travel:** Emissions resulting from business-related travel, including air travel, train journeys, or rental cars used by college personnel for official purposes.
- **Supply Chain:** Emissions associated with the procurement of goods and services for the college. This includes emissions from the production, transportation, and disposal of items such as food, office supplies, furniture, and equipment.
- **Waste Management:** Emissions resulting from waste disposal, including landfilling or incineration of waste generated by the college's facilities and operations.

Sequestration by trees:

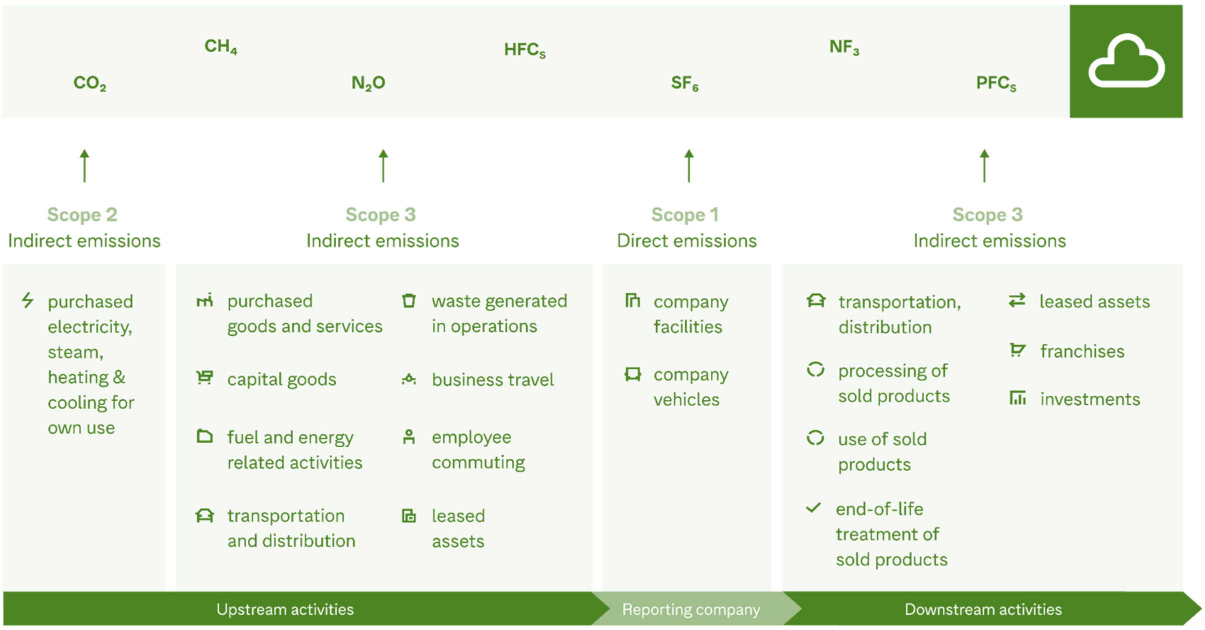
- **Carbon sequestration:** tree planting and forest conservation can be considered a mitigation strategy to offset emissions. While the direct control over the sequestration process may lie with the organization or institute implementing tree planting initiatives, the sequestered carbon is part of the broader carbon cycle and has a broader impact.

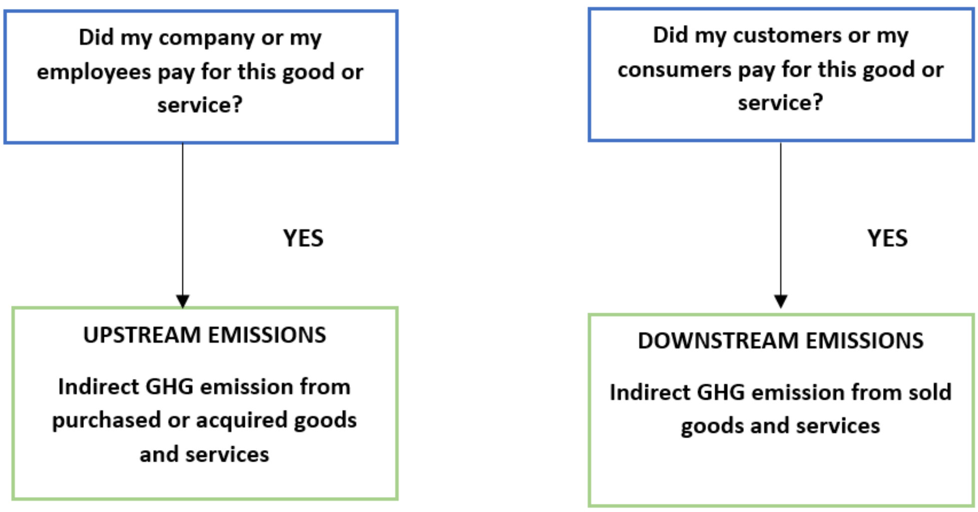
Upstream Emissions

Upstream emissions are the indirect emissions related to a reporting company's suppliers, from the purchased materials that flow into the company to the products and services the company utilizes.

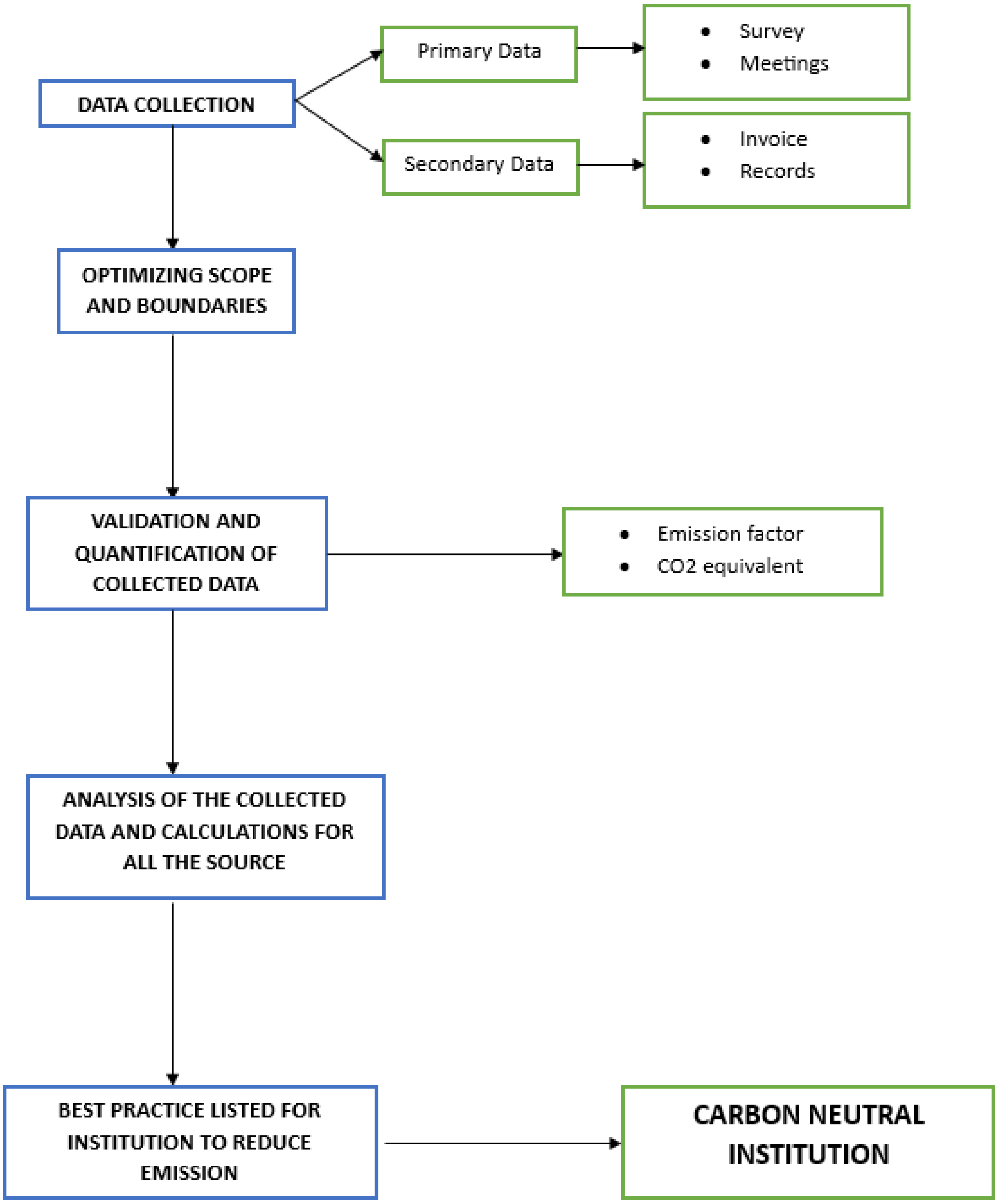
Downstream Emissions

Downstream emissions are the emissions related to customers, from selling goods and services to their distribution, use, and end-of-life stages.





METHODOLOGY



Data Collection

Scope 1 Emissions:

1. Fuel Consumption: (Amount of Fuel or total distance covered/ yr.)

a. Total annual fuel consumption (in litters) for gasoline, diesel, and other fuels.
b. Total consumed for the distance travelled by the college owned vehicles.
c. number of college owned vehicles and types.

2. Natural Gas Usage: (Kg of LPG/ yr.)

a. Total annual natural gas consumption.

3. Biogas and Waste Combustion: (Kg of waste/yr.)

a. Quantity of biogas or produced.
b. Biogas end use.

4. Refrigerants: (Kg of Refrigerant/ year)

a. Types of refrigerants used in equipment.
b. Quantities of refrigerants used (in kilograms or pounds)

Scope 2 Emissions:

1. Electricity Consumption: (KWh / yr.)

a. Total annual electricity consumption (in kilowatt-hours)

3. Renewable Energy & Certificates (RECs): (KWh / yr.)

a. Quantity and type of renewable energy used.

Energy efficient measures on-site:

- The institute has mandated the use of energy efficient air conditioner with fresh air supply to optimize power consumption. The newly built academic complex has centralized air conditioning which implements variable air flow controls and building management system.
- The Institute has progressively replaced the light fittings with LED lights.
- Solar water heaters are used in the dormitories, and guesthouses in a bid to reduce utility power.
- IITM has installed 3 MW of rooftop solar PV systems.
- The campus today is a vast area and requires transportation to facilitate easy commuting to the various zones. It must be noted that the academic zone is situated at about 1.5 km from the main entrance and the heart of the hostel sector is more than 2 km away. The Institute from this financial year an EV buses service free of charge for those who wish to commute between the various points of the campus.
- The institute has a green cover of 68% which directly influences the heat influx of the buildings. The natural vegetation provides natural cover to the building thereby reducing the heat adsorbed by the façade.
- The institute values its rich diversity of species and makes it their priority to co-exist with nature at minimal disturbances. The audit also found that the institute has started testing BLDC fans in the campus. Institute hospital has been audited and has been found that the renovated parts of the hospital has been replaced with BLDC fans.
- With the proposed installation of energy efficient air conditioner mandated, the institute will save a significant amount of energy resulting in lower carbon footprints.
- The institution has also mandated the construction of new buildings to be environmentally friendly i.e., usage of recycled products or eco products in construction.

Opportunities to lower carbon footprint

Building Management System (BMS):

Building Management System (BMS), also known as Building Automation System (BAS), is a computer-based control system designed to manage and monitor the building's mechanical, electrical, and plumbing (MEP) systems, including HVAC, lighting, power, and security systems. The BMS allows the facility manager to control, monitor and optimize the building's MEP systems, creating a comfortable and energy-efficient environment while reducing energy consumption and cost.

Advantages of a BMS system are as follows:

- **Energy Efficiency**: BMS provides an efficient way to manage and optimize the building's energy consumption.
- **Cost Savings**: By reducing energy consumption and optimizing building systems, BMS can help facility managers reduce operational costs, including energy bills, maintenance costs, and equipment replacement costs.
- **Improved Comfort**: BMS can monitor and control the building's environmental conditions, such as temperature, humidity, and air quality, ensuring a comfortable and healthy environment for occupants.
- **Enhanced Security**: BMS can integrate with the building's security systems, including access control and surveillance systems, to provide a secure environment for occupants and assets.

- **Remote Access**: BMS can be accessed remotely, allowing facility managers to monitor and control the building's systems from anywhere, providing real-time data and alerts.

Phaseout of CFL and FTL:

- The phaseout of CFL (Compact Fluorescent Lamp) and FTL (Fluorescent Tube Lamp) lighting with LED (Light Emitting Diode) lighting in the LED industry has been a major trend in recent years. This shift towards LED lighting has been driven by the need for more energy-efficient, environmentally friendly, and cost-effective lighting solutions.
- LED lighting has become the preferred lighting technology for most lighting applications, as it offers several advantages over traditional lighting technologies such as CFL and FTL. LED lighting is highly energy-efficient, with some estimates suggesting that it can save up to 85% of energy costs compared to CFL and FTL lighting.
- LED lighting also has a longer lifespan, requires less maintenance, and has superior lighting quality, making it ideal for various lighting applications. The phaseout of CFL and FTL lighting with LED lighting has been implemented in many countries worldwide, with governments and industry organizations leading the way. They have implemented policies to restrict the manufacture, importation, and sale of CFL and FTL lighting while providing incentives and education to encourage the adoption of LED lighting.
- The benefits of the CFL and FTL phaseout with LED lighting in the LED industry are numerous. LED lighting provides significant energy and cost savings, reducing operational costs and helping businesses become more sustainable. LED lighting also has a lower environmental impact, with fewer hazardous substances and materials, making it safer and more environmentally friendly.
- The shift towards LED lighting in the LED industry has also led to increased innovation and technological advancements, with the development of new and improved LED lighting products, such as smart lighting and connected lighting systems.

Conventional AC fans to BLDC fans:

AC fans, or alternating current fans, operate using AC power to turn a motor that drives the blades. On the other hand, BLDC fans, or brushless DC fans, use DC power to turn a motor that drives the blades. ECM fans, or electronically commutated motors, are a type of BLDC fan that uses a computerized control system to adjust the motor speed and eventually optimize efficiency of the system over 60% in comparison to conventional fan systems. The advantages of BLDC and ECM fans over traditional AC fans include:

- **Energy efficiency**: BLDC and EC fans are more energy efficient than AC fans, as they use less power to achieve the same airflow. Also, like any other DC device, a lower speed corresponds to lower load and higher energy savings. A BLDC fan 30W rating consumes only 6W at 1 speed unlike an AC fan that need consumed full power irrespective of the speed.
- **Lower noise**: BLDC and EC fans are typically quieter than AC fans, as they use a more advanced motor control system that eliminates the humming noise produced by AC fans.
- **Longer lifespan**: BLDC and EC fans have fewer moving parts than AC fans, which makes them less prone to wear and tear. This results in a longer lifespan and lower maintenance costs.

HVAC upgrade:

Upgrading your HVAC system can have many benefits. By adding fresh air ventilation, improving energy efficiency, right sizing your system, using programmable thermostats, and maintaining your system regularly, you can ensure that your HVAC system is running at its best.

- **Fresh air ventilation**: Adding a fresh air ventilation system to your HVAC system can help bring in outside air and improve indoor air quality. It also helps to reduce the build-up of indoor pollutants such as carbon dioxide and volatile organic compounds (VOCs).
- **Improve energy efficiency**: HVAC systems with higher COP (Coefficient of Performance) are more energy efficient and can save you money on your energy bills. Upgrading to a more energy-efficient system can also help reduce your carbon footprint.
- **Right sizing your HVAC system**: Oversized HVAC systems can waste energy and lead to higher costs. By right sizing your HVAC system, you can ensure that it is not too big or too small for your home or building, which can result in lower energy consumption and operating costs. During the audit, it was discovered that the campus's air conditioning systems were 30% oversized. Because the third-party vendor failed to account for the temperature within IIT, which is lower by 3°C to 4°C from the ambient temperature in Chennai which was mentioned earlier in the microclimatic analysis. An energy simulation was later conducted using the IES VE software for the same to estimate the right AC sizing for each building. The other aspect of Air Condition systems being oversized was because the conventional thumb rule of 180 – 200 Sq. Ft per tonnage (tr) was used to determine the sizing of the HVAC systems throughout the air-conditioned spaces of the campus.

Renewable energy potential and impact on internal temperature of the buildings

- The audit found that the placed solar PVs on the terrace of some buildings have not been used to its capacity as they have been placed at adjacent building and tree shadows.
- Due to this, an estimated 28% of the potential energy that can be generated by the solar panels are wasted (3304*4*365 =4823840 kWh).
- As per the reports given by the team, an annual generation of 3475745 kWh is only generated annually by the solar panels installed in the site. These panels can be used to its full capacity by relocating them on other building’s open roofs and the installation of more solar panels will further help IIT reduce its carbon footprint in the environment.
- The use of renewable energy can indirectly contribute to the reduction of energy consumption in buildings, which can help in reducing the amount of heat generated by energy usage.
- This can lead to a decrease in the internal temperature of buildings, resulting in improved thermal comfort for the occupants. This reduction in internal temperature will also reflect in the reduction of work done by the Air Condition systems.

Occupancy sensors:

- It was observed during the audit that areas were left unoccupied, but the AC was still running along with other electrical fixtures in the rooms. The use of occupancy sensors can result in conservation of energy. These sensors can be used to automatically control lighting, heating, ventilation, and air conditioning (HVAC) systems.
- Occupancy sensors can use thermal data to detect the presence of people in a room or space. This is because human bodies emit heat, and thermal sensors can detect these changes in temperature to determine whether someone is present. Thermal occupancy sensors work by measuring the temperature of objects in a room or space. When a person enters the room, their body heat will cause a small increase in temperature that can be detected by the sensor.
- This information is then used to trigger the occupancy sensor, which can be programmed to control lighting, HVAC, or other building systems. One of the primary benefits of using thermal occupancy sensors is that they can be more accurate than other types of sensors, such as motion sensors or sound sensors. This is because thermal sensors are less prone to false positives, which occur when a sensor detects movement or sound that is not actually caused by a person.
- By using thermal data, occupancy sensors can provide a more reliable and accurate way to detect occupancy and control building systems. The use of occupancy sensors using thermal data is an effective way to detect human presence and control building systems for energy conservation and other purposes. By using this technology, building managers can improve energy efficiency, reduce costs, and promote sustainability.

Incorporation of Carbon neutral Campus

- **Energy Efficiency**: Implementing energy-efficient practices and technologies is essential. This includes using energy-efficient lighting systems, optimizing heating, ventilation, and air conditioning (HVAC) systems, and adopting energy-saving practices throughout the campus.
- **Renewable Energy**: Transitioning to renewable energy sources like solar, wind, or geothermal power is crucial. Installing solar panels or wind turbines on campus can help generate clean energy and reduce reliance on fossil fuels.
- **Sustainable Transportation**: Promoting sustainable transportation options is important for reducing carbon emissions. Encouraging walking, biking, or using public transportation can help minimize the use of individual vehicles. Providing electric vehicle (EV) charging stations and incentivizing the use of electric vehicles can also contribute to a carbon-neutral campus.
- **Waste Management:** Implementing effective waste management practices is essential. This includes recycling programs, composting organic waste, reducing single-use plastics, and promoting awareness about sustainable waste disposal among students and staff.
- **Green Building Practices**: Constructing and renovating campus buildings using sustainable design and materials is crucial. Energy-efficient construction, proper insulation, and the use of eco-friendly materials can help reduce energy consumption and emissions.
- **Carbon Offsetting**: Despite efforts to minimize emissions, some carbon emissions may still be unavoidable. Carbon offsetting involves investing in projects that reduce greenhouse gas emissions, such as reforestation or renewable energy projects, to compensate for the remaining emissions. This helps achieve a net-zero carbon footprint.
- **Education and Awareness:** Raising awareness about sustainability and climate change is vital. Educating students, faculty, and staff about the importance of reducing carbon emissions and engaging them in sustainable practices can create a culture of environmental responsibility on campus

ANNEXURE 1- Data Reference

1. Emission factors:

UNIVERSITY OF EXETER

Calculation of CO_2 emissions

Fuel type	Kg of CO2 per unit of consumption
Grid electricity	43 per kWh
Natural gas	3142 per tonne
Diesel fuel	2.68 per litre
Petrol	2.31 per litre
Coal	2419 per tonne
LPG	1.51 per litre

Transport conversion table

Vehicle type	Kg CO2 per litre
Small petrol car 1.4 litre engine	0.17/km
Medium car (1.4 – 2.1 litres)	0.22/km
Large car	0.27/km
Average petrol car	0.20/km
Small diesel car (>2 litres)	0.12/km
Large car	0.14/km
Average diesel car	0.12/km
Articulated lorry, diesel engine	2.68/km (0.35litres fuel per km)
Rail	0.06 per person per km
Air, short haul (500km)	0.18 per person per km
Air, long haul	0.11
Shipping	0.01 per tonne per km

https://legacy.winnipeg.ca/finance/findata/matmgt/documents/2012/682-2012/682-2012_appendix_h-wstp_south_end_plant_process_selection_report/appendix%207.pdf

Emission factors in kg CO2-equivalent per unit

Categories			Label		Default value	
Category 1	Category 2	Category 3	Title	Unit	Emission factor (kg CO2eq per unit)	Uncertainty
Conversion	Gas	GWP	GWP CH4	kg	25.00	0%
Conversion	Gas	GWP	GWP N2O	kg	298.00	0%
Energy	Electricity	Country	Canada	kWh	0.19	10%
Energy	Heat	Combustible	Black coal	kWh	0.32	
Energy	Heat	Combustible	Brown coal	kWh	0.40	10%
Energy	Heat	Combustible	Brown coal briquette	kWh	0.40	10%
Energy	Heat	Combustible	Brown coal coke	kWh	0.50	10%
Energy	Heat	Combustible	CNG	kWh	0.18	
Energy	Heat	Combustible	Coal coke	kWh	0.39	10%
Energy	Heat	Combustible	Crude oil	kWh	0.27	5%
Energy	Heat	Combustible	Diesel (kWh)	kWh	0.30	5%
Energy	Heat	Combustible	Diesel (liter)	liter	2.79	5%
Energy	Heat	Combustible	Ethane	kWh	0.20	
Energy	Heat	Combustible	Fuel oil (kWh)	kWh	0.29	5%
Energy	Heat	Combustible	Fuel oil (liter)	liter	3.19	5%
Energy	Heat	Combustible	Gas flared	kg	3.53	
Energy	Heat	Combustible	Kerosene	kWh	0.27	5%
Energy	Heat	Combustible	LNG (kWh)	kWh	0.21	5%
Energy	Heat	Combustible	LPG (liter)	liter	1.69	10%
Energy	Heat	Combustible	Natural gas	kWh	0.21	5%
Energy	Heat	Combustible	Petroleum coke	kWh	0.35	10%
Energy	Heat	Combustible	UNG	kWh	0.18	
Energy	Heat	Organic combustible	Biodiesel (kWh)	kWh	0.01	
Energy	Heat	Organic combustible	Biodiesel (liter)	liter	0.81	
Energy	Heat	Organic combustible	Bioethanol	kg	1.21	10%
Energy	Heat	Organic combustible	Biogas (kg)	kg	1.61	
Energy	Heat	Organic combustible	Biogas (kWh)	kWh	0.02	
Energy	Heat	Organic combustible	Biogas (m3)	m3	0.12	
Energy	Heat	Organic combustible	Biomass (kg)	kg	0.11	10%
Energy	Heat	Organic combustible	Biomass (kWh)	kWh	0.02	10%

2. Emission factor for energy:

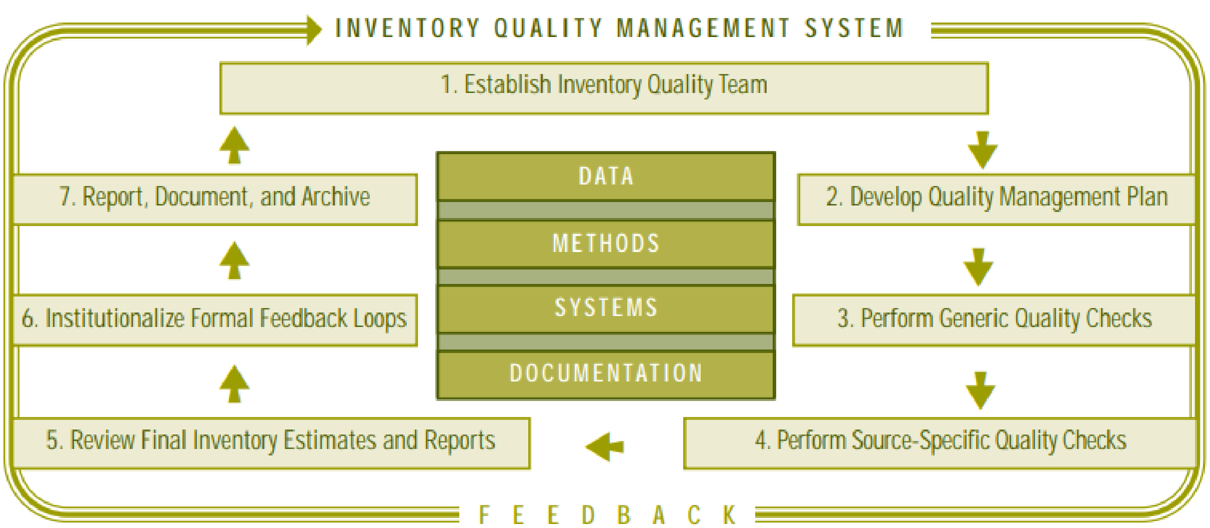
https://cea.nic.in/wpcontent/uploads/baseline/2023/01/Approved_report_emission__2021_22.pdf

*Table S-1: Weighted average emission factor, simple operating margin (OM), build margin (BM) and combined margin (CM) of the Indian Grid for FY 2021-22 (adjusted for cross-border electricity transfers **& excluding RES**), in t CO_2/MWh*

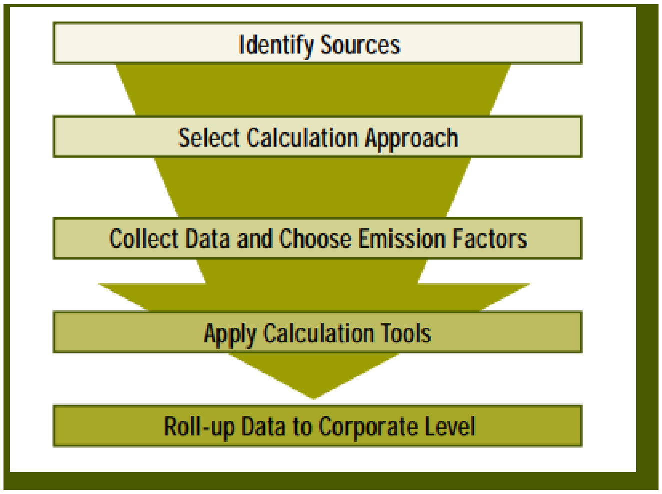
Average	OM	BM	CM
0.81	**0.96**	**0.87**	**0.91**

3. Emission Protocol:

https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf



Steps in identifying and calculating GHG emissions



3. Emission factor for Refrigerants:

https://www.realalternatives.eu/app/images/Tools/fgas-refrigerant-calculator.xls

REFRIGERANT CHARGE CALCULATOR

RESULTS

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Table 1: Charge Calculations **Note - a high and a low refrigerant estimate is calculated for each system**

		Amount of refrigerant in system (kg)					TOTAL (kg)	Refrigerant split (kg)		
System number	System Name	Evaporator	Condenser	Compressor	Liquid line	Vessels	System charge high & low estimate	HFC charge	HCFC charge	Other
System 1 high estimate	0	0.4 kg	0.4 kg	0.0 kg	2.1 kg	0.0 kg	2.9 kg	0.0 kg	2.9 kg	0.0 kg
System 1 low estimate	0	0.2 kg	0.3 kg	0.0 kg	2.1 kg	0.0 kg	2.5 kg	0.0 kg	2.5 kg	0.0 kg

3. AC Details of the facility

AC Details

Building Name	System	Star Rating	No of Units	Make	Model Number	Cooling Capacity KW	Tonnage	BTU/Hr	Base case COP as	≥ 2.5 Base case	Proposed case
New Academic Complex - I	Split	5 Star	6	Hitachi	CSO518HCEA	5.1	1.50	18000	2.9	3.0	4.70
	Air Cooled		1	Hitachi	RCUF508ZY1	175.85	50.00	600000	2.8	2.9	2.98
	Water Cooled		2	Dhanam Bush	DCLC300	984.76	280.00	3360000	5.2	5.3	5.91
Biotech-II/ Sustainability	Water Cooled		3	DAIKIN	PFS1701CCRY	597.89	170.00	2040000	5.2	5.3	6.00
NCCRD	Air Cooled		2	York	YCAE065XRME	228.605	65.00	780000	2.8	2.9	3.18
IC & SR	Air Cooled		2	York	YCAE065XRME	228.605	65.00	780000	2.8	2.9	3.18
Engineering Design Centre	Split	5 Star	30	Hitachi	CSO518HCEA	5.1	1.50	18000	2.9	3.0	4.70
	Split	3 Star	20	Hitachi	CMOG524HCEA	6.3	2.00	24000	2.9	3.0	3.20
ESB Annexure	Water Cooled		3	VOLTAS	CSO518HCEA	615.475	175.00	2100000	5.2	5.3	5.86
CSB Annexure	Water Cooled										
Bio Technology	Split	5 Star	32	Hitachi	CSO518HCEA	5.1	1.50	18000	2.9	3.0	4.70
	Split	3 Star	128	Hitachi	CMOG524HCEA	6.3	2.00	24000	2.9	3.0	3.20
Humanities & Sciences Block	Split	5 Star	45	Hitachi	CSO518HCEA	5.1	1.50	18000	2.9	3.0	4.70
	Split	3 Star	21	Hitachi	CMOG524HCEA	6.3	2.00	24000	2.9	3.0	3.20
Administrative Building	Water Cooled		1	VOLTAS	ACEGWFXR1801MLP2GA	615.475	175.00	2100000	5.2	5.3	5.77
Student Activity Centre(SAC)											
						Total	992.00				