Net Zero Emission By 2050

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VENTURES

# Carbon Footprint Assessment Report

*Ver 3.1 091026*

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Prepared for:

الجامعة الوطنية
National University
Science & Technology للعلوم والتكنولوجيا

Created by:
**Unicorn International LLC**

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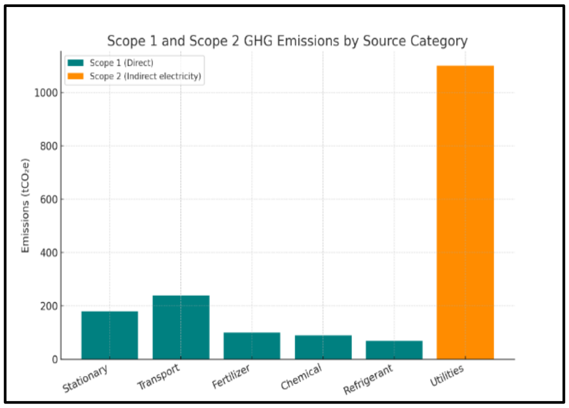
# I) EXECUTIVE SUMMARY

This is the first comprehensive analysis and report on the Greenhouse Gas (GHG) emissions and carbon footprint of the National University (NU), Oman. The study provides an overview of emissions generated by activities across all **National University campuses** including **Head Quarters & College of Pharmacy**, **College of Engineering, School of Fundamental Studies**, **College of Medicine Sohar, and IMCO Sohar** campuses during the period of **September 2022 to August 2024**. The report has been prepared in accordance with the **Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC),** An Accounting and Reporting Standard for Cities – Version 1.1**.** It includes the scope of work, study area description, time frame, methodology, data collection, and GHG emission calculations**.**

## Key Scope and Coverage

- **Emission Sources Analyzed:**
  a) **Stationary Energy Use** – electricity and back up diesel genset

  b) **Transportation Sector** – staff and student commuting, institutional vehicles, and fleet fuel consumption.
  c) **Fertilizer Use** – landscaping, research labs, and green campus maintenance.
  d) **Chemical and Refrigerant Use** – refrigerants, solvents, and medical/academic laboratories.
  e) **Electricity Use**



The figure above shows scope 1 and 2 GHG emissions by source categories which includes stationary, transport, fertilizer, chemical & refrigerant under scope 1 and Utilities under scope 2 for kg CO2 e emissions in each particular sector.

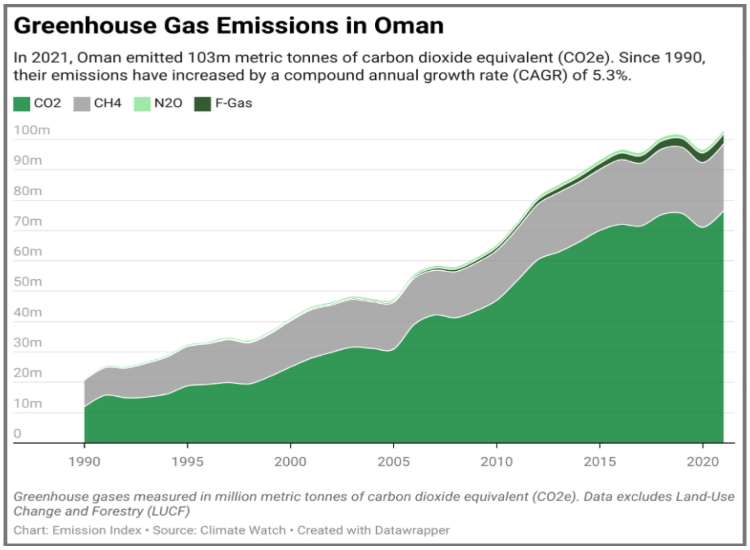
- **Sectoral Analysis:** Emissions are categorized by sector and sub-sector, enabling a detailed understanding of high-impact areas across colleges.
- **Total Carbon Footprint:** Initial results indicate that Electricity consumption (Grid supplied electricity is largest contributor to NU's GHG profile.
- **Emission Intensity:** Per occupancy emissions and percentage occupancy emission for scope 1 & 2 (College wise for each academic year, average yearly emission and different category of scope 1 and 2 were measured) it was benchmarked against Oman's national average and global higher education institutions.

## Mitigation Pathways

The report also proposes strategic mitigation methods to reduce emissions, including Energy Efficiency measures, Renewable Energy Integration, Sustainable building and site planning, Sustainable Transportation, Optimum usage of Fertilizers, use of low GWP refrigerant and implementation of awareness policies.

## About Emission Report

Addressing the global climate crisis has become imperative for nations these days. Approximately 75% of greenhouse gas emissions linked to energy use are now believed to originate from the world's cities, which are home to two-thirds of the world's population. Every country is creating and putting into practice different plans to fight climate change while reducing emissions, addressing sustainable growth, and increasing climate resilience. To achieve a net-zero future in accordance with the Paris Agreement, they require a standard that can be used to quantify their emissions and identify the most effective tactics.


**Greenhouse Gas Emissions in Oman**

In 2021, Oman emitted 103m metric tonnes of carbon dioxide equivalent (CO2e). Since 1990, their emissions have increased by a compound annual growth rate (CAGR) of 5.3%.

*Greenhouse gases measured in million metric tonnes of carbon dioxide equivalent (CO2e). Data excludes Land-Use Change and Forestry (LUCF)*

Chart: Emission Index • Source: Climate Watch • Created with Datawrapper

**Fig. 1 Per capita CO2 emissions for Oman**

As can be seen from the figure, Oman emitted 103 MMT of Carbon dioxide equivalent (CO2 e). Since 1990 their emissions have increased at a compound annual growth rate of 5.3%.Oman's per capita $CO_2$ emissions are still much higher than the global average (~4.8 t), mainly due to its energy structure and industrial activities.

The rise in emissions during 1990 onwards signals the importance of maintaining stronger, targeted measures to stay on track with long-term low-carbon commitments.One such standard that end users can utilize for their facilities to identify, quantify, and prepare reports on greenhouse gas emissions in a consistent way is the new Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC)1. Due to a variety of activities, the emissions are generated both inside and outside the boundary boundaries. GPC offers dependable emissions accounting and reporting procedures that help end users determine baseline emissions, create mitigation targets, improve climate change action plans, and monitor progress over time. The protocol has been revised in accordance with the 2019 enhancements to the 2006 IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Emissions as part of ongoing development.

# II) BUILDING CHARACTERISTICS

## 2.1. College of Engineering (COE), Al Hail

College of Engineering (Al Hail campus) emphasizes academic excellence through its advanced engineering laboratories. These facilities provide students with opportunities to integrate theoretical learning with practical applications, ensuring they graduate with industry-relevant skills. Complemented by specialized programs, internships, and strong library resources, the campus equips graduates for successful careers in engineering and construction.

Campus life at National University is designed to provide a holistic and enriching experience for its diverse student body, encompassing academic support, personal development, and community engagement. With its multiple campuses, including the Caledonian Campus College of Engineering, the College of Pharmacy, and the College of Medicine and Health Services, National University is committed to fostering an environment that supports student growth, leadership, and well-being.

The College of Engineering, Al Hail, provides a robust set of laboratory facilities across its Engineering departments, each tailored to support specific areas of study and research. These well-equipped labs are crucial for delivering practical, hands-on experiences that complement theoretical learning, ensuring that students gain the skills and knowledge necessary for their future careers.

## 2.2 School of Foundation Studies (SOFS), Airport Heights, Muscat

The School of Foundation Studies (SOFS) stands as a pillar of academic excellence and student support within the broader framework of NU’s educational offerings. The institution is meticulously designed to provide a conducive learning environment through its well-thought-out facilities that cater to both academic and personal needs. This essay explores the extensive facilities available at SOFS, highlighting their roles in enhancing educational experience and supporting student well-being. The School of Foundation Studies at NU is dedicated to creating an enriching and supportive educational environment through its comprehensive facilities. From the well-equipped Academic Wing and supportive Faculty Wing to the accommodating and recreational amenities, SOFS ensures that students and staff have access to the resources and services needed for effective learning and personal development

## 2.3 International Maritime College Oman (IMCO), Sohar

The International Maritime College Oman (IMCO) in Sohar stands as a beacon of maritime education and training in the Middle East. Established to address the growing need for skilled professionals in the maritime industry, IMCO plays a crucial role in supporting Oman’s vision for economic diversification and development through advanced maritime and engineering education. By aligning its mission with the broader goals of economic diversification and development, IMCO not only addresses the immediate needs of the maritime sector but also contributes to the long-term vision of a sustainable and prosperous Omani economy. As it continues to evolve and adapt to the dynamic nature of maritime education, IMCO will undoubtedly remain a cornerstone of excellence and innovation in the Middle East's maritime landscape. Sustainability & Research. The college’s curriculum covers various disciplines including marine engineering, nautical science, maritime business, and logistics. These programs are tailored to meet international standards and industry requirements, ensuring that graduates are well-prepared to enter the global maritime workforce.

### 2.4. College of Medicine (COM) Sohar

For the purposes of Oman GHG accounting, the College of Medicine (COM) Sohar functions as the primary reporting entity, incorporating the smaller Rustaq campus as a merged facility. Established in 2001 and formerly known as the Oman Medical College, this institution is the country's first and only private medical education provider. The college offers a 6-year Doctor of Medicine (MD) Program through an academic partnership with West Virginia University, providing clinical training at Ministry of Health centers in both Sohar and Rustaq.

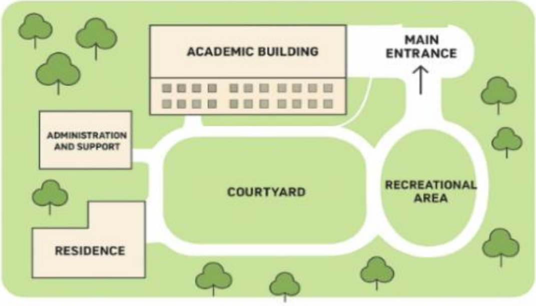
The merged COM Sohar infrastructure supports a population of 1,197 students from 21 countries and 181 staff members across 14 academic departments. The consolidated facilities feature advanced laboratories, maritime simulators, and workshops, alongside centralized administrative and learning spaces. Additionally, the campus provides extensive student support services, including WiFi, recreational areas, and supervised hostel facilities that accommodate more than 752 students. By integrating the Rustaq facility, the campus adopts a purpose-driven architectural ethos focused on low-cost, high-impact interventions and centralized learning

### 2.5. HQ & College Of Pharmacy, Muscat

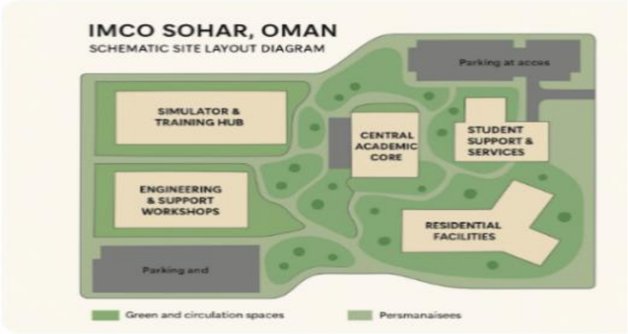
The Department of Pharmaceutical plays a pivotal role in pharmacy education by offering courses that integrate chemistry with the biological sciences to provide a comprehensive understanding of drug development and action. This department is instrumental in equipping students with the necessary knowledge and skills to navigate the complex interface between chemistry and biology, crucial for the pharmaceutical field.

These techniques include interactive lectures, problem-based learning, and laboratory-based instruction. Modern classrooms are often equipped with multimedia tools such as projectors and digital whiteboards, which enhance the learning experience by allowing for dynamic presentations and real-time problem-solving.

1. COE Al Hail

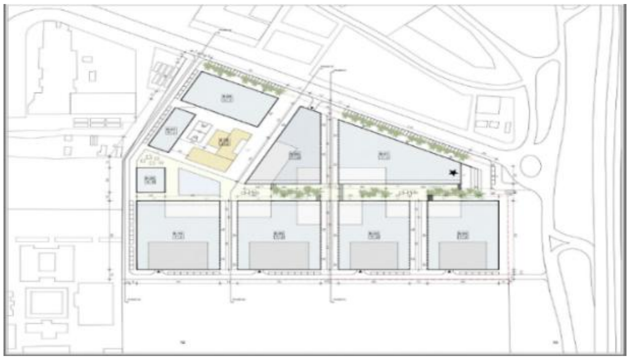


2. SOFS Airport Heights



3.IMCO Sohar

4.COM Sohar



5. CMO Rastaq

6. College of Pharmacy

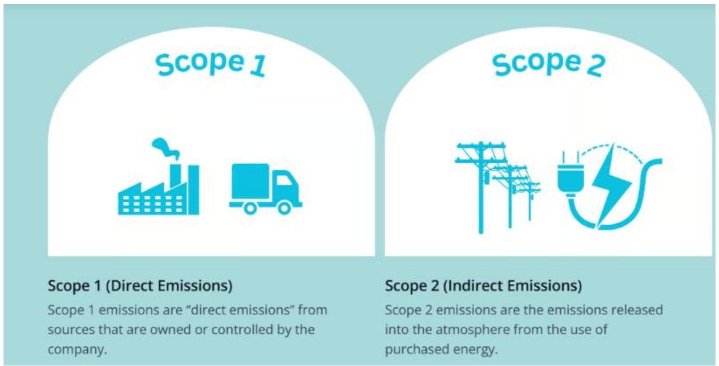
**Fig. 2 Schematic Layout of Institutions under National University, Oman (https://nu.edu.om/)**

# III) METHODOLOGY

**3.1 Global Standards**: The various global standards followed to calculate GHG emissions are as mentioned in the table below:

**3.1.1 GHG Protocol:** When measuring and tracking Carbon emissions / GHG emissions, companies have to outline the scope of emissions they refer to in their reports. The Greenhouse Gas Protocol categorizes emissions into Scope 1 (direct emissions from owned or controlled sources), Scope 2 (indirect emissions from the generation of purchased energy),

The GHG Protocol devised this system of scope-based classification to subdivide the direct and indirect sources of emissions for businesses. In fact, the GHG Protocol is most well-known for its creation of these GHG emissions scopes (Carbon Emissions Scopes).



Scope 1 (Direct Emissions)

Scope 1 emissions are "direct emissions" from sources that are owned or controlled by the company.

Scope 2 (Indirect Emissions)

Scope 2 emissions are the emissions released into the atmosphere from the use of purchased energy.

**Fig. 3 Scope 1 and Scope 2 Emissions**

**3.1.2 ISO 14064:** The ISO 14064 standard provides a framework for organizations to quantify, monitor, report, and verify their greenhouse gas (GHG) emissions and removals, offering guidance at the organizational (Part 1), project (Part 2), and verification (Part 3) levels. By implementing ISO 14064, companies can manage their carbon footprint, identify reduction opportunities, enhance their credibility, and prepare for future climate legislation.

**ISO 14064 (International Organization for Standardization)**

  - **ISO 14064-1**: Requirements for GHG inventories at the organizational level.
  - **ISO 14064-2**: For projects that reduce emissions or enhance removals.
  - **ISO 14064-3**: For validation and verification of GHG inventories and projects.
- Often used for auditing and certification of emissions reports.

**3.1.3 IPCC GHG Protocol:** The IPCC (Intergovernmental Panel on Climate Change) develops scientific reports and methodological guidance for national greenhouse gas inventories, while the GHG Protocol (Greenhouse Gas Protocol) provides the widely-used international standards and tools for companies, governments, and cities to quantify and report their emissions. There are different resources for navigating GHG Protocol tools:

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Calculation Tools and Guidance | GHG Protocol , ISO 14064-1:2018 - Greenhouse gases, IPCC — Intergovernmental Panel on Climate Change

- Cross-sector tools: Applicable to many industries and businesses regardless of sector.
- Country-specific tools: Customized for particular developing countries.
- Sector-specific tools: Principally designed for the specific sector or industry listed, though they may be applicable to other situations.
- Tools for countries and cities: These tools help countries and cities track progress toward their climate goals.

### 3.2 Defining inventory boundary and emission sources

In order to use the GPC for emission analysis, the end user must first define an inventory boundary. The geographic region, time frame, gases, and emission sources covered by the GHG inventory are described here. Any geographic boundary may be used in the GHG inventory. The boundary may align with the administrative boundary of a local government, a borough or ward within a city, a metropolitan area and a collection of administrative divisions, or another geographically or physically separate entity, depending on the inventory's goals. The GPC is designed to account for GHG emissions and takes into consideration the seven gases listed in the Kyoto Protocol in a single reporting year.

GHG emissions from end user activities shall be classified into six main sectors under Scope1 and Scope 2 category: Stationary energy, Transportation, Fertilizer, Chemical & refrigerant, Electricity Emissions

### 3.3 Analyzing the National University's Environmental Footprint: An Integrated Approach to GHG Emissions

The National University has embarked on a crucial initiative to systematically monitor and manage its environmental impact through a campus-wide carbon and nitrogen accounting framework. This framework is designed to estimate greenhouse gas (GHG) emissions in a standardized and reliable manner, leveraging emission factors from the 2024 Greenhouse Gas (GHG) Protocol initiative. The baseline period for this extensive study spans from September 1, 2022, to August 31, 2024, providing a comprehensive two-year temporal boundary for analysis. While the IECC climate zone data is not available for Oman, the methodology employed groups climates by temperature and moisture, a framework adaptable using local data. Importantly, the inventory adheres to the AR-6, 100-year standard for Global Warming Potentials (GWPs), which is a widely recommended version for GHG emission inventories. The accounting framework applies across all National University campuses, including the College of Engineering and Al hail, Headquarters & College of Pharmacy, SOFS Airport Heights, IMCO Sohar, COM Sohar and COM RUSTAQ. For electricity supplied by e-GRID, a location-based emission factor is used.

#### 3.3.1Adopting an Inventory/Footprint Approach and Defining Clear Boundaries

To effectively track the sustainability of its campus activities different methods can be used, including the inventory/footprint approach and budget approach. In the current project an "inventory/footprint

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(Emission_Factors_for_Cross_Sector_Tools_V2.0_0.xlsx), Building America Best Practices Series: Volume 7.3, Guide to Determining Climate Regions by County, CHAPTER 3 CE GENERAL REQUIREMENTS - 2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) approach" has been adopted. This approach connects campus activities with their associated carbon and nitrogen footprints. It focuses on activities that are part of campus and anthropogenic. A budget assesses input and output across the boundaries of a system. A budget can include natural sources not directly related to campus activities, such as atmospheric nitrogen deposition. A critical first step in this process is establishing clear boundaries, which are categorized into three main types: Organizational, Operational, and Temporal.

1. **Organizational Boundaries**: These boundaries delineate which operations or entities a company or institution includes in its emission reporting.

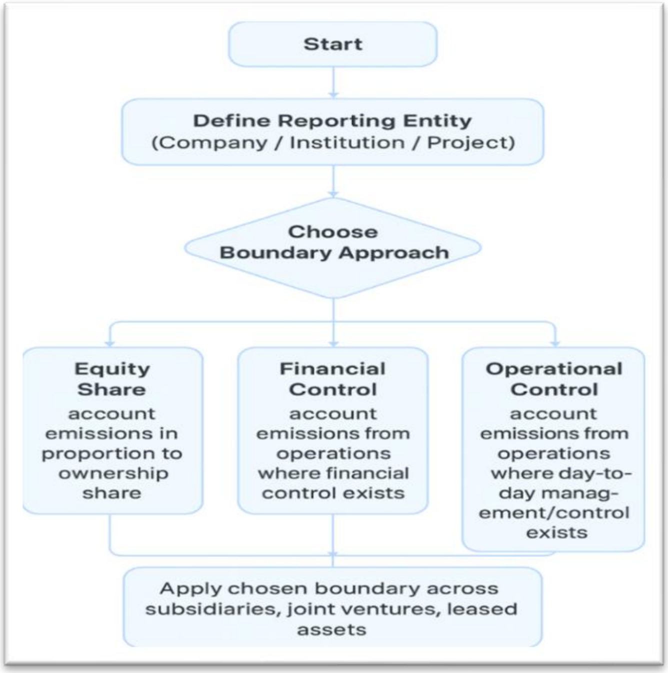

**Fig. 4: Flowchart of Organizational boundaries**

Start with the reporting entity – e.g., a university, company, or government agency.

Equity Share Approach – emissions are reported based on the percentage of equity ownership in an operation (useful for joint ventures).
Financial Control Approach – the entity reports 100% of emissions from operations it financially controls, even without full ownership.
Operational Control Approach – the entity reports 100% of emissions from operations where it has day-to-day authority over policies and operations.

The project uses the operational control approach, meaning the university accounts for emissions from operations it manages daily. This is vital for maintaining consistency, avoiding double-counting, and clearly defining the scope of covered facilities, campuses, or business units, such as all campuses, research

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unhsimap.org/sites/default/files/user-uploads/SIMAP User Guide_DRAFT6.2_2.21.2018.pdf centers, Laboratories and affiliated institutions under its control. Once organizational boundaries are defined, the entity moves on to defining operational boundaries (Scopes 1).

**2. Operational Boundaries**: These define the specific emission sources included within the university's GHG inventory, categorizing them into three scopes:
**Scope 1 (Direct Emissions)**: These originate from sources directly owned or controlled by the university. For instance, on-campus power plants, stationary fuel consumption, university-owned vehicles, backup diesel generators, fertiliser usage, and refrigerant leakage from HVAC systems all fall under this category.
**Scope 2 (Indirect Emissions)**: These encompass indirect emissions from purchased electricity, heating, or cooling consumed by the university which include purchased grid electricity for campus buildings or district heating from external providers.
**Scope 3 (Other Indirect Emissions)**: This broad category covers emissions from activities in the value chain that are not directly owned or controlled by the university but are linked to its operations. Common examples in a university setting include student and staff commuting, air travel for academic purposes, procurement of various goods (e.g., lab equipment, food services), waste generation and disposal, and outsourced services or construction activities.

**Table 1**: Details of various scopes and their related categories

| Scope | Category | Definition & Description | University-Specific Examples |
|---|---|---|---|
| Scope 1 Direct Emissions | Stationary Combustion | Emissions from fuel burned in university-owned or controlled boilers, furnaces, and back up diesel generators. | Natural gas burned in campus central heating plant, backup diesel generators. |
| | Mobile Combustion | Emissions from the combustion of fuel in university-owned vehicles. | Fleet vehicles, campus shuttles and buses, maintenance equipment. |
| | Fugitive Emissions | Intentional or unintentional releases of GHGs from equipment leaks. | Leakage of refrigerants from HVAC and lab cooling systems, methane from on-site wastewater treatment. |
| Scope 2 | Purchased | Emissions from the generation | Electricity purchased |

| Scope | Category | Definition & Description | University-Specific Examples |
|---|---|---|---|
| Indirect Emissions | Energy | of purchased electricity, steam, heating, and cooling consumed by the university. | from the grid, steam or chilled water purchased from a district energy system. |
| Scope 3 Other Indirect Value Chain Emissions | Category 1: Purchased Goods & Services | Emissions from the extraction, production, and transportation of goods and services purchased by the university. | Lab equipment, computers, office supplies, food and catering, construction materials, professional services. |
| | Category 3: Fuel- and Energy-Related Activities | Emissions from the production of purchased fuels and energy not already covered in Scope 1 or 2. | Upstream emissions from the extraction and transmission of natural gas used in our boilers, losses from grid electricity generation (T&D). |
| | Category 5: Waste Generated in Operations | Emissions from the disposal and treatment of waste generated by the university. | Landfill gas from solid waste, wastewater treatment. |
| | Category 6: Business Travel | Emissions from transportation for university activities in vehicles not owned or controlled by the university. | Air travel, train travel, rental cars, and personal vehicles used for work-related trips. |
| | Category 7: Employee Commuting | Emissions from the transportation of employees between their homes and their worksites. | Emissions from cars, buses, trains, and other modes used by faculty and staff for their daily commute. |
| | Category 15: Investments | Emissions associated with the university's investment portfolio. | Emissions from companies and funds within the university's endowment. |

*Source: Based on the GHG Protocol Corporate Standard.*

Setting these operational boundaries is essential for transparent reporting and helps identify key areas for emission reduction. For the current project emissions of Scope 1 and Scope 2 is measured.

3. **Temporal Boundary**: As previously noted, this study analyses emissions from September 1, 2022, to August 31, 2024.

### 3.4 - Emission Calculations

Emission calculation methodologies define the calculation formulas and necessary activity data and emission factors to determine total emissions from specified activities. Most appropriate methodologies are selected based on the purpose of the inventory, availability of data, and consistency with the end user's measurement and reporting programs in which the concerned boundary is located. It is ensured that the different methodologies adapted meet the Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC) which are consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

### 3.5 Calculation overview

For some activities, direct measurements of GHG emissions (e.g., through the use of continuous emissions monitoring systems at power stations) can be used. However, for most emission sources, GHG emissions are estimated by multiplying activity data by an emission factor associated with the activity being measured, as per the following equation:

Emission factor approach for calculating GHG emissions
GHG emission= Activity data x Emission factor

Activity data is a quantitative measure of a level of activity that results in GHG emissions taking place during a given period of time (e.g., volume of gas used, kilometres driven, tonnes of solid waste sent to landfills, waste water treatment, etc.). An emission factor is a measure of the mass of GHG emissions relative to a unit of activity. For example, estimating $CO_2$ emissions from the use of electricity involves multiplying the data on kilowatt-hours (kWh) of electricity used by the emission factor ($kgCO_2/kWh$) for electricity, which will depend on the technology and type of fuel used to generate the electricity.

### 3.6 - Data Collection

Data collection is an integral part of developing and updating a GHG inventory. This includes gathering existing data, generating new data, and adapting data for inventory use.

# IV) ANALYSIS SCOPE 1 & 2

## 4.1 College of Engineering, Al Hail

### Detailed Emission Sources and Trends at College of Engineering-Al Hail

Scope 1 Emissions are direct emissions from sources owned or managed by the University. This includes combustion of fossil fuels from stationery, transport sources, agricultural sources and fugitive emissions from refrigerants and chemicals.
**Scope 1 Stationary Sources (LPG):** This category tracks the direct usage of fuels like LPG for facilities such as the Mess, Cafeteria, Kitchen, and Hostel within the campus.

For the College of Engineering-Al Hail, LPG usage shows a consistent emission of 5.97 kg CO2e per month and 0.0048 kg CO2e of CH4 per month is across the entire period from September 2022 to August 2024.

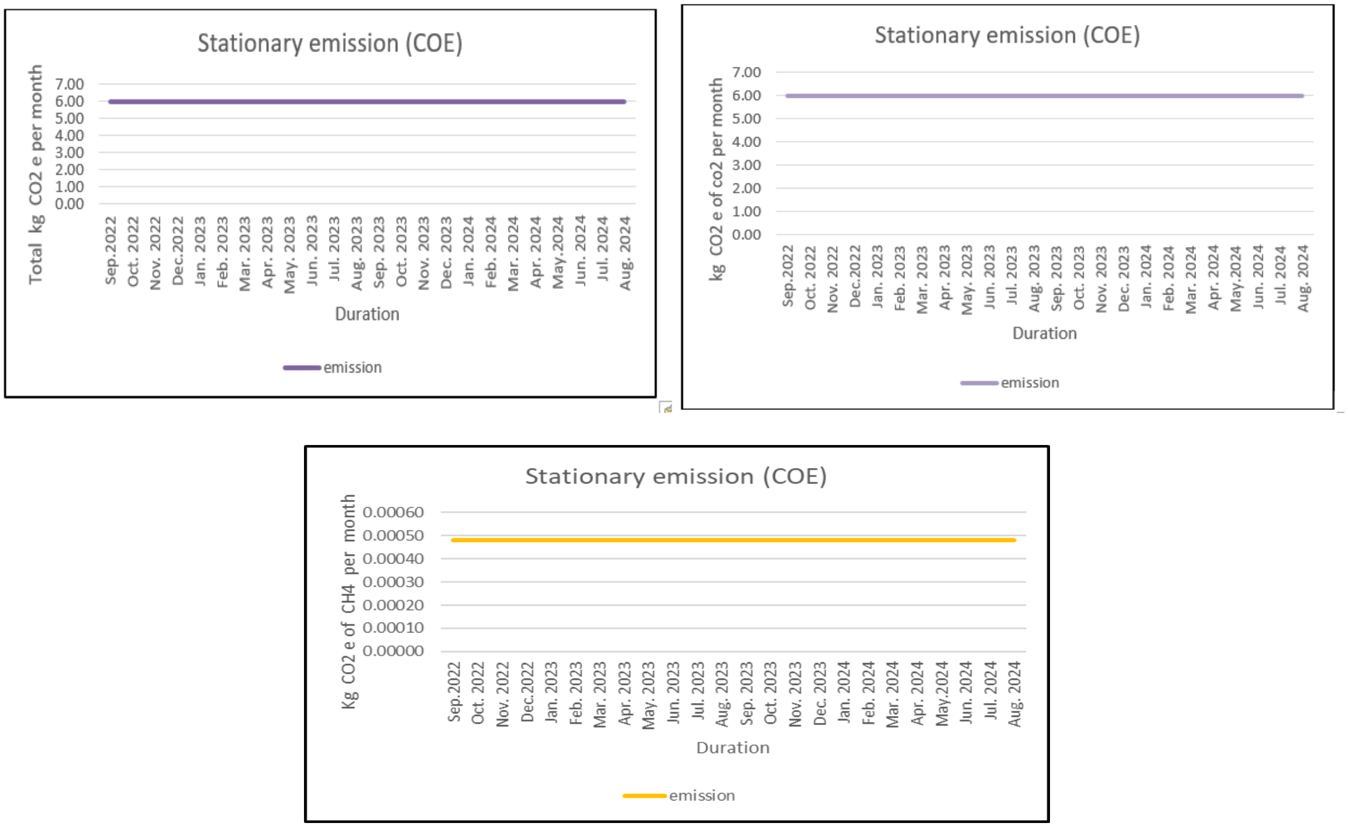


Fig. 5 Graphical representation of GHG Emission from Stationary for COE

**Scope 1 Transport Sources (Gasoline and Diesel):** This tracks the direct usage of fuels like Petrol (Gasoline) and Diesel for the transport fleet owned by the University on campus.
**Gasoline emissions** show significant monthly variations. Emissions were high in October 2022 (5008.865 kg CO2e) and generally fluctuated during academic months. A notable drop occurred during the summer months of July and August 2023 (1188.268 kg CO2e and 1006.641 kg CO2e, respectively). Emissions picked up in academic months and then generally decreased towards the end of the reporting period in 2024.

Graphical Representation of GHG emissions from Transportation

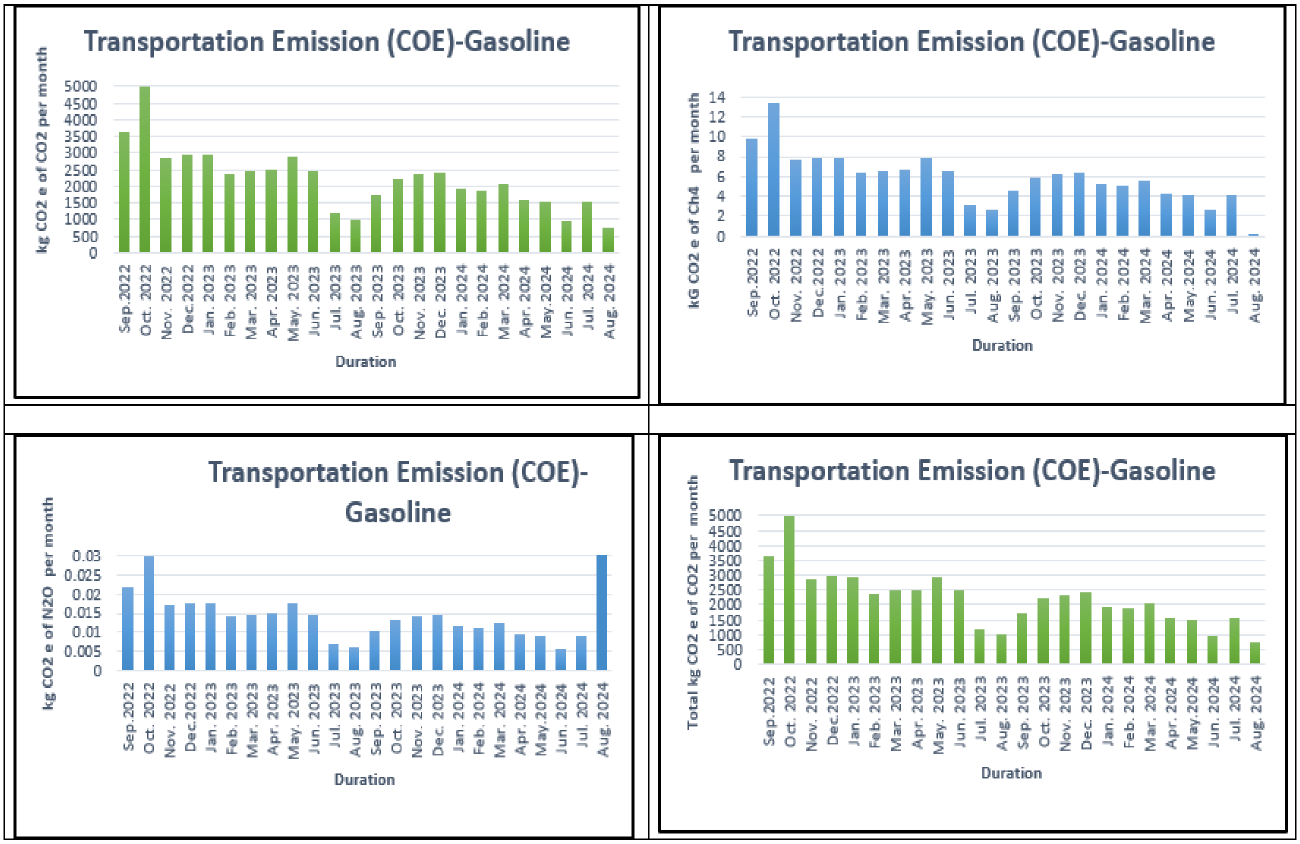


Fig. 6 Graphical representation of GHG Emission from transportation (Gasoline) for COE

Diesel emissions also varied, with a peak in October 2022 (2082.873 kg CO2e) and March 2023 (2088.404 kg CO2e). There were periods of zero emissions recorded for June, July, and August 2023. Emissions continued to fluctuate in the second year, with a general trend of lower values compared to the initial months.

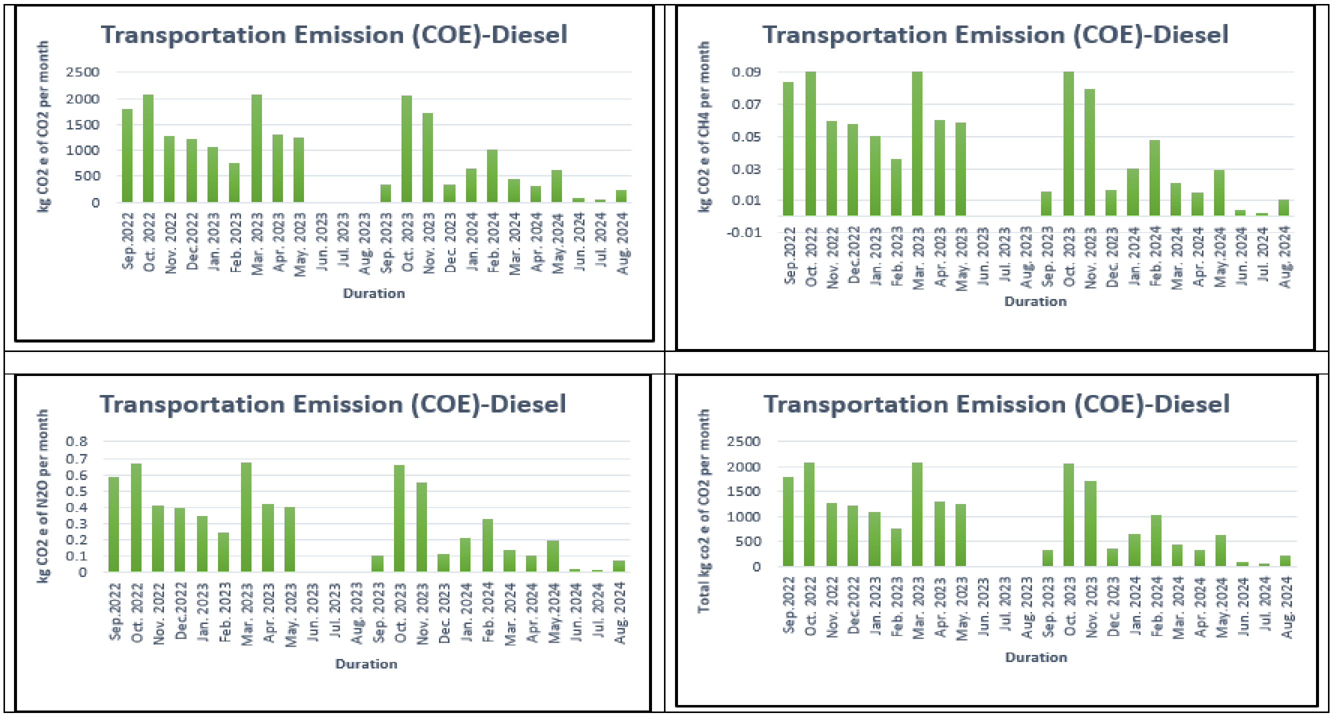


Fig. 7 Graphical representation of GHG Emission from transportation (Diesel) for COE

**Scope 1 Fertilizer Sources (Organic):** This tracks the direct usage of fertilizers for landscaping, gardens, and small farming within the campuses. Organic fertilizer usage for the College of Engineering-Al Hail shows a consistent emission of 9.1695 kg CO2e per month throughout the reporting period.

Graphical Representation of GHG emissions from fertilizer

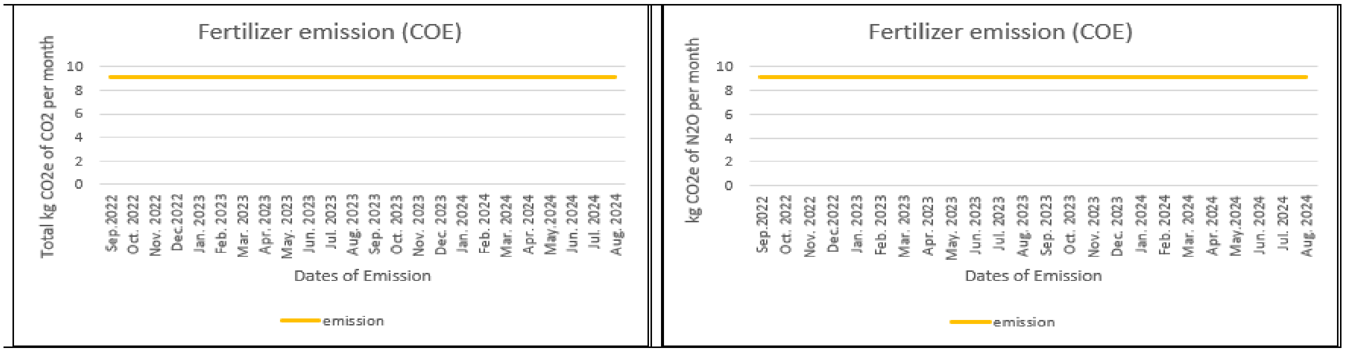


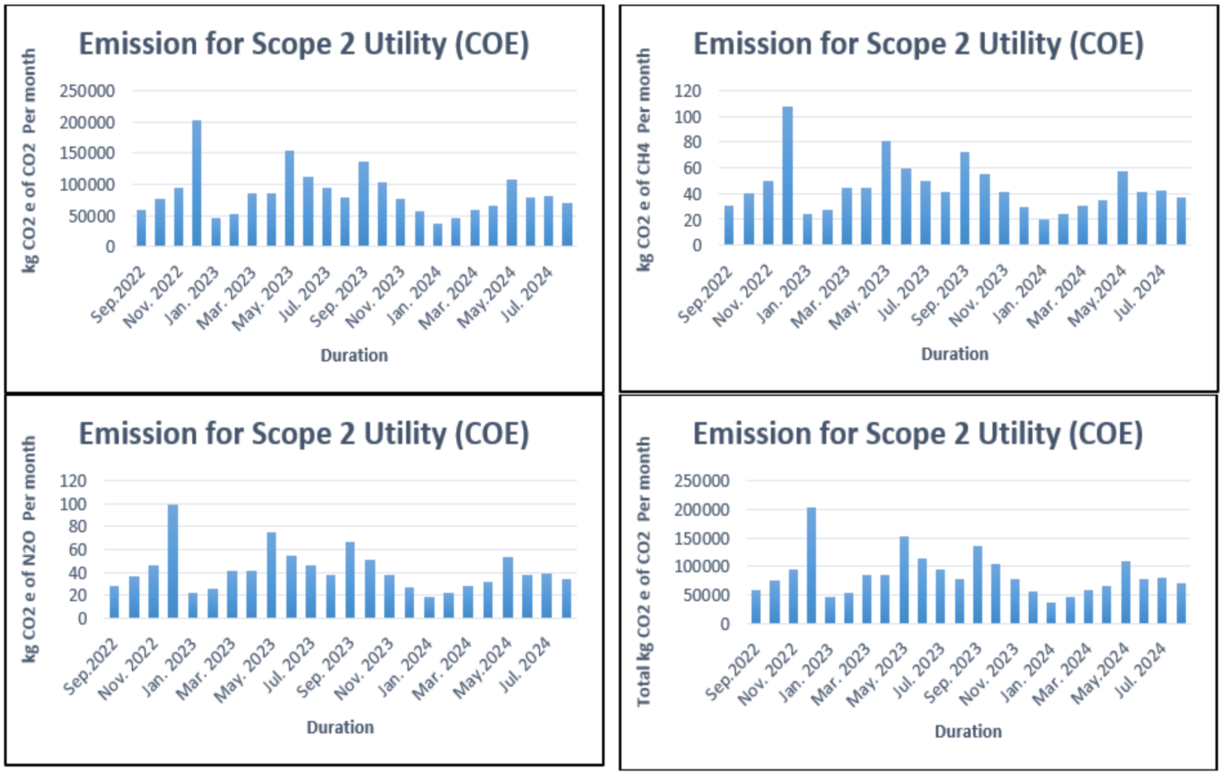
Fig. 8 Graphical representation of GHG Emission from Fertilizer for COE

**Scope 1 Chemicals (Refrigerants and Other Chemicals):** This tracks refrigerant used/refilled in HVAC systems and chemicals used in labs. The specific chemical for refrigerants usage is not mentioned in provided data for College of Engineering-Al Hail. For certain months consumption mentioned in liter hence, it was considered only cleaning agents were used and it does not emit any emissions indicate 0 kg CO2e per month emissions, despite some quantities being reported (e.g., 58 liters, 15.35 liters, 6.7 kilograms, 28 kilograms, 8.5 kilograms). This implies no CO2e emission factors are applied or calculated for these specific entries.

**Scope 2 Emissions** are indirect emissions from sources neither owned nor operated by the University, but whose products (like purchased energy) are directly linked to on-campus energy consumption.

**Scope 2 Utility (Electricity):** This includes purchased energy such as electricity from NAMA or third-party District Cooling Plants (DCP) for chilled water, or steam. Monthly consumption in kWh is mentioned in this category.

**Graphical representation for utility emission**


Emission for Scope 2 Utility (COE)

Emission for Scope 2 Utility (COE)

Emission for Scope 2 Utility (COE)

Emission for Scope 2 Utility (COE)

Fig. 9 Graphical representation of GHG Emission from Electricity for COE

Electricity consumption is the largest source of emissions for the College of Engineering and Al Hail and shows significant monthly variability. Emissions peaked at 202,803.999 kg CO2e in December 2022, and other high points include 153,316.7 kg CO2e in May 2023 and 136,270.504 kg CO2e in September 2023. Lower emissions were observed in months like January 2023 (45,677.2866 kg CO2e) and January 2024 (37,418.4192 kg CO2e).

**Scope 2 Renewables:** As per inventory, renewable electricity selling or purchase is not applicable for the National University of Oman (NU) for period of study.

## Trends and Justification

**Scope 1 Stationary (LPG) and Fertilizers:** The stable and consistent monthly emissions for LPG and organic fertilizers likely reflect a routine operational schedule for services like mess/cafeteria and landscape maintenance throughout the year, or university is adopting standardized approach to data reporting for these categories.

**Scope 1 Transport (Gasoline and Diesel):** The seasonal variability observed in transportation emission. A significant drop in emissions during July and August are highly indicative of reduced university activity during academic summer breaks. Lower emissions during these months suggest less travel by the university fleet when students and many staff may not on campus. The general decreasing trend in the second year might suggest improved fleet management or operational changes reducing overall travel.

**Scope 2 (Electricity):** The High Variability and Seasonality in Electricity Consumption and hence emission is observed. The pronounced monthly fluctuations and peaks often coincide with warmer months (e.g., May, September) strongly suggest a correlation with cooling demand (HVAC systems) in the campus buildings. Higher temperatures typically lead to increased use of air conditioning, which consumes substantial electricity. The lower emissions in cooler months like January and February support this observation. The large peak in December 2022 could be due to specific events or extended operations.

## 4.2 SCHOOL OF FUNDAMENTAL STUDIES, Airport Heights

### 4.2 Detailed Emission Sources and Trends at SOFS Airport Heights

The analysis specifically delves into emissions at the SOFS Airport Heights campus, covering direct emissions (Scope 1) from stationary sources, transport, fertilizers, and chemicals, as well as indirect emissions (Scope 2) from utility consumption.

**Scope 1 Stationary Emission Analysis (LPG):**
Direct emissions from the use of LPG in facilities like the Mess, Cafeteria, Kitchen, and Hostel at SOFS Airport Heights are tracked under Scope 1.

**Emission Fluctuations tied to LPG Consumption**: The graphs clearly illustrate variations in CO2e of CO2, CH4, and total CO2e per unit per month for stationary emissions. These fluctuations are directly correlated with the monthly LPG cylinder usage. For example, months reporting the use of 66 Kilogram LPG cylinders, such as September, October, and November 2022, consistently resulted in a "Total kg CO2e per day" of 197.001. Conversely, periods of reduced consumption, like December 2022, July 2023, and August 2023, where 22 Kilogram LPG cylinders were used, showed a lower "Total kg CO2e per day" of 65.6671. This pattern of higher emissions with greater LPG usage and lower emissions with reduced usage is consistent throughout the entire study period.

**Graphical representation for stationary emission**

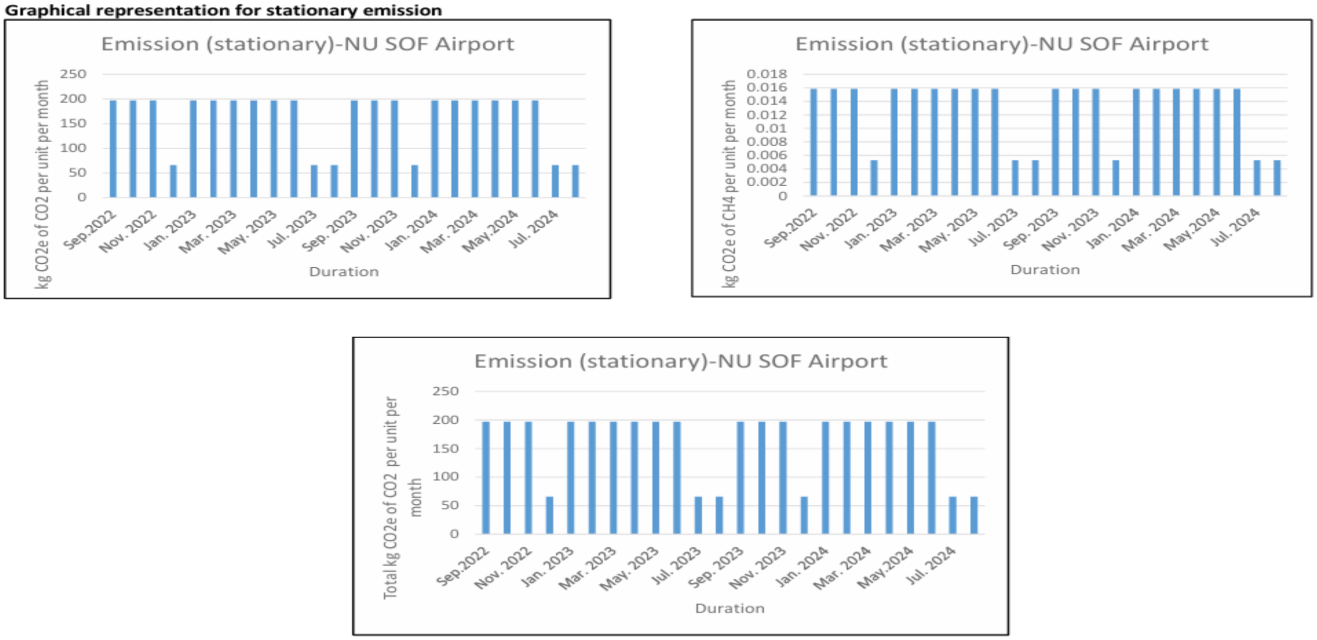


**Fig. 10 Graphical representation of GHG Emission from Stationary for SOFS**

**Scope 1 Transport Emission Analysis (M95 Fuel):** Emissions from the National University's transport fleet, specifically "Passenger Car M95" fuel usage at SOFS Airport Heights, are categorized under Scope

**Graphical representation for transportation emission**

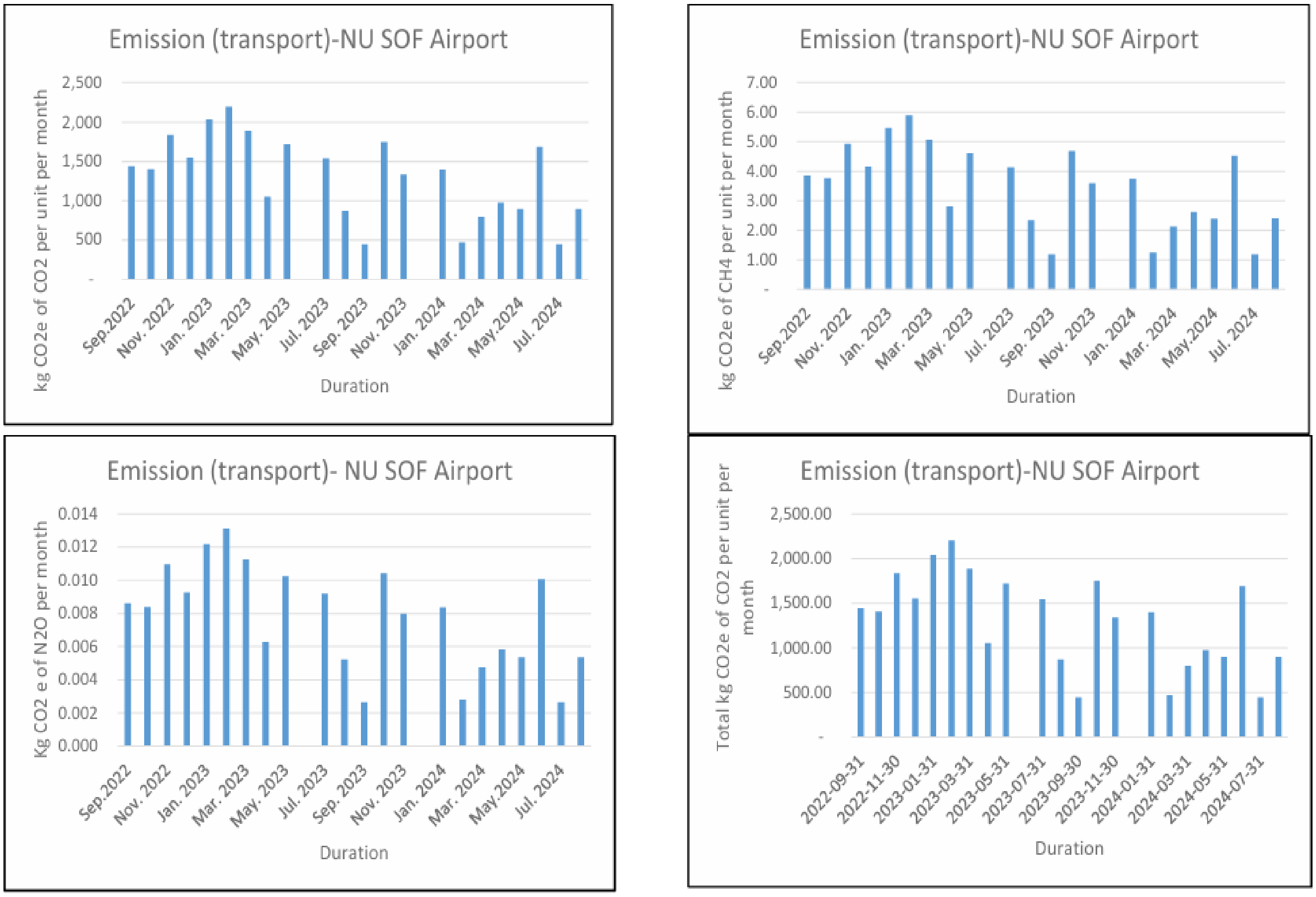


**Fig. 11 Graphical representation of GHG Emission from transportation (M95)for SOFS**

**Emission Trends in Transport:** The graphs reveal varying emission levels for CO2e of CO2, CH4, N2O, and total CO2e per unit per month. The quantity of M95 fuel consumed monthly is the direct driver of these total CO2e emissions. A peak in consumption was observed in February 2023, with 958 litres of fuel used, leading to the highest "Total kg CO2e per month" of 2,199.91. In contrast, months like September 2023 (192 litres) and July 2024 (193 litres) saw significantly lower fuel usage, resulting in lower monthly emissions of 441.19 and 442.19 Total kg CO2e per month, respectively. Furthermore, periods such as June and December 2023 recorded no fuel quantity, indicating negligible or zero emissions during these times. These trends effectively reflect the university's changing operational needs for its transport fleet.

**Scope 1 Fertilizer Emission Analysis:**
Direct usage of fertilizers for landscaping, gardens, and small farming purposes on campus at SOFS Airport Heights falls under Scope 1. Both synthetic and organic fertilizers are included in the data.

**Graphical representation for fertiliser emission**

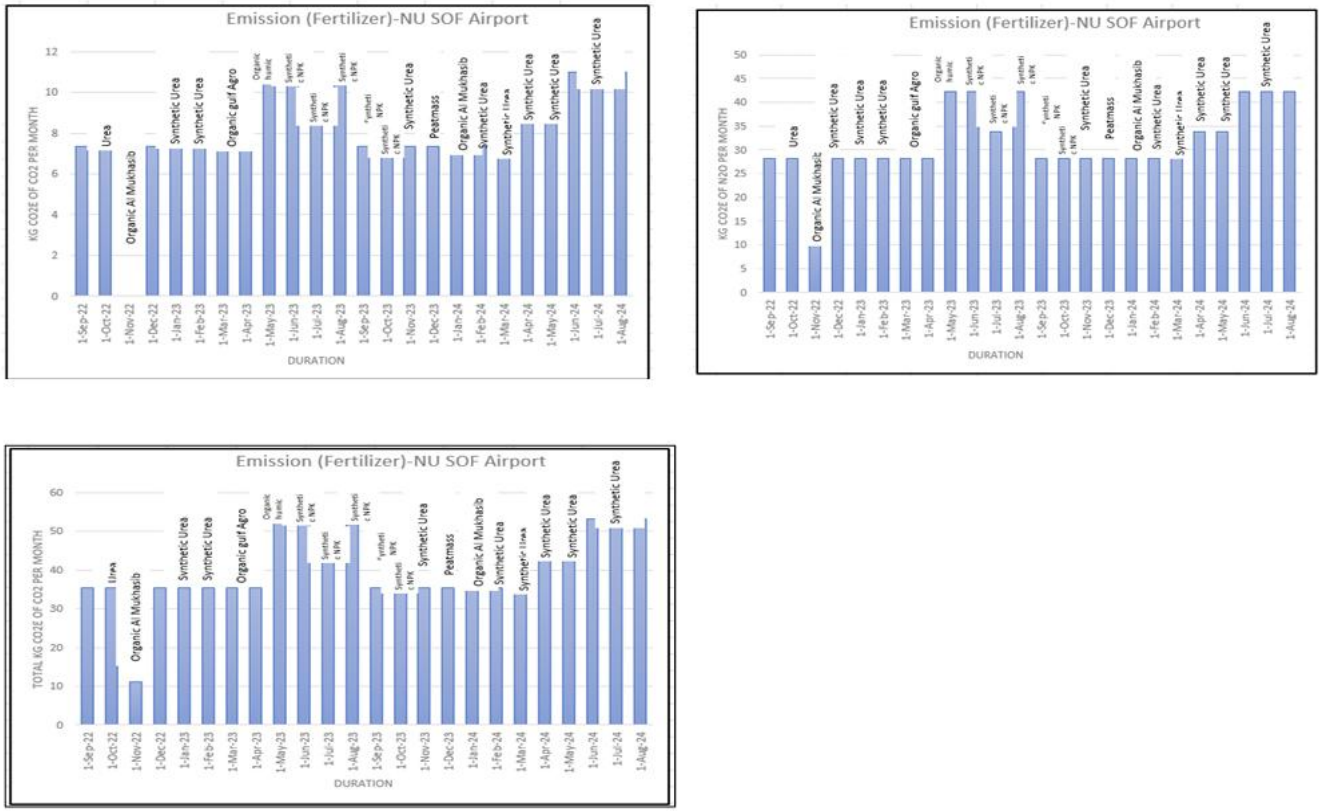


Fig. 12 Graphical representation of GHG Emission from Fertilizer for SOFS

**Emission Contributions from Different Fertilizer Types**: The graphs depict the "kg CO2e of N2O per unit per month" and "Total kg CO2e of CO2 per unit per month" attributed to various fertilizer sources. Synthetic UREA (46% Nitrogen) is identified as a notable contributor, consistently showing high "kg CO2e of N2O per unit" (2.81198) and "kg CO2e of CO2 per unit" (0.73333). For example, 10 kgs of synthetic UREA is linked to 35.4531 Total kg CO2e per day. Other synthetic fertilizers, including various NPK granules and powders, also contribute to emissions, primarily N2O, with their total CO2e amounts varying based on quantity. Organic fertilizers like "al mukhasib," "KALA soil conditioner," and "Organic potting soil" are also used, contributing to emissions; for instance, 6 units of "organic al mukhasib" bags contribute 11.0034 Total kg CO2e per month. These visual breakdowns highlight the diverse impact of agricultural inputs on the campus's carbon footprint.

**Scope 1 Refrigerants and Chemicals Analysis (Cleaning Items):**

The accounting sheet is designed to track refrigerants in HVAC systems and chemicals in labs, the specific data provided for cleaning Items at SOFS Airport Heights indicates a consistent absence of emissions. Throughout the entire period from September 2022 to August 2024, the Refrigerants and Chemicals used at site (only for cleaning) hence it shows zero for all kg CO2e values (CO2, CH4, N2O, and Total kg CO2e per month). This suggests that, within the current framework, cleaning items do not contribute to GHG emissions.

**Scope 2 Electricity Consumption Analysis (Electricity):**
Indirect emissions arising from purchased energy, specifically electricity from NAMA or a third-party (DCP or Steam), are categorized under Scope 2, as they are directly linked to on-campus energy consumption. The provided data focuses on electricity consumption in KWh for SOFS Airport Heights.

**Graphical representation for Grid supplied electricity emission**

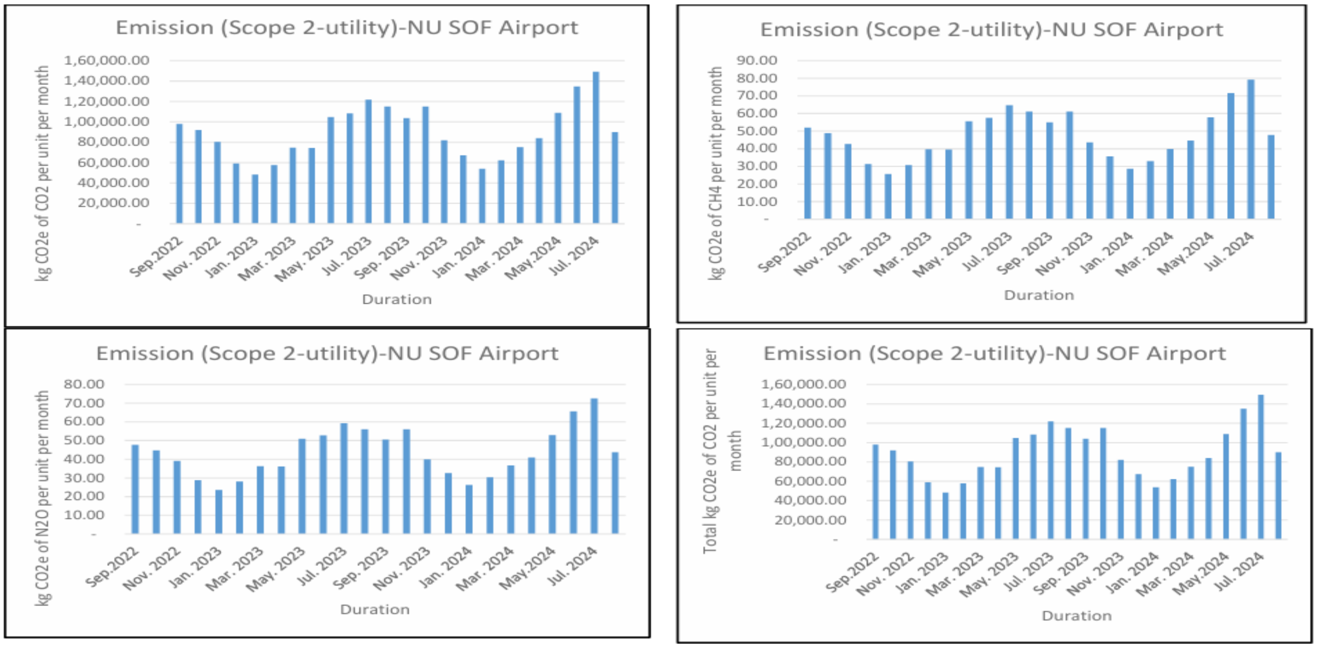


**Fig. 13 Graphical representation of GHG Emission from Electricity for SOFS**

**Electricity Consumption and Correlated Emissions**: The graphs for Scope 2 Electricity emissions show significant monthly fluctuations in CO2e of CO2, CH4, N2O, and total CO2e. These variations directly correspond to the monthly electricity consumption in KWh. Notably, emissions are generally lower during cooler months; for instance, January 2023 recorded 119,389 KWh consumption, resulting in 48,272.69 Total kg CO2e per month. Conversely, consumption surges during warmer months, with July 2024 exhibiting the highest consumption at 369,255 KWh, leading to a "Total kg CO2e per month" of 149,301.29. These trends powerfully illustrate the seasonal demand for electricity and its direct impact on the university's indirect GHG emissions.

## 4.3 IMCO SOHAR

### 4.3 Detailed Emission Sources and Trends at IMCO Sohar

The IMCO Sohar campus generates Greenhouse Gas (GHG) emissions from Stationary Sources, Transportation (Gasoline and Diesel), Fertilizer use (NPK and Urea), Chemical (refrigerant) use, and Electricity Consumption. The data covers the period from September 2022 to August 2024.

## Scope 1 Stationary Emission Analysis:

The primary stationary fuel source is LPG, with consistent monthly emissions of 986.4398376 kg CO2e for most months. There are periods of zero emissions from LPG use in May, July, and August 2023, and July and August 2024. In March and April 2024, emissions were significantly lower at 164.4066396 kg CO2e.

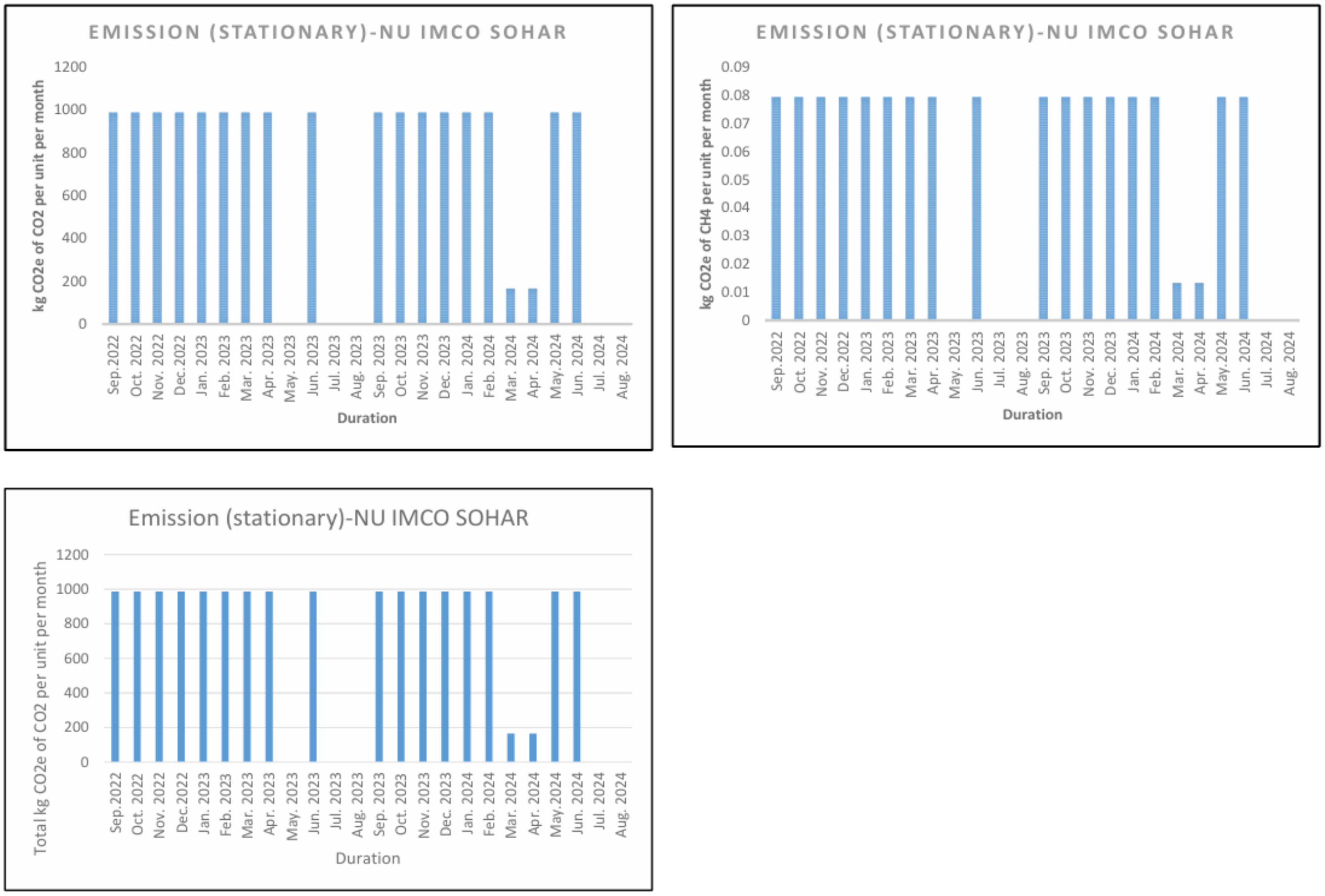


**Fig. 14 Graphical representation of GHG Emission from stationary for IMCO Sohar**

## Scope 1 Transportation Emission Analysis:

**Passenger Car (Gasoline):** This is a significant and variable source of emissions. High emission months include September 2022 (1840.380 kg CO2e), March 2023 (1856.820 kg CO2e), June 2023 (2091.845 kg CO2e and December 2023 (1881.942 kg CO2e). The lowest emissions were in September 2023 (256.224 kg CO2e), February 2023 (671.1635148 kg CO2e), and July 2023 (1066.731 kg CO2e).
Emissions show a range from 255.536 kg CO2e to 2086.224 kg CO2e for CO2 component alone.

**Passenger Car (Diesel):** Emissions from diesel vehicles are sporadic and generally lower than gasoline, but still notable. Emissions are recorded only in specific months November 2022 (257.053 kg CO2e), December 2022 (357.747 kg CO2e). Later, in November 2023 (320.500 kg CO2e), December 2023 (620.650 kg CO2e), March 2024 (166.475 kg CO2e), and May 2024

(183.152 kg CO2e). Most other months record 0 kg CO2e from diesel passenger cars.

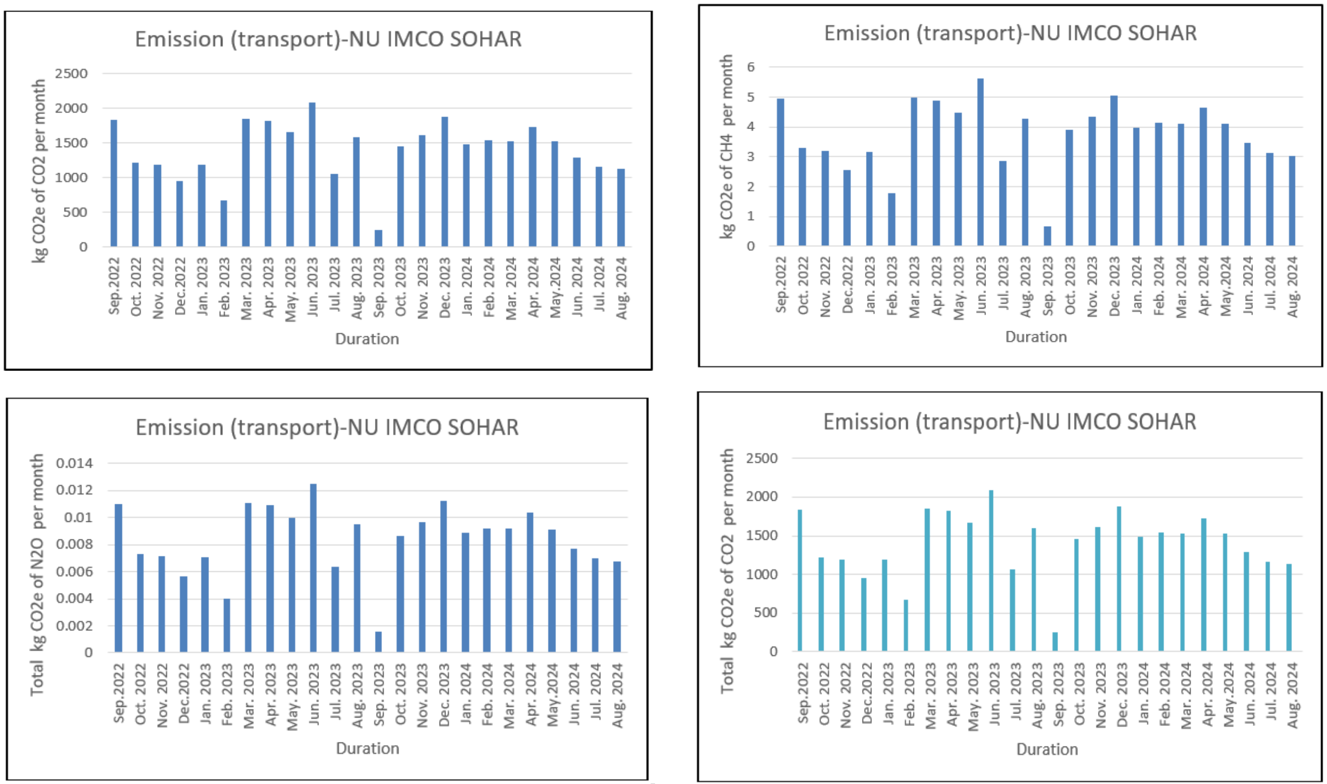


Fig. 15 Graphical representation of GHG Emission from transportation (Gasoline) for IMCO Sohar

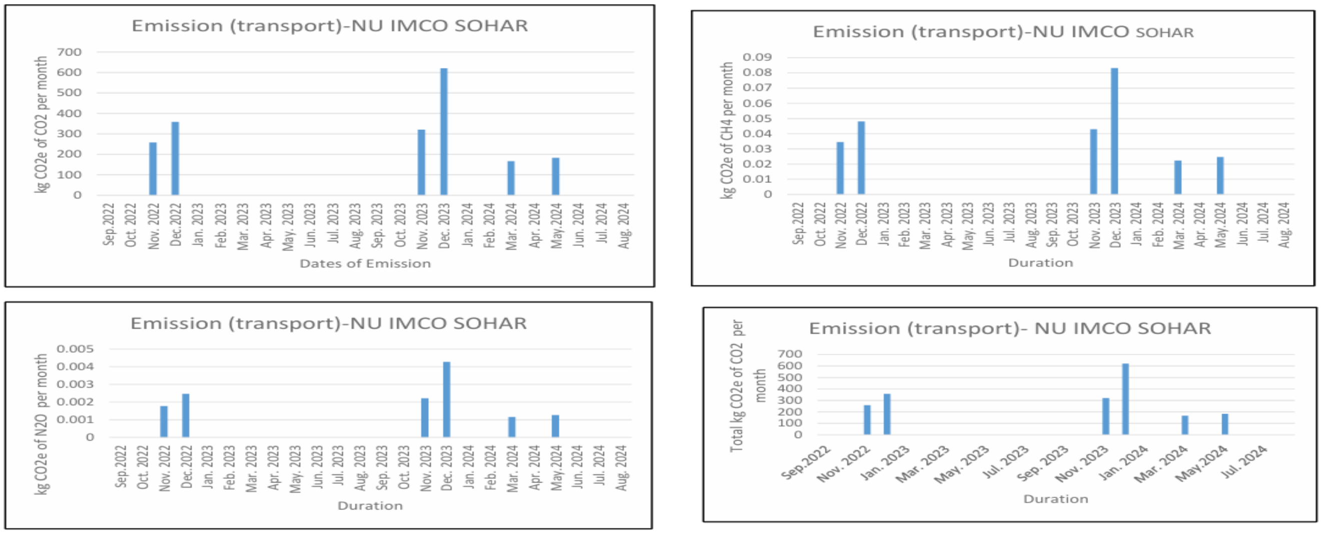


Fig. 16 Graphical representation of GHG Emission from transportation (Diesel) for IMCO Sohar

### Scope 1 Fertilizer Emission Analysis:

The synthetic NPK 15:15:15: fertilizer shows consistent monthly emissions of 3.82 kg CO2e across the entire reporting period from September 2022 to August 2024, with no variation. Similar to NPK, Synthetic Urea results in consistent monthly emissions of 14.76976146 kg CO2e throughout the period, without any monthly fluctuation.

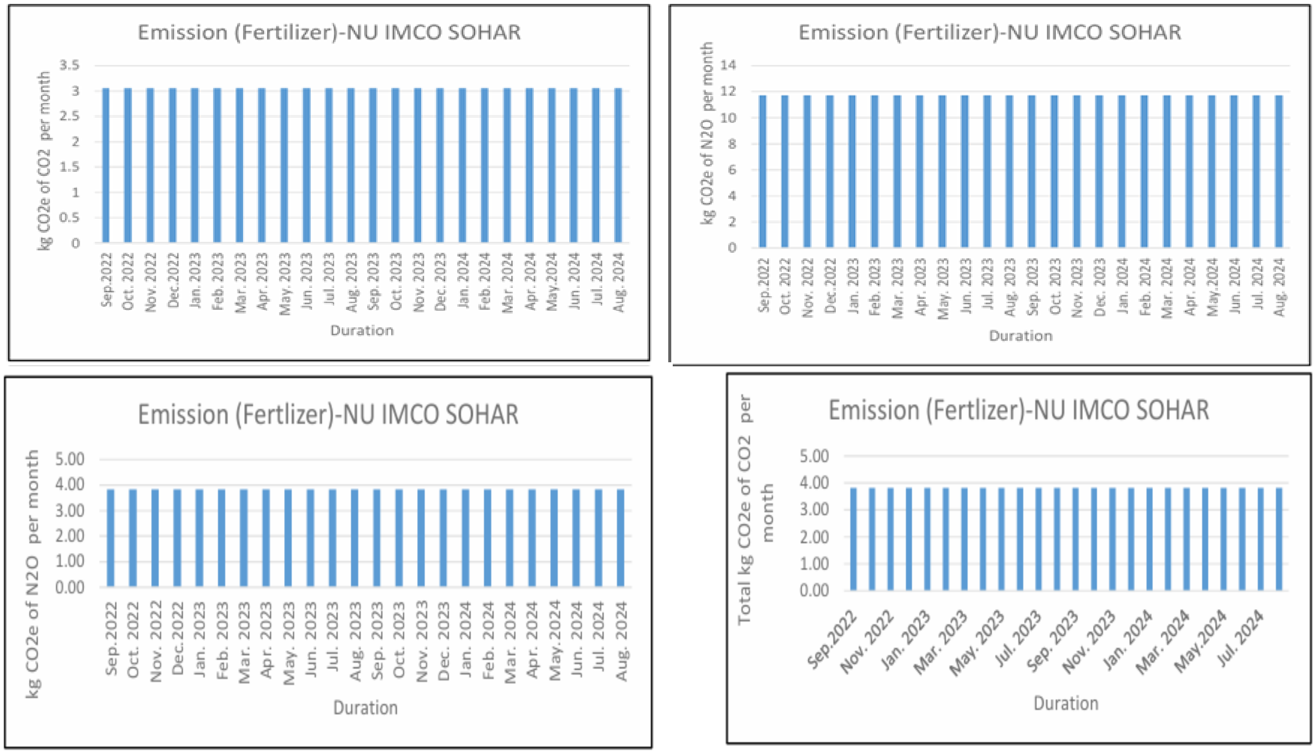


**Fig. 17 Graphical representation of GHG Emission from Fertilizer for IMCO Sohar**

### SCOPE 1 Chemicals and Refrigerants Emission Analysis:

The primary refrigerant used is HFC134a. Emissions from this source are highly sporadic. The significant emissions occurred in November 2022 (172659.072 kg CO2e). Other emission events include December 2023 (43164.768 kg CO2e) and May 2024 (21582.384 kg CO2e). All other months show 0 kg CO2e emissions from HFC134a.

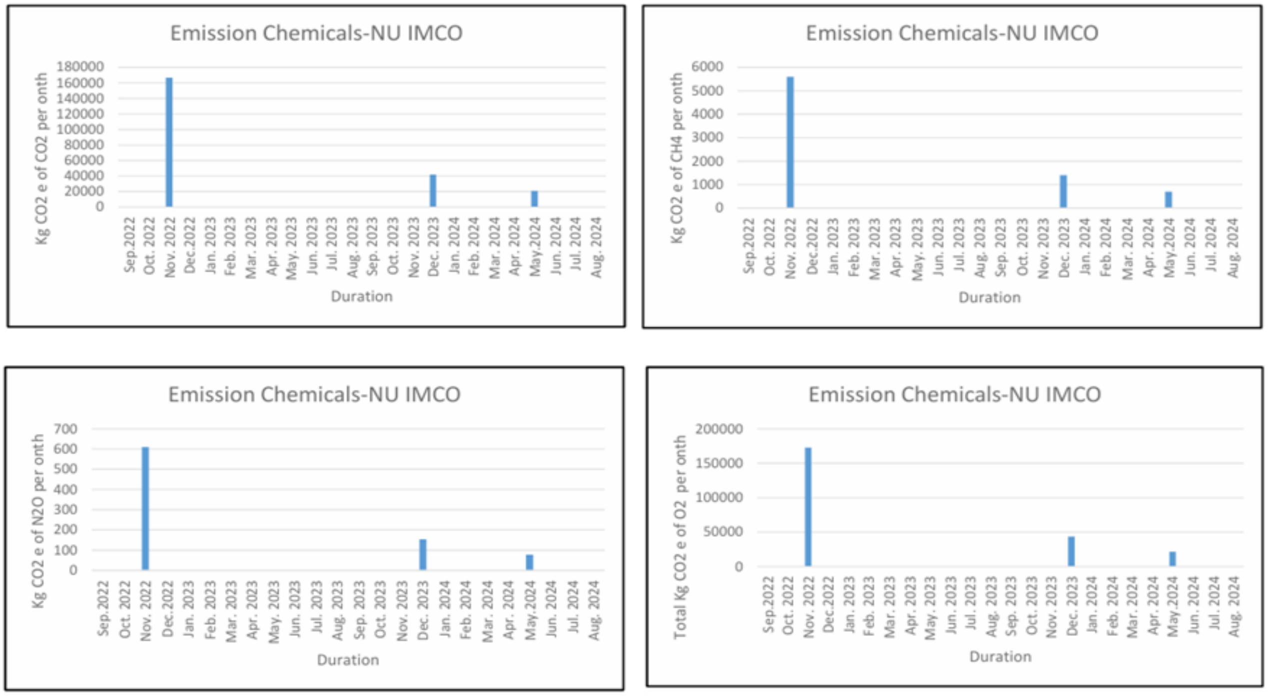


**Fig. 18 Graphical representation of GHG Emission from Chemicals for IMCO Sohar**

**Scope 2 Electricity Consumption Emission Analysis:**
The electricity consumption is the largest single source of GHG emissions at IMCO Sohar and exhibits a seasonal trend. Emissions are generally lower in cooler months, for example, 74,475.37 kg CO2e in January 2023 and 79,691.24 kg CO2e in February 2023. Emissions increase substantially during the hot summer months, indicating high demand for cooling. Peak emissions include 228,469.73 kg CO2e in May 2023, 282,947.68 kg CO2e in June 2023, 274,726.01 kg CO2e in July 2023, and 224,420.75 kg CO2e in September 2023. In the second year, peaks are seen in May 2024 (217,240.64 kg CO2e), June 2024 (231,959.10 kg CO2e), and July 2024 (239,233.42 kg CO2e).

## 2. Trends and Justification

**Stationary Sources (LPG):** The pattern of consistent emissions for most months, with drops or zeros in certain periods (e.g., May, July, August), likely indicates routine operational use (e.g., for kitchens, heating, or specific equipment) that is reduced or paused during academic breaks or periods of lower campus activity. The reduction in March/April 2024 for both LPG sources suggest a temporary decrease in consumption during those months.

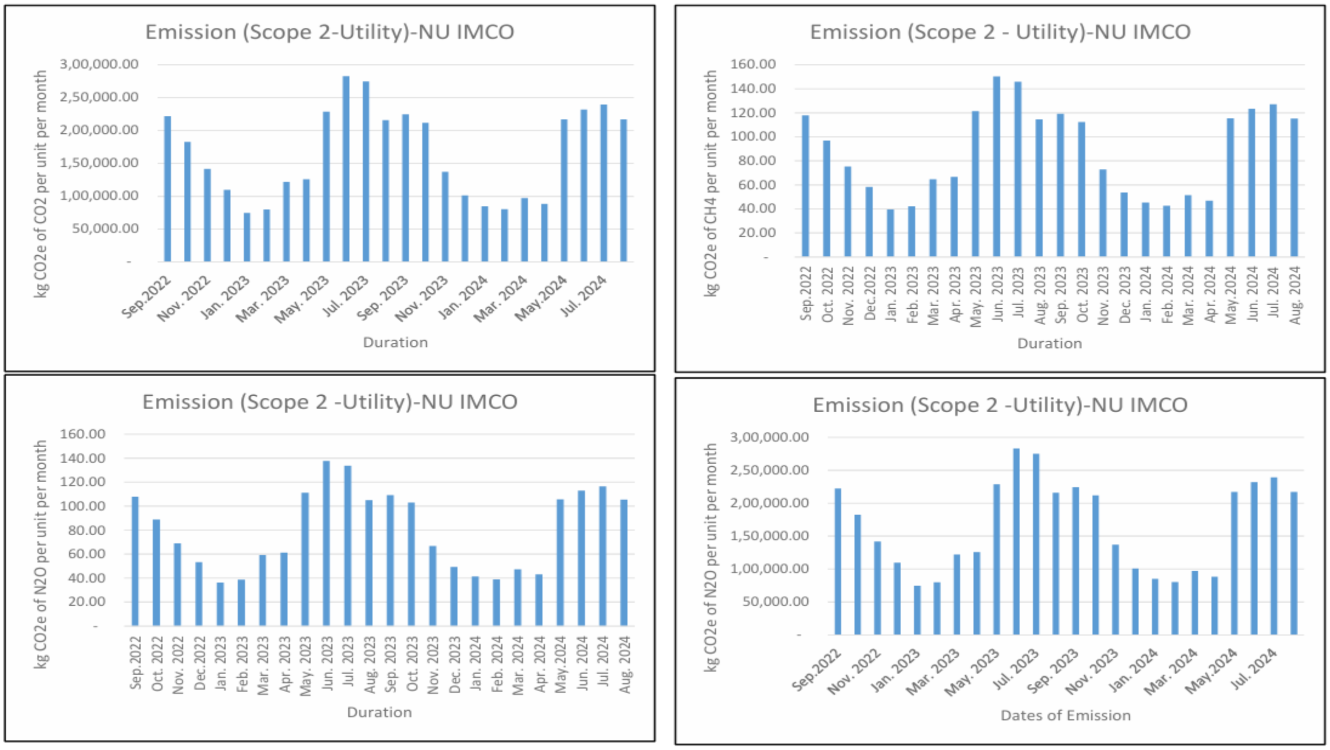


**Fig. 19 Graphical representation of GHG Emission from Electricity for IMCO Sohar**

**Transportation (Gasoline and Diesel):** The significant variability in gasoline emissions, with peaks in specific months and troughs during others, points to fluctuations in campus population and activities. Lower emissions in summer months (e.g., July 2023) suggest reduced student and staff presence during holidays. Diesel emissions being sporadic indicate less routine use, perhaps for specific maintenance or delivery schedules, rather than daily commuting.

**Fertilizer Use (NPK and Urea):** The remarkably consistent monthly emissions from both NPK and Urea indicate a regular, possibly scheduled application for campus landscaping and grounds maintenance, regardless of seasonal changes or specific needs. The low quantities suggest this is for sustained upkeep rather than large-scale new plantings.

**Chemicals (HFC134a):** The highly infrequent but large spikes in HFC134a emissions suggest major servicing, recharging, or replacement events for cooling systems (e.g., air conditioners), rather than ongoing leaks or routine top-ups. Such events would occur only when a unit requires significant refrigerant intervention.

**Electricity Consumption:** This category demonstrates the strongest and most justifiable trend: a clear seasonal pattern correlating directly with ambient temperatures in Oman. The substantial increase in electricity use during the hot summer months (May to September) is directly attributable to the high demand for air conditioning to maintain comfortable indoor temperatures across the campus. The lower emissions in cooler months (e.g., January-February) reflect reduced cooling requirements.

## 4.4 College of Medicine, Sohar

### 4.4 Detailed Emission Sources and Trends at COM Sohar

The COM Sohar campus exhibits various sources of Greenhouse Gas (GHG) emissions, categorized into Stationary Sources, Transportation, Fertilizer use, Chemical (refrigerant) use, and Utility Consumption (Electricity). The data covers the period from September 2022 to August 2024.

### Scope 1 Stationary Emission Analysis (LPG):

The primary stationary fuel source shows consistent monthly emissions, typically around 2149.1064 kg CO2e. However, there are noticeable drops in emissions during month of September 2022 and 2023, and June 2023 and 2024, show emissions of 1880.4681 kg CO2e. July and August 2023 and 2024 record the lowest emissions at 671.59575 kg CO2e. A smaller, separate stationary backup diesel genset source shows minimal and sporadic emissions, such as 4.419036 kg CO2e in September 2022 and 7.36506 kg CO2e in September 2023 and August 2024. Most months for this backup diesel genset source show 0 kg CO2e emissions.

**Graphical representation for Stationary emission**

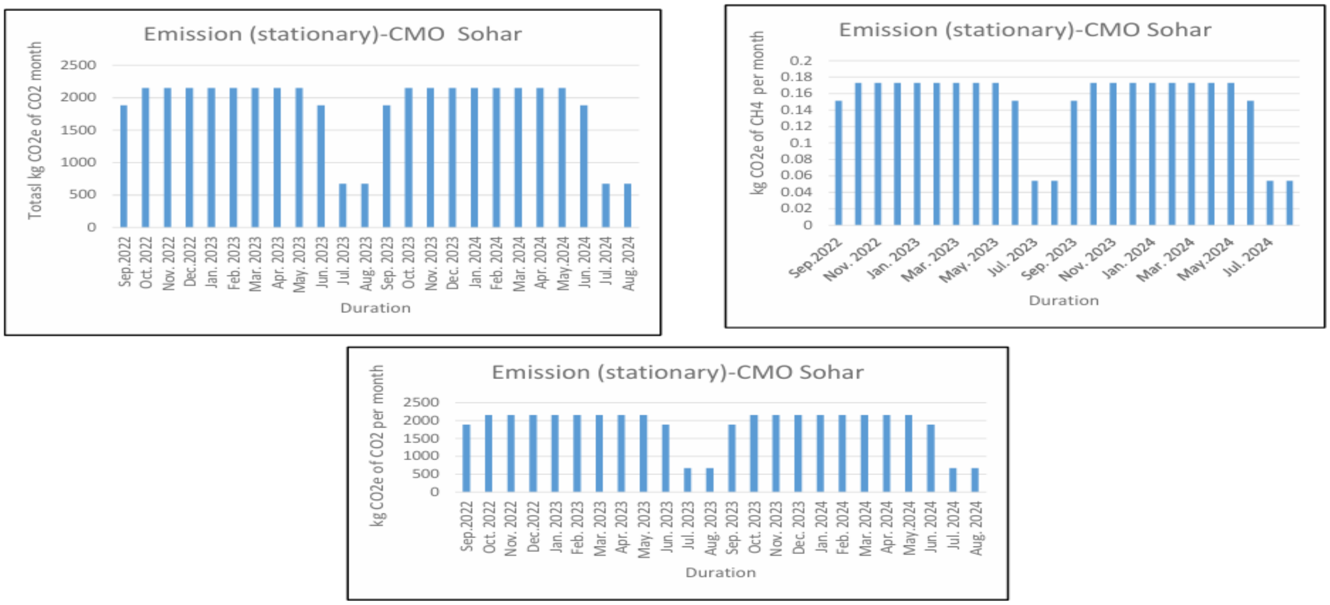


**Fig. 20 Graphical representation of GHG Emission from Stationary source for COM Sohar**

### Scope 1 Transportation Emission Analysis: COM Sohar

Passenger Cars (M95 Petrol): This category shows significant variability in emissions related to the operations of COM Sohar, an institution formerly known as the Oman Medical College. Based on the provided data table, high emission months include December 2023 (9532.621 kg CO2e), May 2023 (9314.110 kg CO2e), and December 2022 (9253.814 kg CO2e). The lowest emissions were recorded in July 2023 (1061.618 kg CO2e), March 2023 (4547.780 kg CO2e), and August 2024 (4702.479 kg CO2e).

Medium Duty Vehicles (Diesel): Emissions from diesel vehicles also fluctuate according to the institutional requirements of the campus. High emission months include March 2024 (6816.785 kg CO2e), December 2023 (6046.394 kg CO2e), and April 2023 (6011.376 kg CO2e). The lowest emissions were documented in August 2024 (218.003 kg CO2e), July 2023 (1116.860 kg CO2e), and July 2024 (1160.017 kg CO2e).

**Fig. 21 Graphical representation of GHG Emission from transportation for COM Sohar**

## Scope 1 Fertilizer Emission Analysis:

Fertilizer emissions are sporadic and generally much lower than other categories. Common sources include peatmoss, compost, NPK15-15-15, and UREA. Compost usage in October 2022, August 2023, and July 2024 resulted in 366.78 kg CO2e per month. Peatmoss in September 2022, September 2023, and August 2024 contributed 275.085 kg CO2e per month. UREA usage (e.g., December 2022, November 2023, May 2024) generated 265.89825 kg CO2e per month. NPK15-15-15 contributed 68.77125 kg CO2e in months like November 2022, October 2023, and June 2024. Many months show zero emissions from fertilizers.

**Graphical presentation for Fertilizer emission**

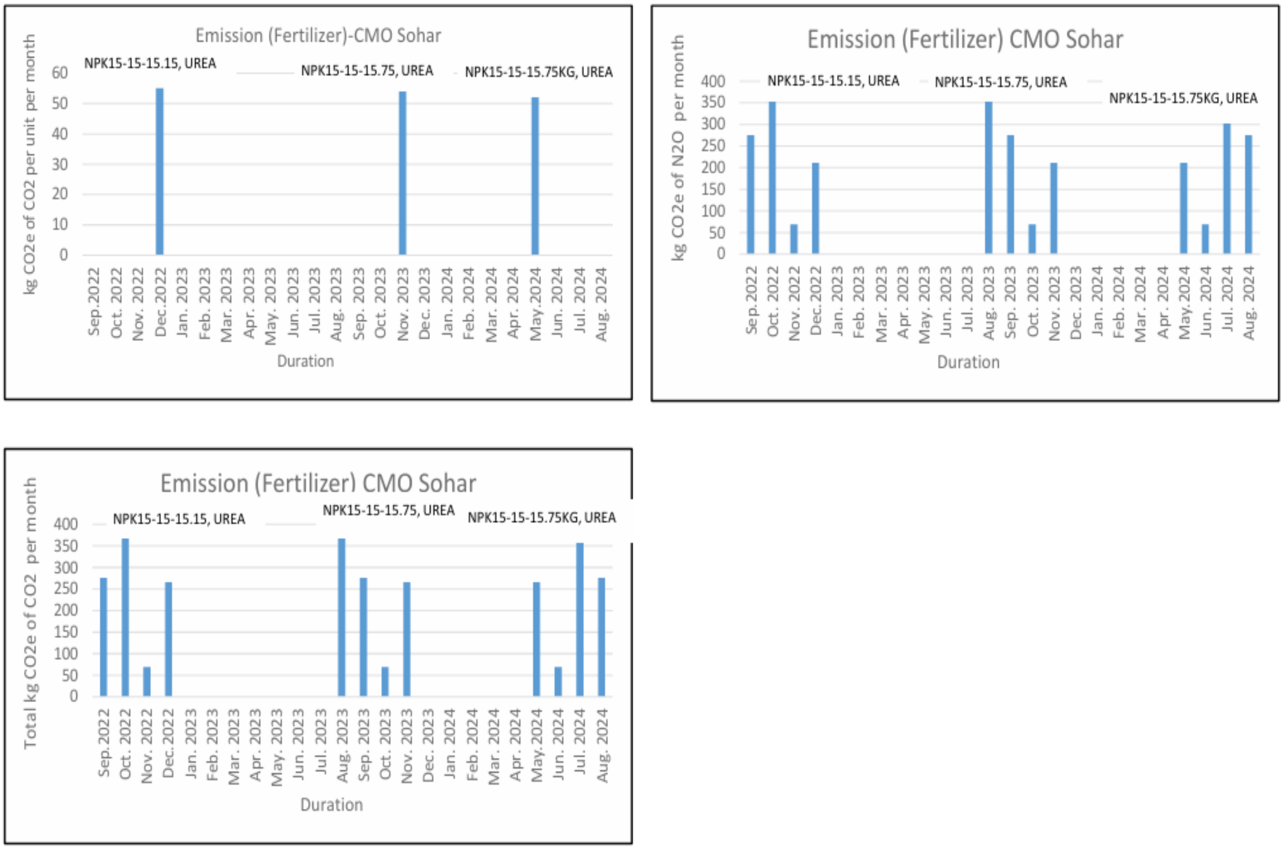


**Fig. 22 Graphical representation of GHG Emission from Fertilizer for COM Sohar**

## Scope 1 Chemicals and Refrigerants Emission Analysis:

This category is a significant and consistent contributor to emissions, primarily from HFC32 and HCFC22. The campus alternatively using HFC32 and HCFC22 almost every month. HFC32 (5.4 kg), when used, results in 10977.93 kg CO2e per month. HCFC22 (13 kg), when used, results in 26428.35 kg CO2e per month, which is the highest individual monthly emission from a single source type **after electricity**.

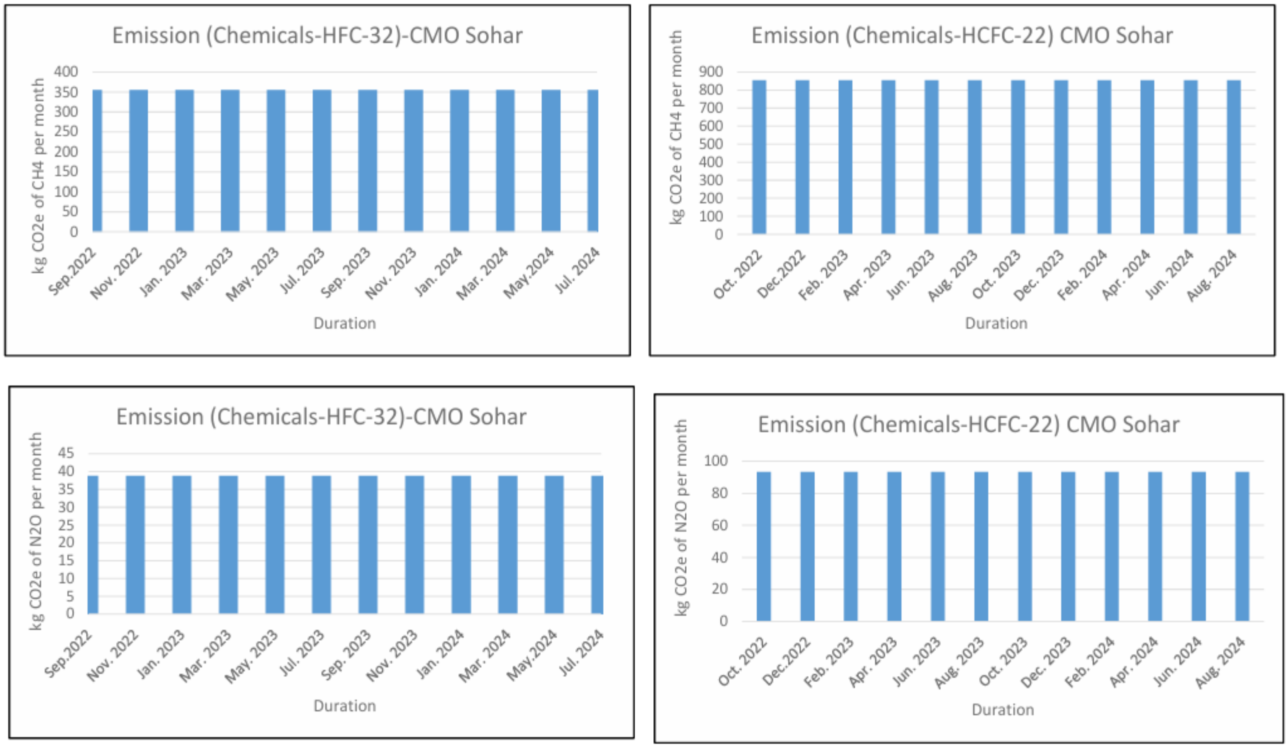


**Fig. 23 Graphical representation of GHG Emission from Chemicals for COM Sohar**

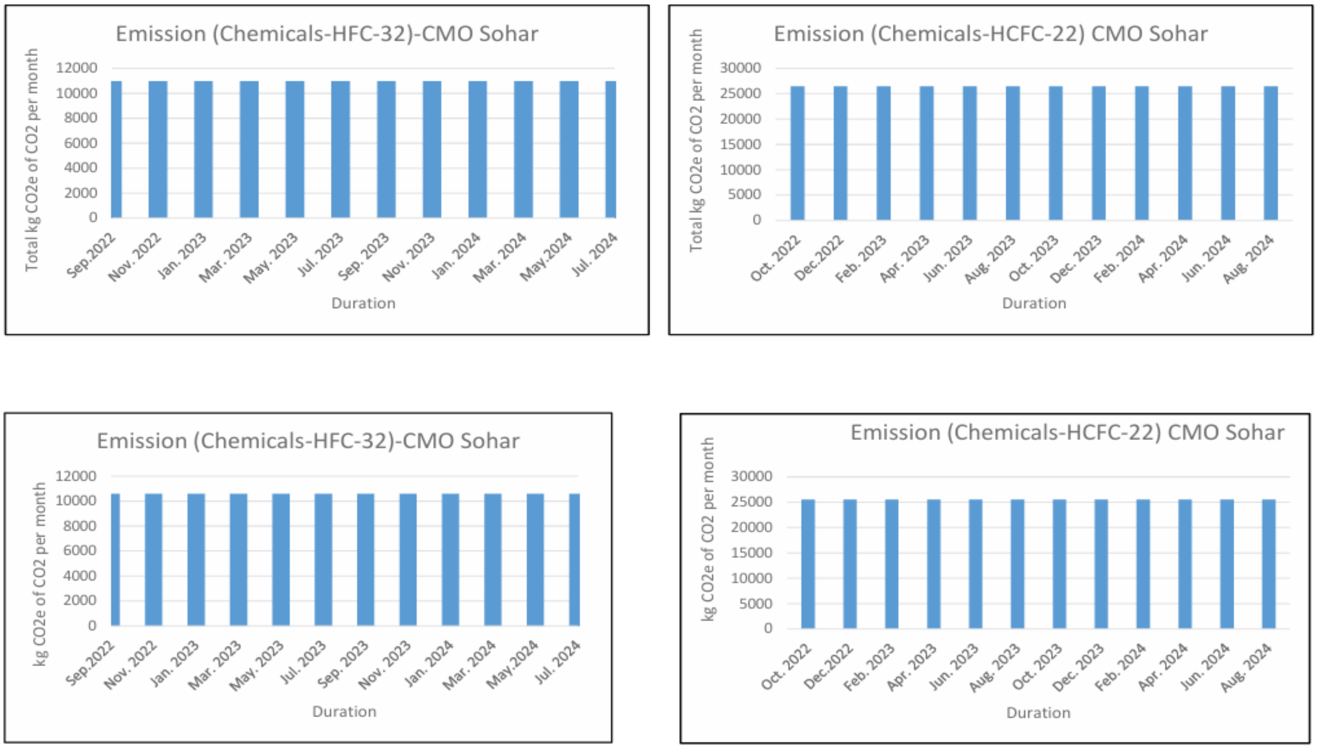


**Fig. 24 Graphical representation of GHG Emission from Chemicals for COM Sohar**

**Scope 2 Electricity Consumption Emission Analysis:**
Electricity consumption is the largest single source of GHG emissions at COM Sohar, showing a distinct seasonal trend. Emissions are generally lower in cooler months, for example, 55620.75 kg CO2e in January 2023 and 58285.24 kg CO2e in November 2022. Emissions surge dramatically during the hotter months, indicating high demand for cooling. Peak emissions include 2,36,173.60 kg CO2e in August 2023 and 2,51,861.58 kg CO2e in May 2024. Other high months are 2,36,173.60 August 2023 (kg CO2e), 2,10,206.64 July 2023 (kg CO2e), (2,51,861.58 kg CO2e) may 2024, (2,44,671.77 kg CO2e) June 2024, (2,17,808.41 kg CO2e) July 2024.

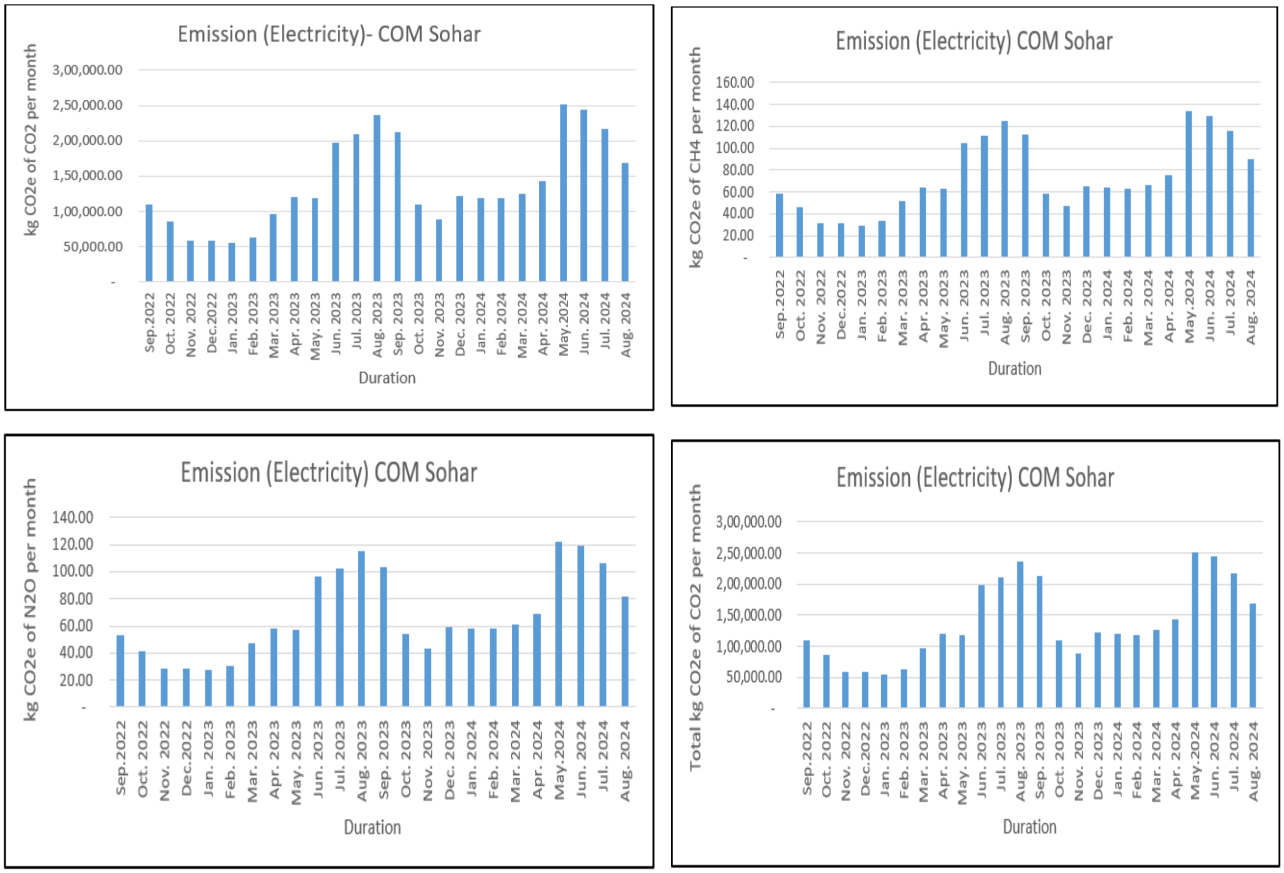


Fig. 25 Graphical representation of GHG Emission from Electricity for COM Sohar

**Trends and Justification**

- **Stationary Sources:** The consistent baseline emissions with drops in June, July, and August across both years suggest a core operational requirement for these sources that is reduced or paused during typical academic breaks or lower activity periods, such as summer.
- **Transportation:** The high variability in transportation emissions, with peaks and valleys, is likely linked to specific university activities, student and staff travel patterns, or maintenance schedules for vehicles. For instance, lower emissions in July 2023 might correspond to reduced travel during a summer break. Higher emissions in December and October could relate to the academic calendar or specific events.
- **Fertilizer Use:** The sporadic nature of fertilizer application directly reflects horticultural or

landscaping needs at specific times of the year, such as planting seasons or preparation for new academic terms.

- **Chemicals (Refrigerants):** The alternating pattern of HFC32 and HCFC22 use every month and their significant contribution to total emissions indicates a regular cycle of maintenance, recharging, or replacement of refrigerants in cooling systems, likely for air conditioning or laboratory equipment. The higher emissions from HCFC22 compared to HFC32 are due to the larger quantity used (13 kg vs 5.4 kg) and potentially different emission factors.

- **Electricity Consumption:** This category shows a strong seasonal pattern. Emissions are significantly higher in the hot summer months (May to September), peaking in May-August. This is primarily justifiable by the intensive use of air conditioning systems to manage high ambient temperatures in Oman during these months, reflecting increased energy demand for cooling across the campus.

## 4.5 Head Quarters & College of Pharmacy, Muscat

### Detailed Emission Sources and Trends at College of Pharmacy

The College of Pharmacy campus generates Greenhouse Gas (GHG) emissions primarily from Stationary Sources (LPG Gas Cylinders), Transportation (M95 fuel for Passenger Cars and Medium Duty Vehicles), and Electricity Consumption. The data covers the period from September 2022 to August 2024. No data for fertilizer use or chemical (refrigerant) emissions were provided for the College of Pharmacy campus in the sources.

**Scope1 Stationary Emission Analysis (LPG Gas Cylinder):**
LPG usage at the College of Pharmacy campus shows a fluctuating pattern. Emissions are recorded as 0 kg CO2e for September 2022, August 2023, and September 2023, and August 2024. For several months, the campus reports emissions of 119.394 kg CO2e (corresponding to 40 kg of LPG or 2 cylinders). These months include October, November, December 2022, March, April, May 2023, October, November 2023, January, February, May, June, July 2024. Other months show emissions of 59.697 kg CO2e (corresponding to 20 kg of LPG or 1 cylinder). These include January, February, June, July 2023, December 2023, March, April 2024.

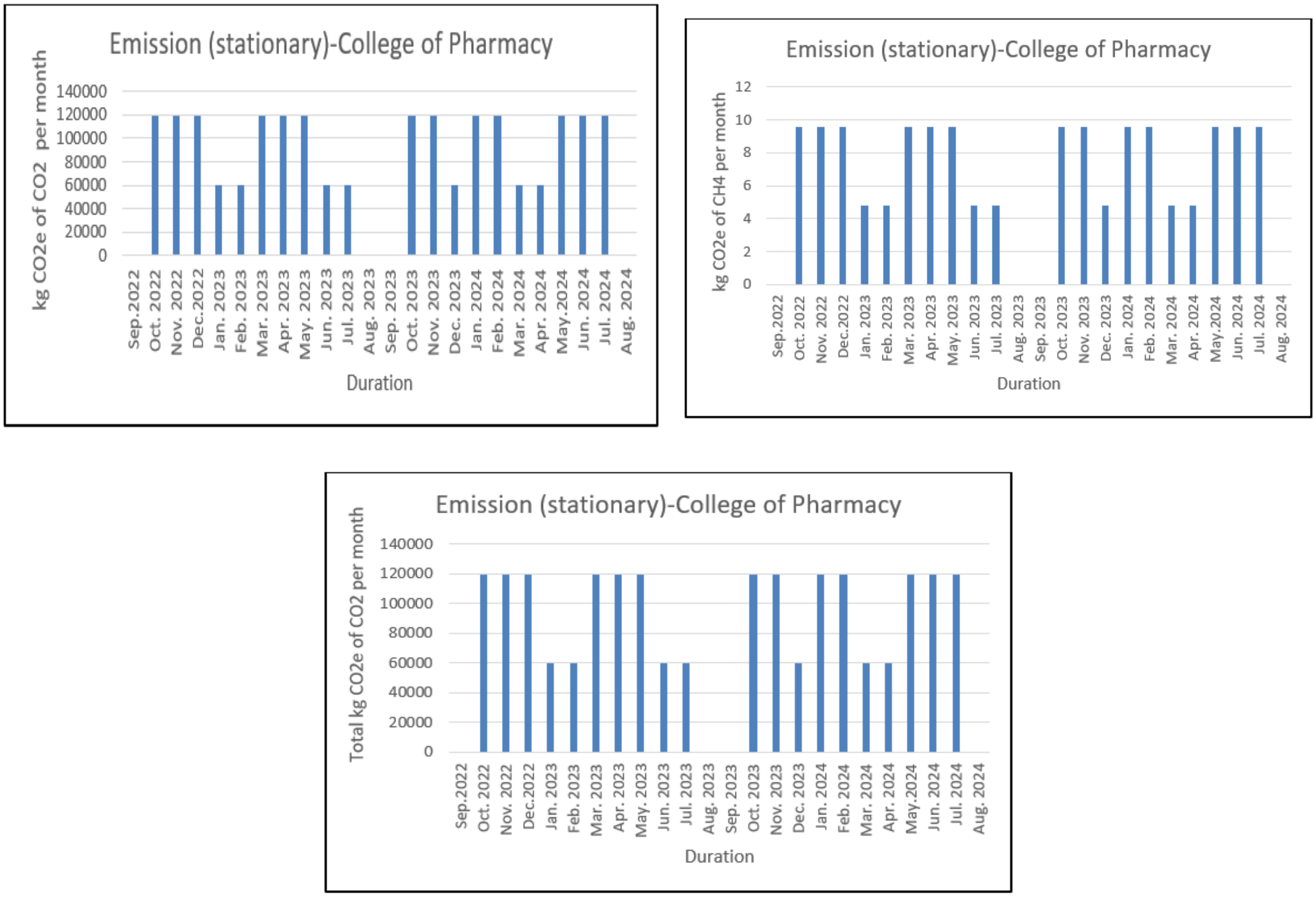


Fig. 26 Graphical representation of GHG Emission from Stationary for HQ & COP

**Scope1 Transportation Emission Analysis:**

**Passenger Car (M95):** This is a highly consistent emission source. The campus consistently uses 1300 liters of M95 fuel per month across the entire reporting period from September 2022 to August 2024. This results in a uniform total emission of 2,985.02061 kg CO2e per month for every month in the reported period.

**Medium Duty Vehicle (M95):** Similar to passenger cars, emissions from medium-duty vehicles are also highly consistent. The campus consistently uses 179 litres of M95 fuel per month from September 2022 to August 2024. This results in a uniform total emission of 410.6568596 kg CO2e per month for every month in the reported period.

**Fig. 27 Graphical representation of GHG Emission from transportation for HQ & COP**

**Scope 2 Electricity Consumption Emission Analysis:**
Electricity consumption is a significant source of GHG emissions and shows a clear seasonal trend. Emissions are generally lower during cooler months, such as 29,842.06 kg CO2e in January 2023 and 36,905.73 kg CO2e in February 2023. In the second year, January 2024 recorded 31,416.53 kg CO2e and February 2024 recorded 34,210.46 kg CO2e. Emissions increase substantially in hotter months, indicating high demand for cooling. Peak emissions include 72,550.35 kg CO2e in May 2023, 70,582.06 kg CO2e in June 2023, and 82,921.84 kg CO2e in July 2023. In the second year, peaks are seen in May 2024 (72,683.37 kg CO2e), June 2024 (70,618.86 kg CO2e), and July 2024 (92,834.02 kg CO2e). The highest electricity emissions for the entire period appear to be in July 2024 (92,834.02 kg CO2e).

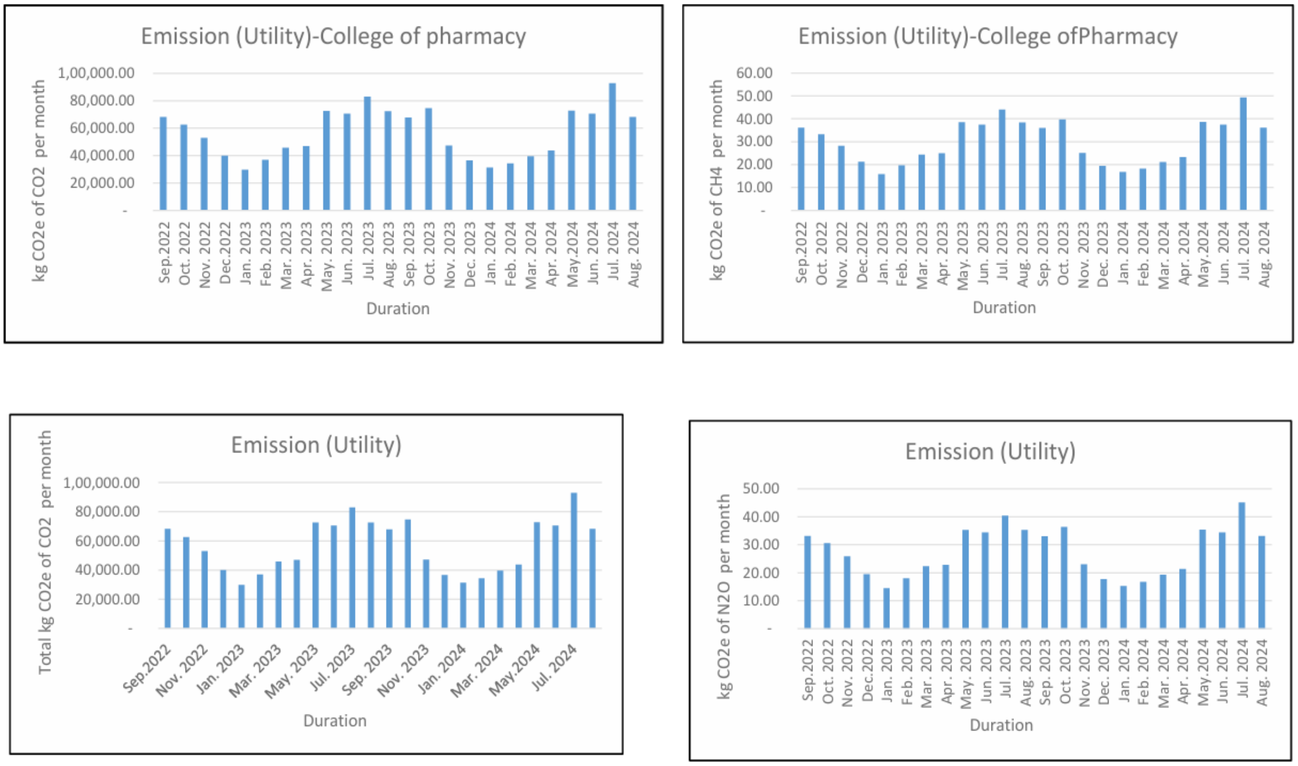


Fig. 28 Graphical representation of GHG Emission from Electricity for HQ & COP

**Trends and Justification**
**Stationary Sources (LPG Gas Cylinder):** The varying monthly LPG emissions (0 kg, 20 kg, or 40 kg equivalent) shows a demand-driven or scheduled usage pattern, it may likely tie to academic calendars or specific campus events. Zero emissions during certain months (e.g., September 2022, August 2023, September 2023, August 2024) align with typical university holiday periods when facilities like cafeterias or laboratories might have reduced operations. The consistent use of 20 kg or 40 kg during active months points to routine operations, possibly for cooking in a canteen or specific laboratory heating requirements.
**Transportation (M95 for Passenger Cars and Medium Duty Vehicles):** The remarkable

consistency in monthly fuel consumption and, consequently, emissions for both passenger cars and medium-duty vehicles indicates a stable and predictable operational fleet and commuting pattern. This is unlike some other campus data that might show seasonal drops. This pattern could be due to a fixed number of university vehicles used for essential services, staff transport, or administrative tasks that continue consistently throughout the year, even during student breaks, or it could reflect a consistent base level of staff commuting.

**Electricity Consumption:** The strong seasonal trend in electricity emissions, with clear peaks in the hot summer months (May-August) and troughs in the cooler winter months (December-February), is directly attributable to the dominant need for air conditioning in Oman's climate. The higher emissions during these periods reflect the increased energy required to cool campus buildings for comfort and functionality.

**Comparison of various colleges for Scope 1 and Scope 2 emission**

The detail comparison of greenhouse gas (GHG) emissions from various colleges of the National University of Oman and assessment is based on the GHG protocol initiative and covers a temporal boundary from September 1, 2022, to August 31, 2024, encompassing two academic years. The organizational boundaries include the College of Engineering-Al Hail (COE), SOFS Airport Heights (SOF Airport), IMCO Sohar, University HQ and the College of Pharmacy (COP), COM Sohar and COM Rustaq.

Emissions are categorized into Scope 1 (direct emissions) and Scope 2 (indirect emissions). Scope 1 includes direct emissions from sources owned or managed by the University, such as fossil fuel combustion (stationary, transport), agricultural sources (fertilizers), and fugitive emissions from refrigerants and chemicals. Scope 2 covers indirect emissions from purchased energy like electricity, steam, and chilled water.

## V) Analysis of Campus- Year wise and Average Emission Trends

The analysis of campus-wise emission trends for academic years 22-23, 23-24, and the average trend for different sources of Scope 1 (stationary, Transportation, Fertilizer, Chemical & Refrigerant) and Scope 2 (Electricity emission), is analyzed and explained. The analysis focuses on the "percentage emission per occupancy" as provided in the sources for each college and year. The occupancy was considered as per below data.

| | 2022 - 23 | | | 2023 - 24 | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | **Faculty & Staffs** | **Students** | **Total** | **Faculty & Staffs** | **Students** | **Total** | **Total two years** |
| COE | 185 | 1906 | 2091 | 179 | 1566 | 1745 | 3836 |
| SOF | 61 | 691 | 752 | 65 | 585 | 650 | 1402 |
| IMCO | 114 | 1309 | 1423 | 114 | 1257 | 1371 | 2794 |
| COPH | 72 | 261 | 333 | 70 | 252 | 322 | 655 |
| CMO SOHAR | 205 | 963 | 1168 | 220 | 1094 | 1314 | 2482 |
| TOTAL | 637 | 5130 | 5767 | 648 | 4754 | 5402 | 11169 |

## 5.1 COLLEGE OF ENGINEERING & AI HAIL (COE)

### Analysis of Campus-Wise Emission Trends (Percentage Emission Per Occupancy)

For academic year 22-23, COE's highest per capita percentage emission was from electricity at 96.16%, indicating that Electricity consumption dominates its individual carbon footprint. This was followed by Gasoline at 2.73% and Diesel at 1.09%. Stationary, Fertilizer, and Chemical emissions were very low, with Stationery and Fertilizer both at 0.01% and Chemical emissions at 0.00%.

In academic year 23-24, the trend for COE remained consistent, with electricity again being the highest contributor at 96.94%. Gasoline emissions decreased to 2.21%, and Diesel to 0.83%. Stationery and Fertilizer remained at 0.01%, while Chemical emissions were 0.00%.

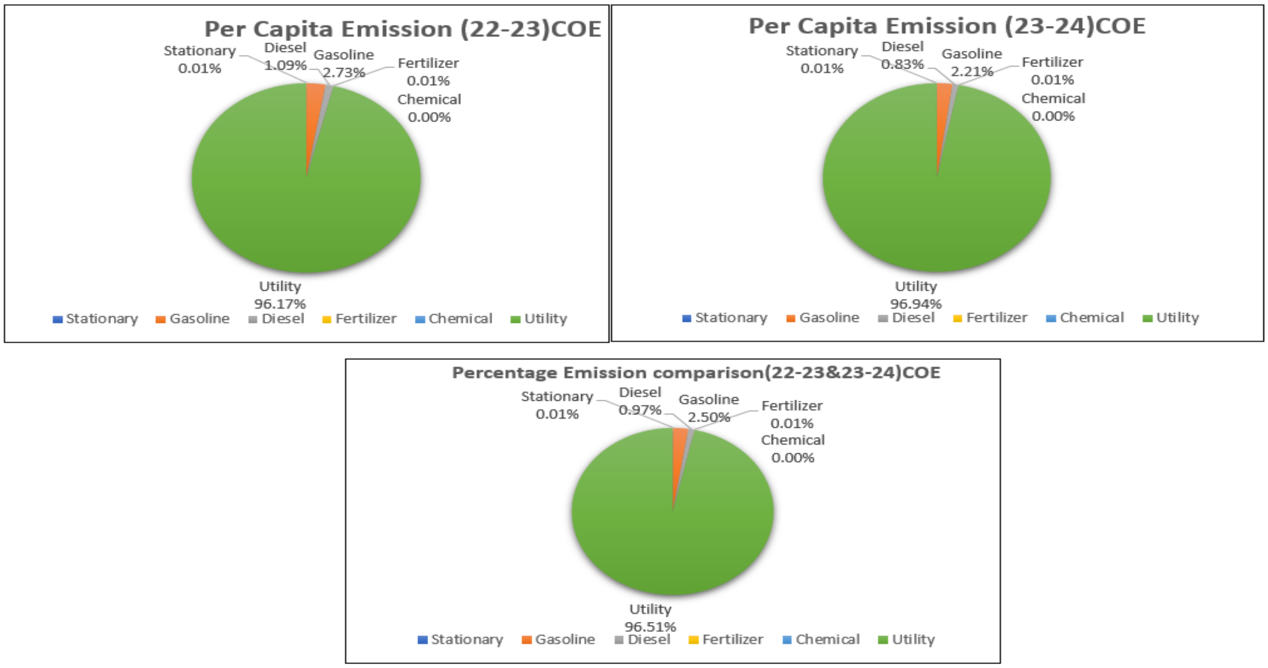


**Fig. 29 Year wise per Capita Emission for COE**

The average trend for COE confirms this pattern. Electricity emissions represent 96.51% of the total per capita emissions. Gasoline averaged 2.50% and Diesel 0.97%. Stationery and Fertilizer remained at 0.01%, with Chemical emissions consistently at 0.00%. across both years and on average, Electricity consumption is the dominant source of per capita emissions for COE.

### Analysis of Campus-Wise Emission Trends (Emission Per Occupancy)

For academic year 22-23, COE's highest emission per occupancy was from Electricity at 544.07 units. Gasoline was the second highest at 15.47 units, followed by Diesel at 6.16 units. Stationery and Fertilizer contributed very little, with 0.03 units and 0.05 units respectively, while Chemical emissions were 0.00 units.

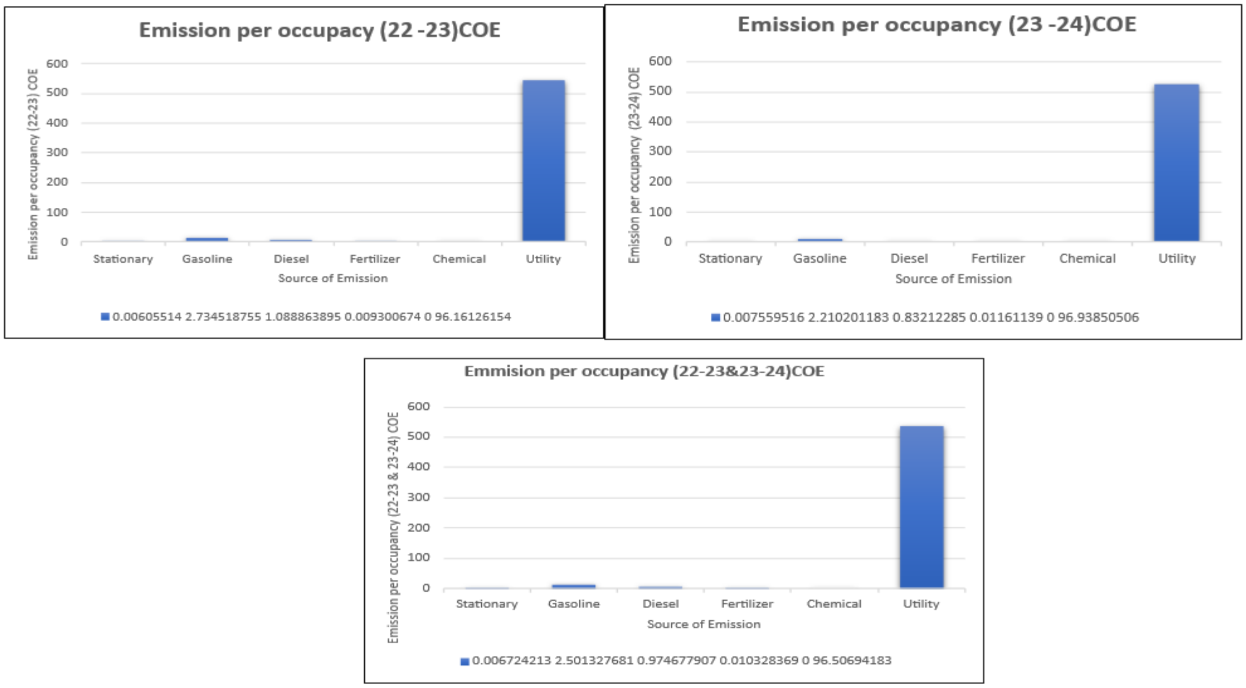


**Fig. 30 Year wise Emission per occupancy for COE**

In academic year 23-24, Electricity continued to be the highest source of emission per occupancy for COE, at 526.43 units. This represented a slight decrease from the previous year. Gasoline emissions decreased to 12.00 units, and Diesel to 4.52 units. Stationery and Fertilizer showed minor increases to 0.04 units and 0.06 units respectively, with Chemical emissions remaining at 0.00 units.

The average trend for COE reveals that Electricity is overwhelmingly the largest contributor to emission per occupancy, averaging 536.05 units. Gasoline averaged 13.89 units, and Diesel 5.41 units. Stationery and Fertilizer averaged 0.04 units and 0.06 units, respectively, with Chemical emissions consistently at 0.00 units. The overall trend shows Electricity dominating, with slight fluctuations in transportation-related emissions.

## 5.2 SOF AIRPORT HEIGHT (SOFS)

### Analysis of Campus-Wise Emission Trends (Percentage Emission Per Occupancy)

In academic year 22-23, SOFS Airport Heights also showed Electricity as the primary source of per capita percentage emissions, accounting for 98.09%. M95 (transportation) was a distant second at 1.66%, followed by Stationary at 0.19%. Organic and Synthetic fertilizers had very low contributions at 0.01% and 0.05% respectively, with Chemical emissions at 0.00%.

For academic year 23-24, Electricity emissions slightly increased to 98.80%, reinforcing its dominance in SOF's per capita footprint. M95 emissions decreased to 0.97%. Stationary was at 0.17%, Organic at 0.01%, and Synthetic at 0.04%. Chemical emissions remained at 0.00%.

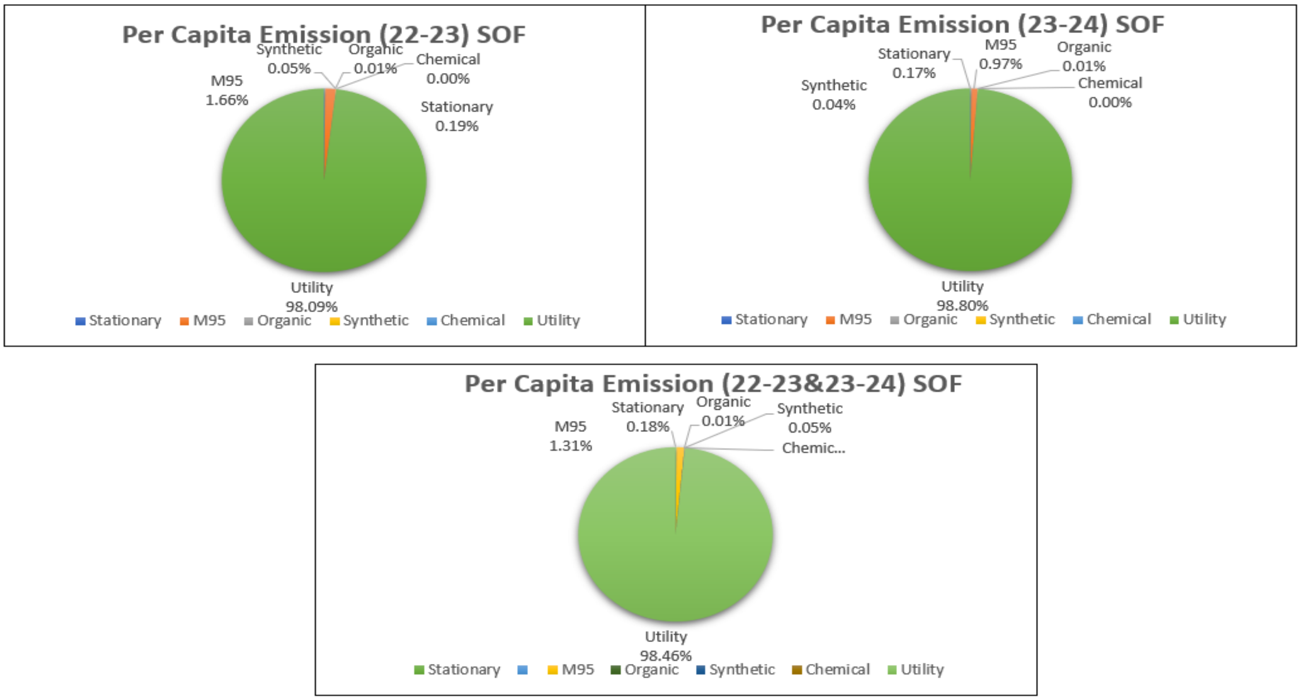


**Fig. 31 Year wise per capita emission for SOF**

The average trend for SOF shows Electricity at 98.46% of per capita emissions. M95 averaged 1.31% and Stationary 0.18%. Organic fertilizer was 0.01% and Synthetic 0.05%, with Chemical emissions consistently at 0.00%. SOF exhibits an even stronger reliance on Electricity consumption as its main per capita emission source compared to COE.

**Analysis of Campus-Wise Emission Trends (Emission Per Occupancy)**

In academic year 22-23, SOF Airport Heights' emission per occupancy was primarily driven by Electricity, reaching 1374.53 units. M95 (transportation) was the next most significant at 23.32 units, followed by Stationary at 2.62 units. Organic and Synthetic fertilizers contributed marginally at 0.10 units and 0.70 units respectively, and Chemical emissions were 0.00 units.
For academic year 23-24, Electricity emissions per occupancy increased significantly to 1732.04 units, maintaining its position as the largest source. M95 emissions decreased to **17.06** units. Stationary emissions rose to 3.03 units, Organic fertilizer to 0.14 units, and Synthetic fertilizer to 0.77 units. Chemical emissions remained at 0.00 units.

The average trend for SOF shows Electricity with a substantial emission per occupancy of 1540.28 units. M95 averaged 20.42 units, and Stationary 2.81 units. Organic and Synthetic fertilizers averaged 0.12 units and 0.74 units, respectively, with Chemical emissions consistently at 0.00 units. The data indicates a strong and increasing reliance on Electricity consumption as the main per capita emission source for SOFS.

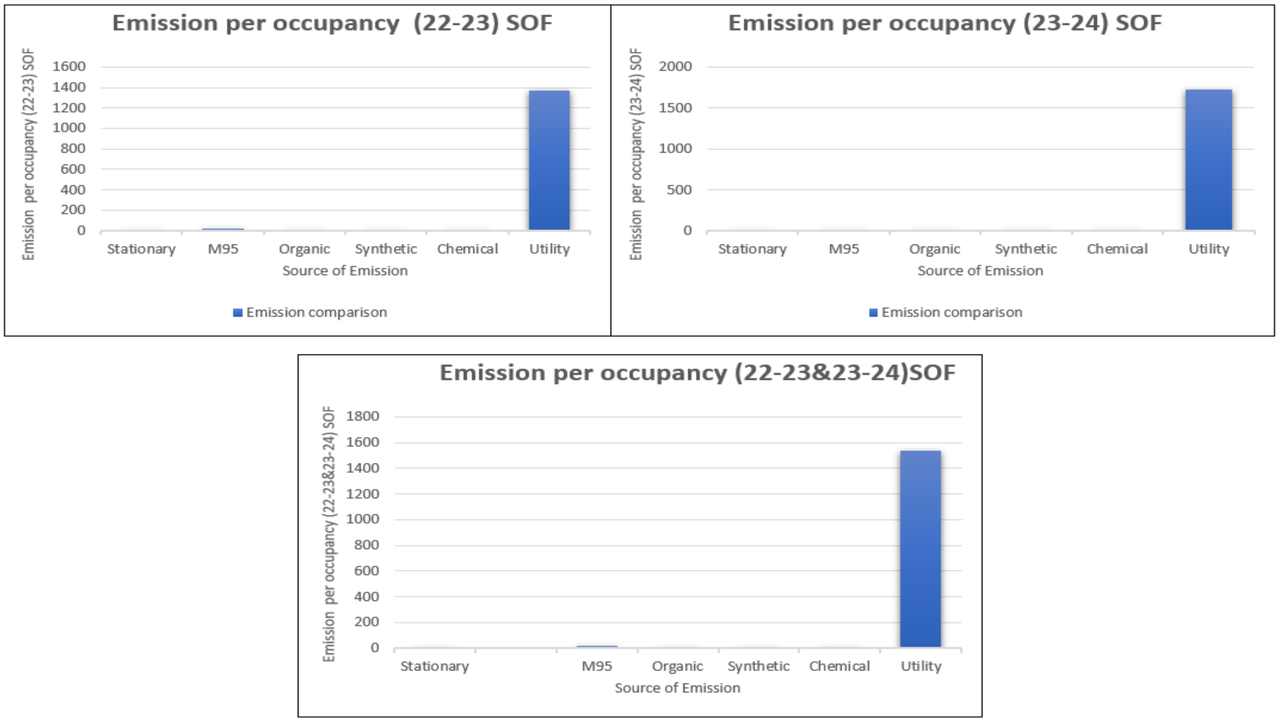


**Fig. 32 Year wise emission per occupancy for SOF**

## 5.3 IMCO SOHAR

## Analysis of Campus-Wise Emission Trends (Percentage Emission Per Occupancy)

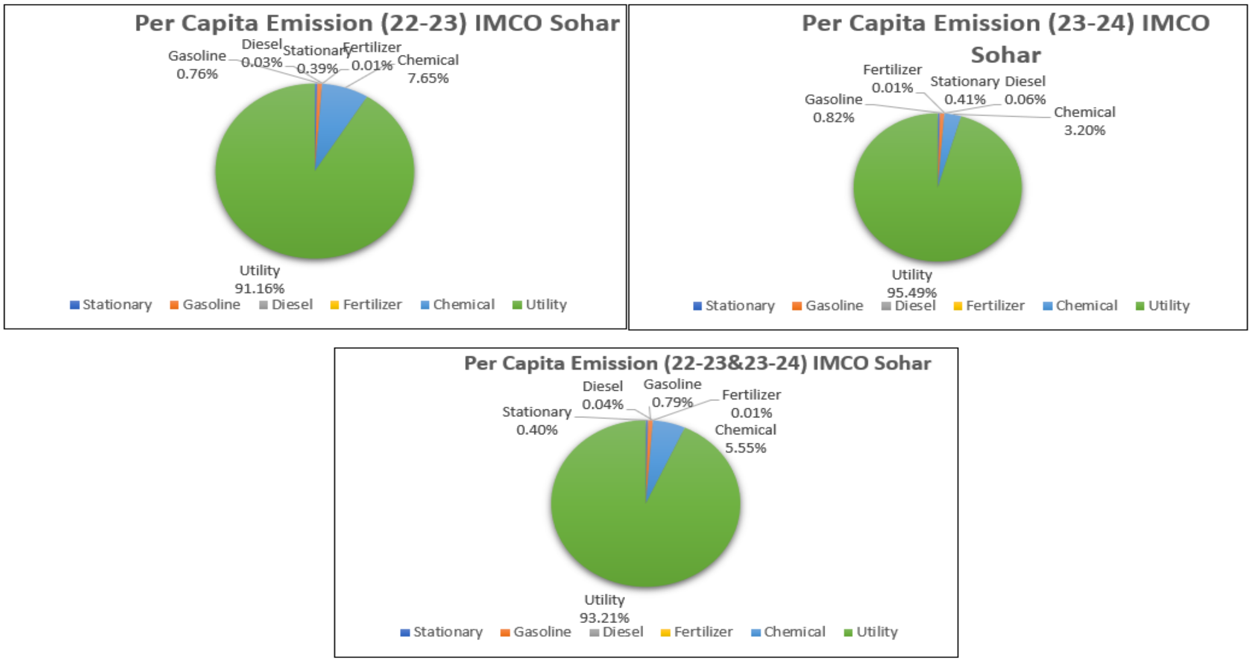


**Fig. 33 Year wise per capita Emission for IMCO Sohar**

In academic year 22-23, IMCO SOHAR's per capita emissions were predominantly from Electricity at 91.16%. Chemical emissions were the second highest at 7.65%. Gasoline (0.76%), Stationary (0.39%), Diesel (0.03%), and Fertilizer (0.01%) had much smaller contributions.

For academic year 23-24, IMCO SOHAR continued to show Electricity as the highest per capita emission source, increasing to 95.49%. Chemical emissions significantly decreased to 3.20%. Gasoline (0.82%) and Stationary (0.41%) saw slight increases, while Diesel was 0.06% and Fertilizer 0.01%. This indicates a shift towards even greater dominance of Electricity emissions, with chemical emissions becoming less significant on a per capita basis.

The average trend for IMCO SOHAR shows Electricity at 93.21% of per capita emissions. Chemical emissions averaged 5.55%, Gasoline 0.79%, and Stationary 0.40%. Diesel was 0.04% and Fertilizer 0.01%. The Electricity sector consistently represents the vast majority of IMCO SOHAR's per capita emissions.

## Analysis of Campus-Wise Emission Trends (Emission Per Occupancy)

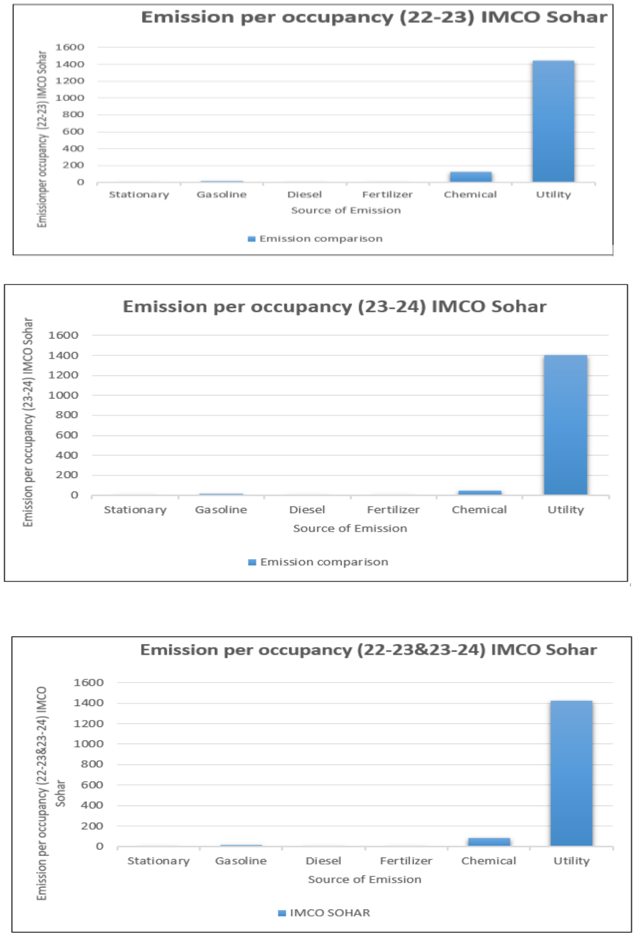


**Fig.34 Year wise emission per occupancy for IMCO Sohar**

In academic year 22-23, IMCO SOHAR's emission per occupancy was predominantly from Electricity at 1446.84 units. Chemical emissions were the second highest at 121.33 units. Gasoline (12.73 units), Stationary (6.23 units), Diesel (0.43units), and Fertilizer (0.15 units) had much smaller contributions.

For academic year 23-24, IMCO SOHAR continued to show Electricity as the highest emission per occupancy source, although it significantly decreased to 1407.52 units. Chemical emissions also drastically decreased to 47.23 units. Gasoline (12.13 units), Diesel (0.94 units), Stationary (6.00 units), and Fertilizer (0.16 units) all saw reductions in their per-occupancy emissions. This indicates a substantial reduction across most categories in 23-24 compared to 22-23.

The average trend for IMCO SOHAR shows Electricity at 1427.5 units. Chemical emissions averaged 84.97 units, Gasoline 12.1 units, and Stationary 6.11 units. Diesel was 0.68 units and Fertilizer 0.16 units. Despite the large drop in 23-24, the high 22-23 values mean Electricity and Chemical remain significant average contributors.

## 5.4 COM SOHAR

### Analysis of Campus-Wise Emission Trends (Percentage Emission Per Occupancy)

For academic year 22-23, COM SOHAR's per capita emissions were highest in Electricity at 78.07%. Chemical emissions contributed a significant 12.55%, followed by M95 transportation at 4.78% and Medium Duty transportation at 2.65%. Stationary emissions were 1.24%, while Fertilizer was very low at 0.07%.

In academic year 23-24, Electricity remained the largest source for COM SOHAR, increasing to 83.17%. Chemical emissions decreased to 9.70%, while M95 (3.74%) and Medium Duty (2.35%) transportation also saw slight decreases. Stationary emissions were 0.96%, and Fertilizer remained low at 0.07%.

The average trend for COM SOHAR shows Electricity as the dominant category at 81.47%. Chemical emissions averaged 10.97%, M95 4.02%, and Medium Duty 2.38%. Stationary was 1.09%, and Fertilizer remained at 0.07%. While Electricity consumption is still the highest, Chemical emissions represent a notably higher per capita share in COM SOHAR compared to COE and SOF.

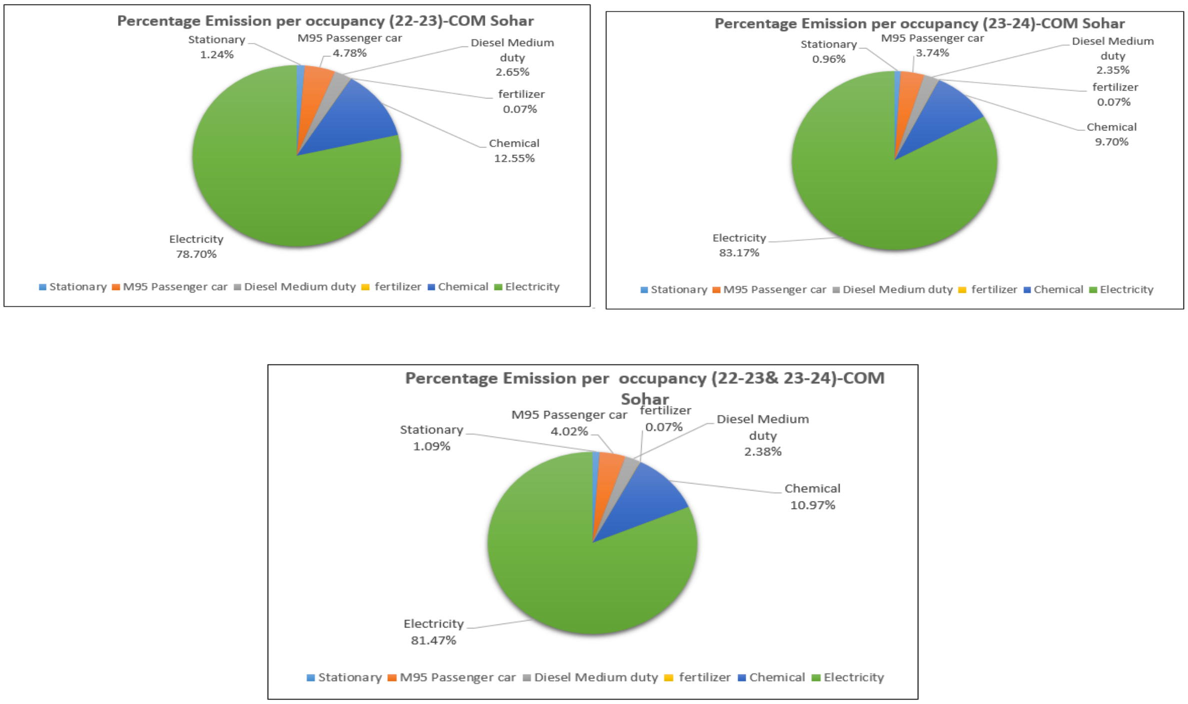


Fig. 35 Year wise per capita emission for COM Sohar

## Analysis of Campus-Wise Emission Trends (Emission Per Occupancy)

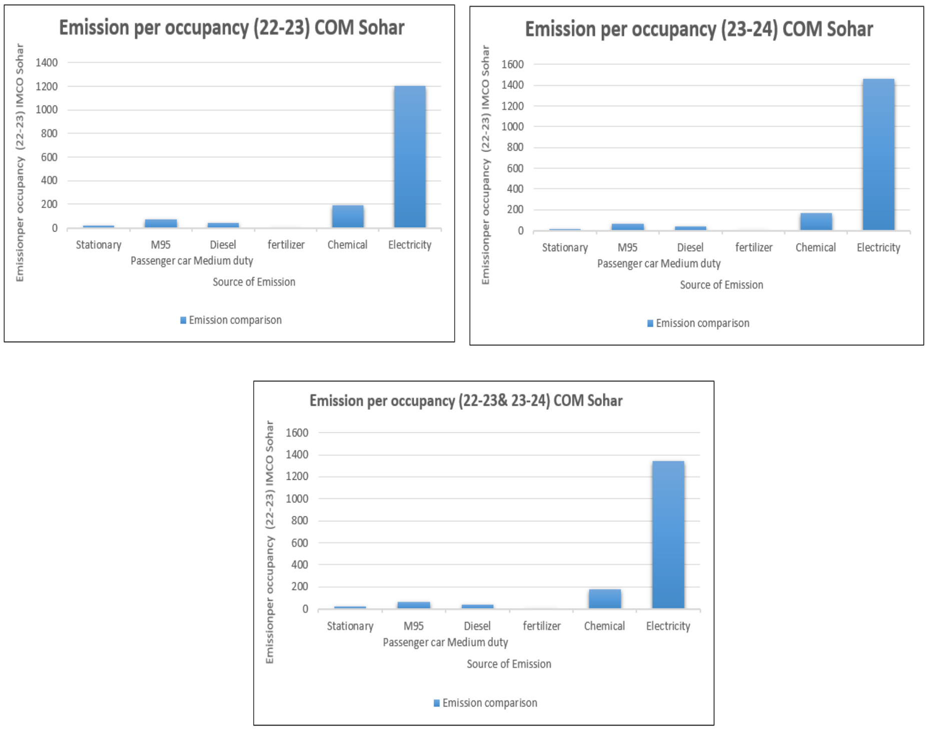


Fig. 36 Year wise emission per occupancy for COM Sohar

For academic year 22-23, COM SOHAR's emission per occupancy was highest in Electricity at 1207.07 units. Chemical emissions contributed significantly with 192.41 units, followed by M95 transportation at 73.30 units and Medium Duty transportation at 40.67 units. Stationary emissions were 19.08 units, and Fertilizer was 1.15 units.

In academic year 23-24, Electricity remained the largest source for COM SOHAR, increasing to 1463.94 units. Chemical emissions decreased to 170.80 units. M95 (65.87 units) and Medium Duty (41.44 units) transportation also saw slight changes, with M95 decreasing and Medium Duty increasing slightly. Stationary emissions decreased to 16.96 units, while Fertilizer slightly increased to 1.20 units.

The average trend for COM SOHAR shows Electricity as the dominant category at 1343.06 units. Chemical emissions averaged 180.85 units, M95 66.24 units, and Medium Duty 39.31 units. Stationary was 17.96 units, and Fertilizer averaged 1.18 units. Electricity is the primary source, with Chemical emissions also forming a substantial portion of the per capita footprint.

## 5.5 COLLEGE OF PHARMACY & HQ (COPH)

### Analysis of Campus-Wise Emission Trends (Percentage Emission Per Occupancy)

For academic year 22-23, COPH's per capita emissions were overwhelmingly from Electricity at 94.23%. M95 (transportation) was the second highest at 4.95%, followed by M95 Med Duty (transportation) at 0.68%. Stationary emissions were 0.13%. Other categories were not explicitly provided in the year-wise data for COPH.

In academic year 23-24, the pattern for COPH was very similar, with Electricity at 94.21%. M95 was 4.97%, and M95 Med Duty was 0.68%. Stationary emissions were 0.14%.

The average trend for COPH shows Electricity at 94.22% of per capita emissions. M95 averaged 4.96%, M95 Med Duty 0.68%, and Stationary 0.14%. COPH demonstrates a highly concentrated per capita emission profile, primarily from Electricity consumption.

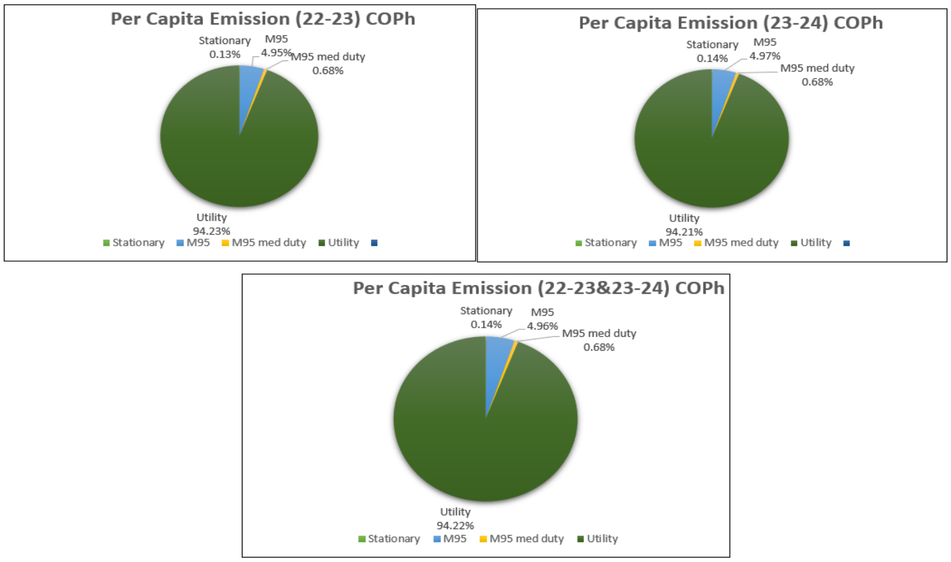


**Fig. 37 Year wise per capita Emission for COPh**

## Analysis of Campus-Wise Emission Trends (Emission Per Occupancy)

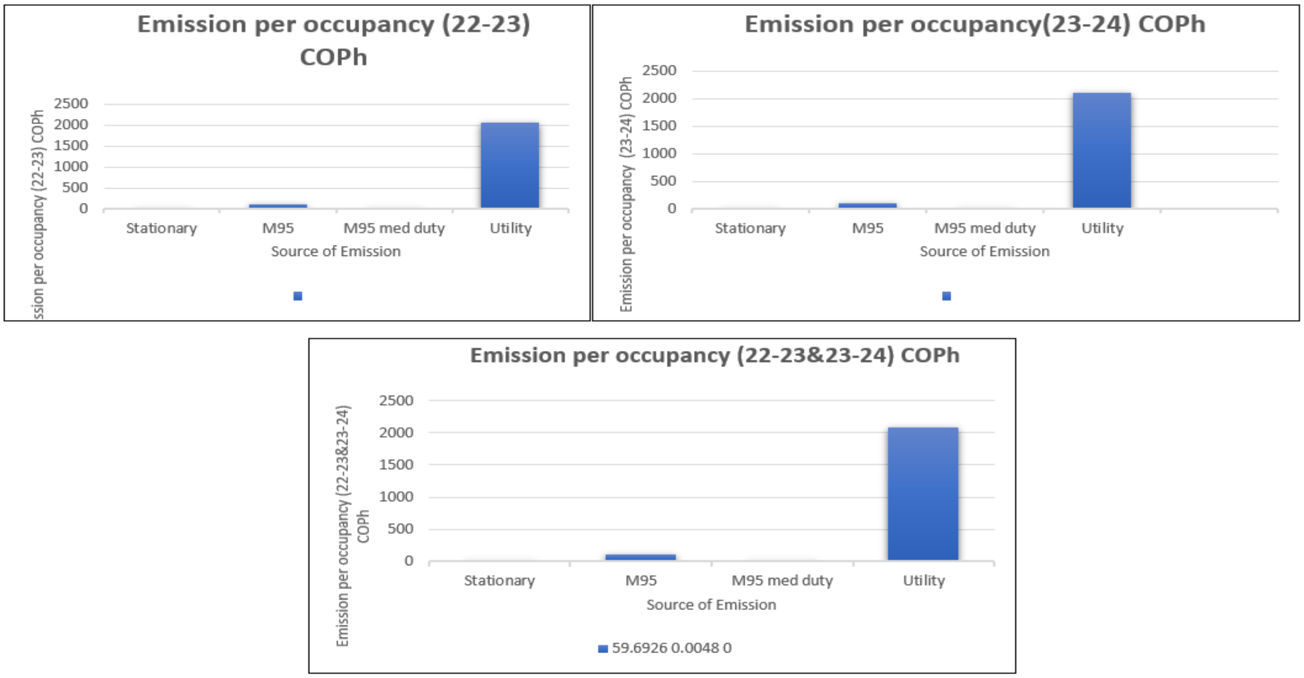


Fig. 38 Year wise Emission per occupancy for COPh

For academic year 22-23, COPH's emission per occupancy was overwhelmingly from Electricity at 2047.01 units. M95 (transportation) was the second highest at 107.57 units, followed by M95 Med Duty (transportation) at 14.80 units. Stationary emissions were 2.87 units.

In academic year 23-24, the pattern for COPH was very similar, with Electricity slightly increasing to 2109.66 units. M95 emissions also increased to 111.24 units, and M95 Med Duty to 15.30 units. Stationary emissions rose to 3.15 units. All listed categories showed a slight increase in per-occupancy emissions in 23-24.

The average trend for COPH shows Electricity at 2077.81 units. M95 averaged 109.37 units, M95 Med Duty 15.05 units, and Stationary 3.01 units. Electricity consistently represents the vast majority of COPH's per capita emissions, with transportation being the next notable source.

## Summary Table: Highest and Lowest Emission Per Occupancy

This table presents the "Emission per occupancy" values for each source category across academic years 22-23, 23-24, and their average. It also highlights the highest and lowest values observed within these three periods for each specific source category.

## Summary Table: Highest and Lowest % Emission Per Occupancy

| Campus | Source Category | 22-23(% Emission/ Occupancy) | 23-24 (% Emission/ Occupancy) | Average(% Emission /Occupancy) | Highest Value | Lowest Value |
|---|---|---|---|---|---|---|
| **COE** | Stationary | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% |
| | Gasoline | 2.73% | 2.21% | 2.50% | **2.73%** | 2.21% |
| | Diesel | 1.09% | 0.83% | 0.97% | 1.09% | 0.83% |
| | Fertilizer | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% |
| | Chemical | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | Electricity | 96.16% | 96.94% | 96.51% | **96.94%** | 96.16% |
| **SOFS** | Stationary | 0.19% | 0.17% | 0.18% | 0.19% | 0.17% |
| | M95 | 1.66% | 0.97% | 1.31% | **1.66%** | 0.97% |
| | Organic | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% |
| | Synthetic | 0.05% | 0.04% | 0.05% | 0.05% | 0.04% |
| | Chemical | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | Electricity | 98.09% | 98.80% | 98.46% | **98.80%** | 98.09% |
| **IMCO SOHAR** | Stationary | 0.39% | 0.41% | 0.40% | 0.41% | 0.39% |
| | Gasoline | 0.76% | 0.82% | 0.79% | 0.82% | 0.76% |
| | Diesel | 0.03% | 0.06% | 0.04% | 0.06% | 0.03% |
| | Fertilizer | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% |
| | Chemical | 7.65% | 3.20% | 5.55% | **7.65%** | 3.20% |
| | Electricity | 91.16% | 95.49% | 93.21% | **95.49%** | 91.16% |
| **COM SOHAR** | Stationary | 1.24% | 0.96% | 1.09% | 1.24% | 0.96% |
| | M95 | 4.78% | 3.74% | 4.02% | 4.78% | 3.74% |
| | Med. Duty | 2.69% | 2.35% | 2.38% | 2.69% | 2.35% |
| | Fertilizer | 0.07% | 0.07% | 0.07% | 0.07% | 0.07% |
| | Chemical | 12.55% | 9.70% | 10.97% | **12.55%** | 9.70% |
| | Electricity | 78.70% | 83.17% | 81.47% | 78.70% | **83.17%** |
| **COP & HQ** | Stationary | 0.13% | 0.14% | 0.14% | 0.14% | 0.13% |
| | M95 | 4.95% | 4.97% | 4.96% | **4.97%** | 4.95% |
| | M95 Med Duty | 0.68% | 0.68% | 0.68% | 0.68% | 0.68% |
| | Electricity | 94.23% | 94.21% | 94.22% | **94.23%** | 94.21% |

| Campus | Source Category | 22-23 (Emission/ Occupancy) | 23-24 (Emission/ Occupancy) | Average (Emission/ Occupancy) | Highest Value | Lowest Value |
|---|---|---|---|---|---|---|
| **COE** | Stationary | 0.03 | 0.04 | 0.04 | 0.04 | 0.03 |
| | Gasoline | 15.47 | 12 | 13.89 | **15.47** | 12 |
| | Diesel | 6.16 | 4.52 | 5.41 | 6.16 | 4.52 |
| | Fertilizer | 0.05 | 0.06 | 0.06 | 0.06 | 0.05 |
| | Chemical | 0 | 0 | 0 | 0 | 0 |
| | Electricity | 544.07 | 526.43 | 536.05 | **544.07** | 526.43 |
| **SOF** | Stationary | 2.62 | 3.03 | 2.81 | 3.03 | 2.62 |
| | M95 | 23.32 | 17.06 | 20.42 | **23.32** | 17.06 |
| | Organic | 0.1 | 0.14 | 0.12 | 0.14 | 0.1 |
| | Synthetic | 0.7 | 0.77 | 0.74 | 0.77 | 0.7 |
| | Chemical | 0 | 0 | 0 | 0 | 0 |
| | Electricity | 1374.53 | 1732.04 | 1540.28 | **1732.04** | 1374.53 |
| **IMCO SOHAR** | Stationary | 6.23 | 5.99 | 6.11 | 6.23 | 5.99 |
| | Gasoline | 12.03 | 12.13 | 12.1 | 12.13 | 12.03 |
| | Diesel | 0.43 | 0.94 | 0.68 | 0.94 | 0.43 |
| | Fertilizer | 0.15 | 0.16 | 0.15 | 0.16 | 0.15 |
| | Chemical | 121.3 | 47.22 | 84.9 | 121.3 | 47.22 |
| | Electricity | 1446.84 | 1407.5 | 1427.5 | 1446.84 | 1407.5 |
| **COM SOHAR** | Stationary | 19.08 | 16.96 | 17.96 | 19.08 | 16.96 |
| | M95 | 73.3 | 65.8 | 66.24 | 73.3 | 65.8 |
| | Med. Duty | 40.67 | 41.4 | 39.3 | 41.4 | 40.67 |
| | Fertilizer | 1..15 | 1.2 | 1.18 | 1.2 | 1..15 |
| | Chemical | 192.41 | 170.80 | 180.85 | 192.41 | 170.80 |
| | Electricity | 1207.07 | 1463.9 | 1343.06 | 1463.9 | 1207.07 |
| **COP & HQ** | Stationary | 2.87 | 3.15 | 3.01 | 3.15 | 2.87 |
| | M95 | 107.57 | 111.24 | 109.37 | **111.24** | 107.57 |
| | M95 Med Duty | 14.8 | 15.3 | 15.05 | 15.3 | 14.8 |
| | Electricity | 2047.01 | 2109.66 | 2077.81 | **2109.66** | 2047.01 |

The above summary table represents Highest and Lowest % Emission Per Occupancy and Emission Per Occupancy which leads to several key conclusions.

Electricity consumption consistently represents the highest percentage of per capita GHG emissions across all colleges and academic years, typically ranging from 78% to 98%. Most campuses observed an increase in their per capita Electricity emissions from 22-23 to 23-24, indicating a growing impact from energy and resource consumption. Conversely, many Scope 1 categories, particularly transportation and chemical emissions, generally saw a decrease in their per capita percentage contribution in 23-24 compared to 22-23. COM SOHAR notably had a higher per capita chemical emission percentage compared to others, although it also experienced a decrease in this category. Minor contributions from stationery and fertilizer sources remained largely consistent and negligible across all institutions.

The following summary outlines the greenhouse gas (GHG) emission trends and their justifications for the National University (NU) of Oman across the 2022-23 and 2023-24 academic years.

### 1. Scope 2: Electricity – The Dominant Trend

**Trend:** Electricity consumption consistently represents the highest percentage of per capita emissions across all campuses, ranging from 78.70% to 98.80%. For most campuses, there was a visible increase in per capita Electricity emissions in the 23-24 academic year compared to 22-23.

**Justification:** This trend highlights that energy for cooling (HVAC), lighting, and laboratory operations is the primary driver of the university's carbon footprint. The year-on-year increase in per capita impact suggests that the energy required to maintain campus infrastructure is growing faster than the occupant population, or that energy use intensity increased during the second year.

### 2. IMCO Sohar – The Dilution Effect

**Trend:** Despite its extensive maritime facilities, IMCO Sohar saw its per capita Electricity emissions decrease from 1446.84 units in 22-23 to 1407.5 units in 23-24.

**Justification:** This favorable trend is justified by the **increased student occupancy** (1,423 in 22-23 and 1,371 in 23-24). A larger population base "dilutes" the total energy consumption of the maritime simulators and large workshops, making the individual carbon weight significantly lower than in previous years.

### 3. COM Sohar (Merged) – High Intensity Hub

**Trend:** The merged COM Sohar campus (combining Sohar and Rustaq) shows a high per capita chemical emission percentage of 12.55% in 22-23. Furthermore, its per capita Electricity impact rose significantly from 1207.07 units to 1463.9 units.

**Justification:** The merger concentrates the university's most energy-intensive medical and laboratory infrastructure into a single reporting entity. The rising per capita trend indicates that the baseline operational energy for medical facilities remained high even as the student/staff count (1,314 total in 23-24) showed only moderate growth.

### 4. COPH & HQ – The Highest Individual Impact

**Trend:** COPH maintains the highest absolute per capita emissions of all campuses, specifically for Electricity (2109.66 units) and Transportation (111.24 units) in the 23-24 year.

**Justification:** This is justified by the campus's small occupant base (322 total in 23-24). When the substantial emissions required to operate a high-tech pharmacy building and the administrative HQ are divided among a small number of people, the per-person carbon footprint becomes heavily "inflated" compared to a large-scale campus like COE.

**5. Scope 1 (Transportation & Chemicals) – General Reduction**

**Trend:** Many Scope 1 categories, particularly transportation and chemical emissions, generally saw a decrease in their per capita percentage contribution in 23-24 compared to 22-23.

Justification: This downward trend indicates improved fleet management or a reduction in high-impact events, such as the major recharging of high-GWP refrigerants (e.g., HCFC22), which create sporadic spikes in the carbon footprint.

# VI Analysis of scope 1 scope 2 Emission based on source (all campus together)

### Emission per Occupancy, Differences and Trends Between Total Emission and Per Capita Emission/ GHG Potential for all campuses

The detail analyses of the greenhouse gas (GHG) emissions from various colleges across different emission scopes has been conducted.
Scope 1 (Stationary, Transportation, Fertiliser, Chemical & Refrigerant) and Scope 2 (Electricity Consumption). The analysis below focuses on the percentage of total emissions and the percentage of emissions per occupancy (per capita) for each category, identifying the highest, lowest, and moderate shares, and highlighting any differences in trends.

## 6.1 SCOPE 1 STATIONARY SOURCE

### 6.1.1 Analysis of Percentage of Total Emission for GHG Potential

This percentage share of each institution in the overall emissions for stationary categories, indicating their contribution to the total GHG potential.
**Highest: COM SOHAR** accounts for the largest share with 60% of the total stationary emissions.
**Moderate: IMCO SOHAR** contributes a moderate 20.43%, while SOF is at 9.39% and **COP & HQ at 10.04%.**
**Lowest: COE AI HAIL** has a negligible share of 0.12% (approximately 0.01%).

### 6.1.2 Analysis of Emission per Occupancy (Per Capita) for GHG Potential

This section analyses the GHG potential per individual or occupant, using both "Emission per occupancy" and "% Emission/occupancy" based on following occupancy in campuses. The number of occupants considered in study is as under.

| | 2022 - 23 | | | 2023 - 24 | | | |
|---|---|---|---|---|---|---|---|
| | Faculty & Staffs | Students | Total | Faculty & Staffs | Students | Total | Total two years |
| COE | 185 | 1906 | 2091 | 179 | 1566 | 1745 | 3836 |
| SOF | 61 | 691 | 752 | 65 | 585 | 650 | 1402 |
| IMCO NEW | 114 | 1309 | 1423 | 114 | 1257 | 1371 | 2794 |
| COPH | 72 | 261 | 333 | 70 | 252 | 322 | 655 |
| CMO SOHAR | 205 | 963 | 1168 | 220 | 1094 | 1314 | 2482 |
| TOTAL | 637 | 5130 | 5767 | 648 | 4754 | 5402 | 11169 |

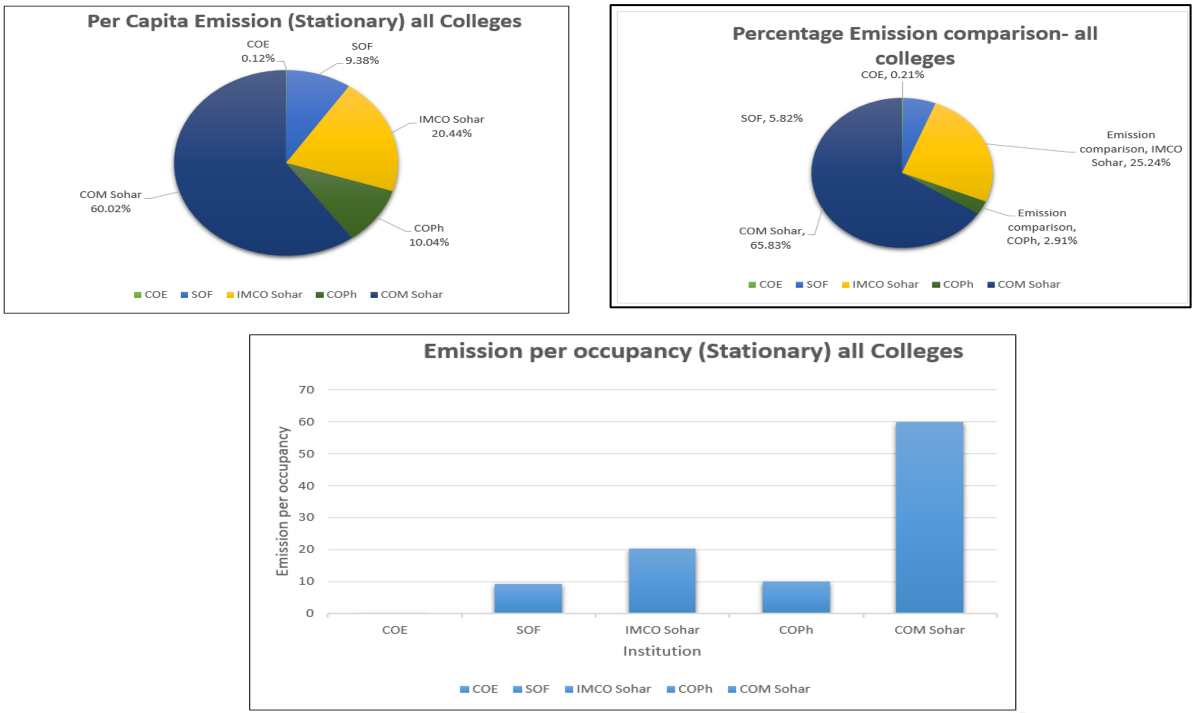


Fig. 39 Percentage emission comparison

**Highest: COM SOHAR** exhibits the highest emission per occupancy (17.96) and percentage emission per occupancy at 60%.

**Moderate: IMCO Sohar** follows with 6.11emission per occupancy and 20.43% per occupancy. COP (10.04%) and SOFS (9.38%) also show moderate per capita impacts.

**Lowest: COE** has the lowest emission per occupancy (0.037) and percentage emission per occupancy at 0.12

**Differences and Trends Between Total Emission and Per Capita Emission**

For stationary emission the institutions with the highest and lowest total emissions tend to follow similar trends in per capita emissions. The trends are **consistent. COM SOHAR** is the highest contributor in both total and per capita emissions, while **COE** is consistently the lowest. **IMCO SOHAR** also maintains a moderate position in both metrics.

## 6.2 SCOPE 1 TRANSPORTATION SOURCE

### 6.2.1Analysis of Percentage of Total Emission for GHG Potential

This percentage share of each institution in the overall emissions for transportation categories, indicating their contribution to the total GHG potential.

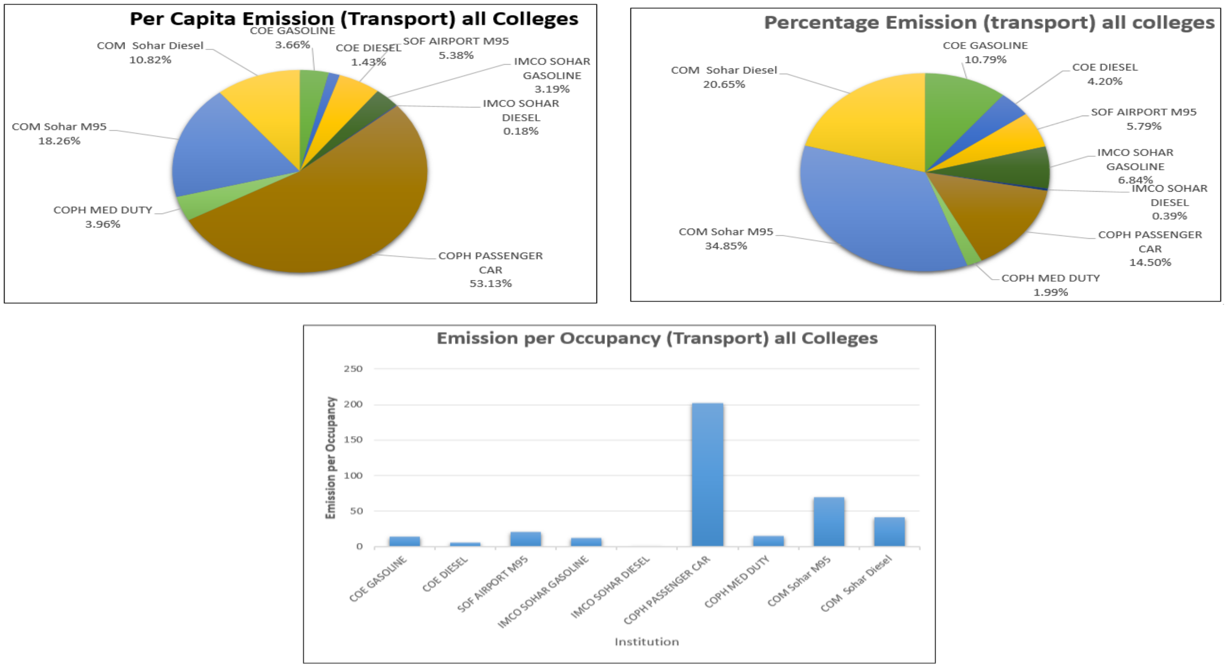


**Fig. 40 Emission per occupancy (all Colleges)**

**Highest: COM SOHAR** M95 is the largest contributor to total transportation emissions, representing 34.85%.
**Moderate: COP &** HQ PASSENGER CAR (14.5%), COM SOHAR MED.DUTY (20.65%) and **COE** GASOLINE (10.79% ) show moderate contributions.
**Lowest: IMCO SOHAR DIESEL** has the smallest share at 0.39%. Other low contributors include **COE** DIESEL (4.20%) and COP&HQ MED DUTY (1.99%).

### 6.2.2 Analysis of Emission per Occupancy (Per Capita) for GHG Potential

This section analyses the GHG potential per individual or occupant, using both "Emission per occupancy" and "% Emission/occupancy" based on following occupancy in campuses.

**Highest: COPH** exhibits the highest emission per occupancy (201.8) and percentage emission per occupancy at 53.13%.

Moderate: COM Sohar M95 & diesel 69.37 & 41.1 and percentage emission 18.26 & 1082 respectively. COE Diesel has the lowest emission per occupancy (5.41) and percentage emission per occupancy at 1.43 %. per occupancy. SOF (3.38%) also shows moderate per capita impacts.

**Lowest: IMCO Sohar** follows with 0.68 emission per occupancy and 0.18%.

**Differences and Trends Between Total Emission and Per Capita Emission**
For transportation emission with the highest and lowest total emissions tend to follow different trends in per capita emissions.

There is a significant difference in the highest contributor. While **COM SOHAR** M95 accounts for the **largest share** of total transportation emissions (34.85%), **COP&HQ PASSENGER CAR demonstrates a much higher per capita** impact (53.31%). This suggests that although COM SOHAR M95 contributes more to the overall transportation emissions, the emissions generated per person or per vehicle use at COPH for passenger cars are substantially higher, possibly due to fewer occupants or intensive vehicle usage. IMCO SOHAR DIESEL remains the lowest for both total and per capita.

## 6.3 SCOPE 1 FERTILISER SOURCE

### 6.3.1 Analysis of Percentage of Total Emission for GHG Potential

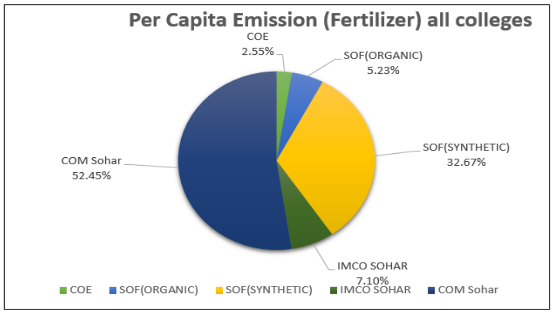
This percentage share of each institution in the overall emissions for fertiliser categories, indicating their contribution to the total GHG potential.
**Highest: COM SOHAR** dominates fertiliser emissions with 61.14% of the total.
**Moderate: SOFS (SYNTHETIC)** contributes 21.5%. **IMCO SOHAR** has a share of 9.31%.
**Lowest: SOFS (ORGANIC)** (3.44%) and **COE** (4.59%) have the lowest shares.

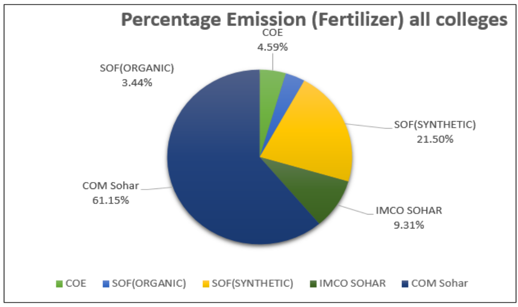
### 6.3.2 Analysis of Emission per Occupancy (Per Capita) for GHG Potential

This section analyses the GHG potential per individual or occupant, using both "Emission per occupancy" and "% Emission/occupancy" based on following occupancy in campuses.
**Highest: COM SOHAR** reports the highest emission per occupancy(1.18) and percentage emission per occupancy at 52.45%.
**Moderate: SOFS(SYNTHETIC)** has a moderate impact with 0.735 emission per occupancy and 32.67% per occupancy. **IMCO SOHAR** contributes 7.09% per occupancy.
**Lowest: COE** has the lowest emission per occupancy (0.057) and percentage emission per occupancy at 2.54%.

**Differences and Trends Between Total Emission and Per Capita Emission**

For fertiliser emission the institutions with the highest and lowest total emissions tend to follow similar trends in per capita emissions. The trends are consistent. **COM SOHAR is clearly the highest** contributor in both total (61.14%) and per capita (52.45%) emissions, and **COE is the lowest.**





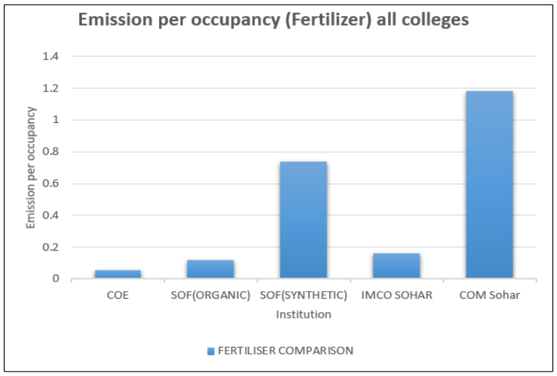


**Fig. 41 Emission per occupancy (Fertilizer)**

## 6.4 SCOPE 1 CHEMICAL & REFREGERENT SOURCE

### 6.4.1 Analysis of Percentage of Total Emission for GHG Potential

This percentage share of each institution in the overall emissions for chemical & refrigerant categories, indicating their contribution to the total GHG potential.

Highest: COM SOHAR is responsible for the majority of these emissions, at 65.4%.

Moderate: IMCO SOHAR contributes 34.59%.

**Lowest: COE and SOFS AIRPORT** report 0% total emissions in this category.

### 6.4.2 Analysis of Emission per Occupancy (Per Capita) for GHG Potential

This section analyses the GHG potential per individual or occupant, using both “Emission per occupancy” and “% Emission/occupancy” based on following occupancy in campuses.

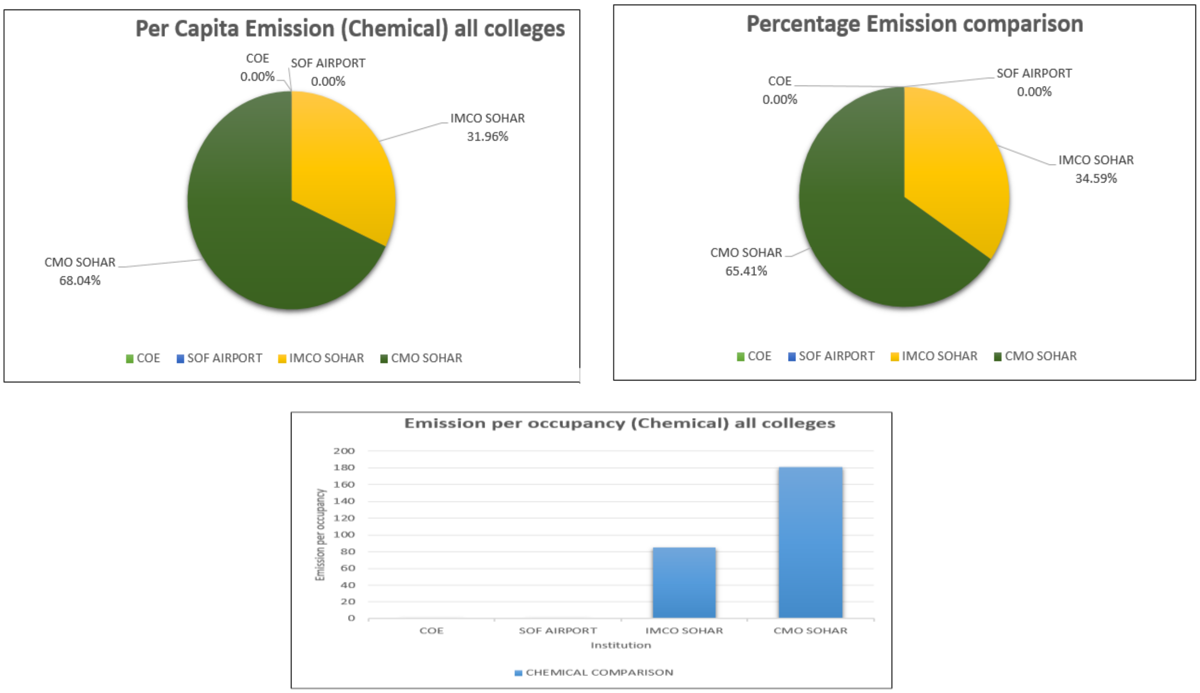
**Highest: COM SOHAR** shows the highest emission per occupancy (180.8) and percentage emission per occupancy at 68.03%.

**Moderate: IMCO SOHAR** has a moderate impact with 84.97 emission per occupancy and 31.96% per occupancy.

**Lowest: COE and SOFS AIRPORT** report 0 emission per occupancy and 0% percentage emission per occupancy.

**Differences and Trends Between Total Emission and Per Capita Emission**

For chemical & refrigerant emission the institutions with the highest and lowest total emissions tend to follow similar trends in per capita emissions. The trends are **c**onsistent. **COM SOHAR consistently has the highest total (65.41%)** and per capita (68.03%) emissions, while COE and **SOFS AIRPORT have zero emissions** in both metrics.


Per Capita Emission (Chemical) all colleges

Percentage Emission comparison

Emission per occupancy (Chemical) all colleges

Fig. 42 Per capita emission (chemicals)

## 6.5 SCOPE 2. Electricity CONSUMPTION SOURCE

### 6.5.1 Analysis of Percentage of Total Emission for GHG Potential

This percentage share of each institution in the overall emissions for Electricity consumption grid supplied electricity categories, indicating their contribution to the total GHG potential.
**Highest: IMCO SOHAR** has the largest percentage of total Electricity emissions at 30.92%.
**Moderate: COM SOHAR** (25.83%), SOF AIRPORT (16.74%), and COE (15.94%) also have significant shares.
**Lowest: COPH** has the lowest share with 10.55%.

### 6.5.2 Analysis of Emission per Occupancy (Per Capita) for GHG Potential

This section analyses the GHG potential per individual or occupant, using both "Emission per occupancy" and "% Emission/occupancy" based on following occupancy in campuses.
**Highest: COPH** has the highest emission per occupancy (2077.8) and percentage emission per occupancy at 30.01%.
**Moderate: IMCO Sohar** (1427.5 emission per occupancy; 20.61 %), COM SOHAR (1343) emission per occupancy; 19.39%), and SOF AIRPORT (1540.276 emission per occupancy; 22.24%) also show significant per capita impacts.
**Lowest: COE** has the lowest emission per occupancy (536.049) and percentage emission per occupancy at 7.74%.

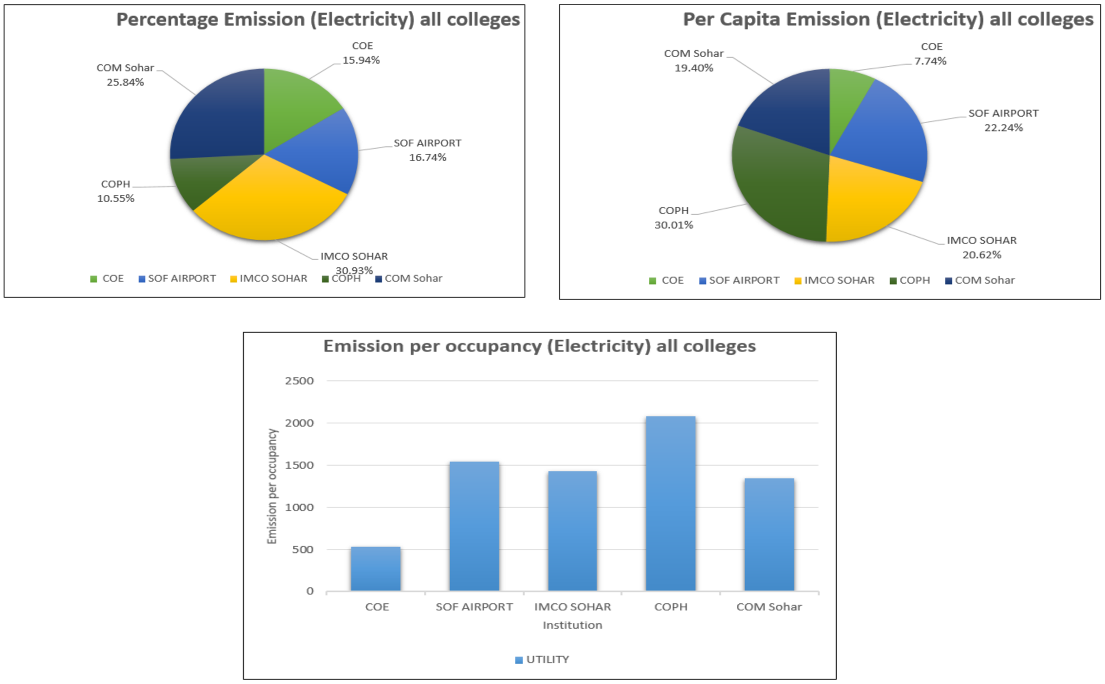


**Fig. 43 Per capita emission (Electricity)**

**Differences and Trends Between Total Emission and Per Capita Emission**
For Electricity emission the institutions with the highest and lowest total emissions tend to follow different trends in per capita emissions. There is a minor difference in the lowest contributor and the ranking of moderate contributors. While **IMCO SOHAR is the highest for percentage total emission (30.92%) where as COPH has highest** per capita (30.01%) emissions. **COPH** has the lowest share with 10.55%. whereas **COE** has the lowest emission per occupancy (536.049) and percentage emission per occupancy at 7.74%. indicating a higher Electricity consumption per occupant relative to its overall contribution.

The differences noted in the comparison table between total emissions and per capita emissions highlight varying intensities of GHG potential depending on whether the entire campus's footprint or an individual's share is considered.

## Table of Comparison and Justification for Significant Difference:

| Emission Source Category | Metric | Highest | Moderate | Lowest | Differences/Trends |
|---|---|---|---|---|---|
| **SCOPE 1 STATIONARY SOURCE** | **% Total Emission** | COM SOHAR (65.8%) | IMCO SOHAR (25.23%), SOFS (5.8%), COP & HQ (2.9%) | COE (0.21%) | Consistent: COM SOHAR highest, COE lowest for both total and per capita emissions. Trends align well. |
| | **% Per Capita** | COM SOHAR (60.0%) | IMCO SOHAR (20.43%), SOFS (9.38%), COP & HQ (10.05%) | COE (0.12%) | |
| **SCOPE 1 TRANSPORTATION** | **% Total Emission** | COM SOHAR M95 (34.85%) | COPH PASSENGER CAR (14.50%), COM SOHAR MED.DUTY (20.65%), COE GASOLINE (10.79%) | IMCO SOHAR DIESEL (0.39%) | **Significant Difference**: While COM SOHAR M95 leads in total emissions, COPH PASSENGER CAR has a much higher per capita impact (43.20%). This suggests a higher intensity of use or fewer occupants per vehicle for COPH Passenger Car. |
| | **% Per Capita** | COPH PASSENGER CAR (53.13%) | COM SOHAR M95 (18.26%), COM SOHAR MED.DUTY (10.82%) | IMCO SOHAR DIESEL (0.18%) | |
| **SCOPE 1 FERTILISER** | **% Total Emission** | COM SOHAR (61.14%) | SOF(SYNTHETIC) (21.50%), IMCO SOHAR (9.31%) | SOF(ORGANIC) (3.44%) | Consistent: COM SOHAR is consistently the highest, and COE consistently among the lowest, for both total and per capita emissions. |
| | **% Per Capita** | COM SOHAR (52.45%) | SOF(SYNTHETIC) (32.67%), IMCO SOHAR (7.09%) | COE (2.54%) | |
| **SCOPE 1 CHEMICAL & REFRIGERANT** | **% Total Emission** | COM SOHAR (65.41%) | IMCO SOHAR (34.59%) | COE, SOF AIRPORT (0%) | Consistent: COM SOHAR leads significantly in both total and per capita emissions. COE and SOF Airport have zero emissions in both categories. |
| | **% Per Capita** | COM SOHAR (68.03%) | IMCO SOHAR (31.09%) | COE, SOF AIRPORT (0%) | |
| **SCOPE 2** Electricity **CONSUMPTION** | **% Total Emission** | IMCO SOHAR (30.92%) | COM SOHAR (25.84%), SOF AIRPORT (16.74%), COE (15.94%), | COPH (10.55%) | **Minor Differences**: IMCO SOHAR is highest for both. However, COPH is the lowest in total emissions, but COE is the lowest in per capita emissions. COPH shows a disproportionately higher per capita impact (30.0%) relative to its total share (10.55%). |
| | **% Per Capita** | COPH (30.00%) | IMCO SOHAR (20.60%), COM SOHAR (19.39%), SOF AIRPORT (22.2%) | COE (7.74%) | |

## Justification for Significant Difference:

### 1. Scope 1: Transportation (Significant Difference)

The most pronounced disparity between total and per capita metrics is found in the transportation sector.
Total Emission Trend: COM Sohar M95 accounts for the largest share of total transportation emissions at 34.85%. This reflects a high volume of collective transportation activity, including a larger fleet and longer distances traveled.

Per Capita Trend: In contrast, COPH Passenger Cars exhibit a much higher per capita impact at 53.13%, despite a more moderate share of the total footprint (14.50%).

**Justification:** This significant difference suggests that while COM Sohar generates more emissions overall, the intensity of use per individual at COPH is higher. This is likely due to fewer occupants per vehicle, meaning the carbon weight of each trip is distributed among a smaller number of people, or a higher individual usage frequency for pharmacy-related activities.

2. Scope 2: Electricity Consumption (Minor/Notable Difference)
Electricity consumption, primarily grid-supplied electricity, shows how population size can "dilute" or "concentrate" a campus's carbon footprint.

Highest Total: IMCO Sohar leads the university in total Electricity emissions at 30.92%. This is justified by the energy-intensive maritime simulators and the large physical infrastructure of the campus.

Highest Per Capita: COPH has the highest per capita impact at 30.00%, even though its total emission share is only 10.55%.

**Justification for COPH Intensity:** This disproportionately high per-person impact at COPH (30.00% per capita) is attributed to a smaller occupant base (655 total) relative to its energy-consuming infrastructure and the presence of energy-intensive laboratory equipment.

The COE Efficiency Trend: COE presents the opposite trend; while it contributes 15.94% of total Electricity emissions, its per capita share is the lowest at 7.74%. This is justified by a large occupant population (3,836 total), which effectively dilutes the individual share of emissions, making the campus more "efficient" per person despite its high total load.

### 3. Consistent Trends (Stationary, Chemicals, and Fertilizers)

In these categories, the campus with the largest total footprint also maintains the highest per capita intensity, indicating these are university-wide "hotspots."

Stationary Sources (LPG): COM Sohar is the highest in both total (65.8%) and per capita (60.0%) emissions. This consistency is driven by the routine operational demand for mess halls and laboratory heating that serves the entire population.

Chemicals & Refrigerants: COM Sohar remains the dominant contributor, responsible for 65.41% of total emissions and 68.03% of per capita emissions. The justification lies in the high-GWP refrigerants (like HCFC22) used in medical cooling systems, which create massive individual impacts when systems are recharged.

Fertilizers: COM Sohar leads both total (61.14%) and per capita (52.45%) metrics, reflecting a high intensity of landscaping maintenance relative to its size.

In summary, these differences highlight that a campus with a high overall emission might not necessarily have the highest per capita emission, and vice versa. Per capita metrics provide insights into the intensity of consumption per individual, which can be influenced by population size, specific activities, and infrastructure efficiency.

### 6.6 Per capita total CO2e emission for various college campuses in National university of Oman.

The data from Year 23–24 is utilized as the primary basis for comparisons and analysis because it represents the most current data year available for NU, Oman (which covers 2022–2023 and 2023–2024). Analyzing the most recent year allows for a contemporary assessment of the National University of Oman's carbon performance and its current standing in global benchmarks.

| College | Builtup area (m2) | 22-23(KG CO2e) | ton kg CO2e | TOTAL STAFF+ STUDENTS | 23-24(KG CO2e) | ton kg CO2e | TOTAL STAFF+ STUDENTS | Total (Kg co2e) | ton kg CO2e | Total two years(staff= students) | per capita CO2eyear 22-23 | per capita CO2eyear 23-24 | per capita CO2e average | per m2 built-up area CO2eyear 22-23 | per m2 built-up area CO2eyear 23-24 | Average two years built-up area CO2eyear |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COE | 29,503 | 1183076 | 1183.07 | 2091 | 947638.5 | 947.63 | 1745 | 2130714 | 2130.714 | 3836 | 0.57 | 0.54 | 0.56 | 0.04 | 0.03 | 0.036 |
| SOF | 18,370 | 1053754 | 1053.75 | 752 | 1139475.5 | 1139.47 | 650 | 2193229 | 2193.229 | 1402 | 1.40 | 1.75 | 1.56 | 0.06 | 0.06 | 0.060 |
| IMCO | 31,811 | 2020825 | 2020.8 | 1423 | 2258415 | 2258.41 | 1371 | 4279240 | 4279.24 | 2794 | 1.42 | 1.65 | 1.53 | 0.06 | 0.13 | 0.035 |
| COM, Sohar | 35,832 | 1791072.5 | 1791.07 | 1168 | 2312975.2 | 2312.97 | 1314 | 4104046 | 4104.0467 | 2482 | 1.53 | 1.76 | 1.65 | 0.05 | 0.06 | 0.057 |
| HQ &COPh | 13,902 | 723357.8 | 723.35 | 333 | 721073.6 | 721.073 | 322 | 1444431 | 1444.431 | 655 | 2.17 | 2.24 | 2.21 | 0.05 | 0.05 | 0.052 |
|  | 129418 | 6772085 | 6772.0 | 4673 | 9400402 | 9400.40 | 5402 | 12130835 | 12130.83 | 10075 | 1.45 | 1.74 | 1.20 | 0.05 | 0.07 | 0.047 |

Table: CF of  NU and various campuses in NU

### 6.6.1 Comparison based on Occupancy (Carbon Footprint per Capita, 23–24):

Higher Carbon footprint Campuses: The HQ & COPh campus recorded the highest per capita CF at 2.24, followed by CMO, Sohar and SOF at 1.76 and 1.75 respectively. These figures indicate that these campuses had a higher carbon footprint relative to their number of occupants compared to the NU average of 1.74.

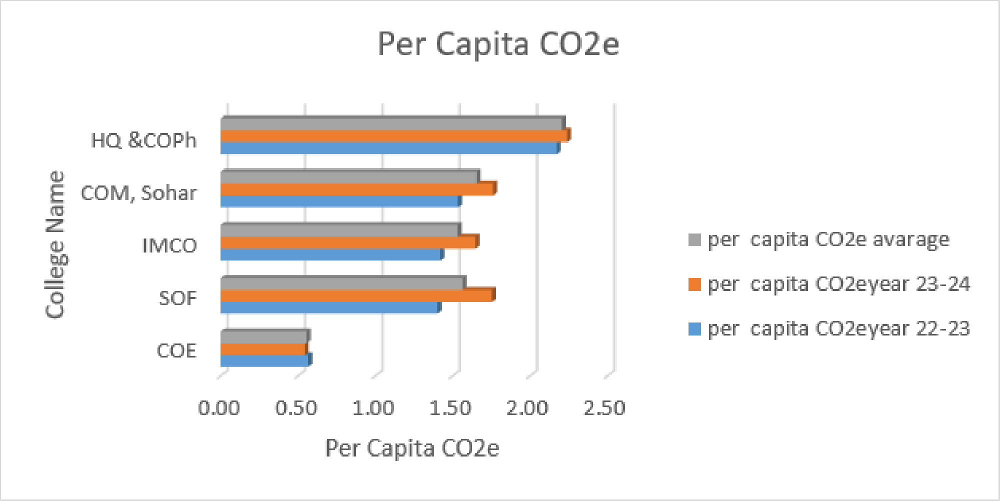


**Fig. 44 Graphical representation per capita carbon footprint per Occupancy for NU Oman**

This may be due to less occupancy in respective campuses. Consequently, When the operational emissions (Scope 1 and Scope 2) required to maintain the physical infrastructure are spread among fewer individuals, the resulting per capita carbon footprint becomes significantly inflated.

Lower Carbon footprint Campuses: IMCO (1.65), and COE (0.54) all performed better than the NU aggregate baseline of 1.74, with COE demonstrating the lowest per capita emission.

This may be due to more occupancy in respective campus. When the operational emissions (Scope 1 and Scope 2) required to maintain the physical infrastructure are spread among more individuals, the resulting per capita carbon footprint becomes significantly less.

### 6.6.2 Comparison based on per m$^2$ Built up area (Carbon Footprint per Capita, 23–24):

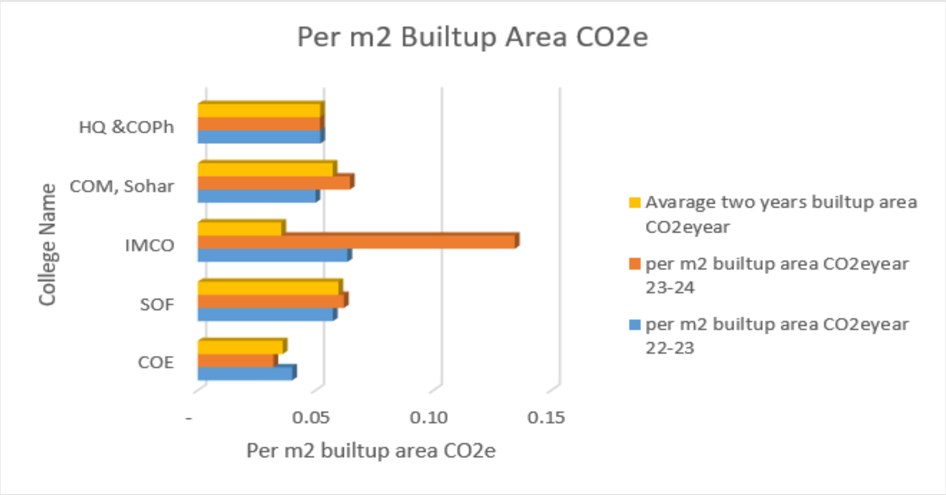


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**Fig.45 Graphical representation carbon foot print per m$^2$ Built-up area for NU Oman.**

The IMCO Sohar campus displayed higher carbon intensity per unit area (0.13) compared to the NU aggregate baseline of 0.073. The reason may be significantly low built-up area.
The remaining campuses COE, SOF, CMO Sohar, HQ & COPh, IMCO had 0.03,0.06,0.06 ,0.05 respectively which is lower than average 0.07 or less, indicating lower carbon intensity per physical unit area relative to the university aggregate.

### 6.7 Comparison of NU carbon foot print with Global CF for various universities:

Here is a list of $CO_2$ emissions for universities in the **Gulf region** based on available reporting
**King Saud University (KSU), Saudi Arabia (2024):**
Total GHG emissions of approximately 453,511.37 tonnes $CO_2$e, with Scope 2 (electricity) accounting for 423,345.97 tonnes and Scope 1 (direct emissions) 30,165.4 tonnes.
**American University of Sharjah (AUS), UAE:**
Total emissions were 94,553.30 t$CO_2$e, with Scope 2 (electricity) contributing 61.12% and Scope 3 (commute) 36.54%.
**King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia (2024):** Total GHG emissions (Scope 1 and 2) of 158,668 tons of $CO_2$e.
**Prince Sultan University (PSU), Saudi Arabia (2023):**
Reported an independent assessment of 5,000 tonnes $CO_2$e saved by its sustainability actions and earned CarbonNeutral® certification.
**University of Hafr Al Batin (UHB), Saudi Arabia (2024):**
Reduced its annual emissions from 4,452 metric tons (2021) to 3,072 tonnes in 2024.
**King Abdullah University of Science and Technology (KAUST), Saudi:**
An early spatial assessment estimated 127.7 tons $CO_2$e (note: this appears limited to specific campus buildings rather than full scope inventory).

The global comparison table utilizes standardized metrics where performance is normalized, with 1.00 representing the best performer in a given category. The comparison is conducted using the GHG protocol corporate accounting standards. The year 2023–24 data was considered for NU, Oman's global comparison as it seems the right approach for benchmarking since it represents the most recent and relevant operational year Carbon footprints (CF) in alignment with international standards like the GHG Protocol. Key contributors to emissions in this region include high electricity consumption (often exceeding 60% of total emissions) for cooling, and, in some cases, significant transport-related emissions.

| **University** | CF performance [kg CO2e/m2] normalized to 1.0 for the best performer | CF performance [Mt $CO_2$e/capita] normalized to 1.0 for the best performer |
|---|---|---|
| ETH Zürich, CH | **1.00** | 1.53 |
| U Talca, Chile | 1.29 | 1.03 |
| U Lüneburg, Germany | 1.92 | **1.00** |
| TU Johor Bahru, Malaysia | 1.20 | 2.59 |
| U Cork, Ireland | 3.03 | 2.04 |
| UAM Mexico City | 1.37 | 1.42 |
| UCB Birkenfeld, Germany | 2.36 | 1.36 |

| | | |
|---|---|---|
| King's College London, GB | 4.28 | 1.74 |
| U Potsdam, Germany | 4.19 | 1.37 |
| NTU, Singapore | 2.13 | 4.66 |
| U Tongji Shanghai, China | 2.40 | 4.67 |
| DeMU Leicester, GB | 4.43 | 1.44 |
| UM College Park MD, USA | 3.80 | 5.84 |
| U Melbourne, Australia | 5.50 | 3.64 |
| U Mankato MN, USA | 6.06 | 3.97 |
| KU Leuven, Belgium | 3.26 | 3.97 |
| U Cape Town, RSA | 2.83 | 3.92 |
| Yale U New Haven CT, USA | 3.71 | 11.19 |
| U Brisbane, Australia | 6.11 | 5.10 |
| U Pittsburgh PA, USA | 7.67 | 6.34 |
| **NU, Oman** | **1.82** | **1.74** |

Carbon footprinting of universities worldwide: Part I—objective comparison by standardized metrics | Environmental Sciences Europe | Full Text

The carbon intensity values derived per capita CO2e is 1.74 MT CO2e /capita/year and per $m^2$ built up area CO2e is .07 MT CO2e/$m^2$/year. The normalization of carbon footprint indicators for the National University, Oman, was carried out. In this study, standardized comparison values were established to enable objective cross-institutional assessment. The per capita benchmark corresponds to Leuphana University Lüneburg (Germany), which represents an emission intensity of 1.0 MT $CO_2$e per person per year, and is assigned an index value of 1.0. Similarly, the per square metre benchmark is based on ETH Zürich (Switzerland), which reports an emission intensity of 40 kg $CO_2$e per $m^2$ per year (equivalent to 0.04 t $CO_2$e/$m^2$/year), also normalized to an index of 1.0. These reference values serve as global best-practice baselines for assessing the relative performance of universities in terms of carbon efficiency per occupant and per built-up area. The normalization index per capita for NU is found to be 1.74 per occupancy/capita and per $m^2$ of built-up area is 1.82. For comparision this values of NU, Oman was added in the table below with data of other 20 universities.

Based on 2023–24 data, the National University of Oman's carbon footprint is 1.74 t $CO_2$e per capita and 0.073 MT $CO_2$e per $m^2$. When normalized to standardized benchmarks, NU Oman records 1.74 × Leuphana University (per capita) and 1.82 × ETH Zurich (per $m^2$).

These results place NU Oman within the mid-range of global universities, though slightly above top European performers. Transitioning to renewable electricity and improving energy efficiency in HVAC and lighting could reduce emissions by ~40–50 %, aligning NU Oman with global best-practice levels.

**Limitations of this ranking study:**

1. Scope and boundary condition are inconsistent as in this study scope 3 is omitted.

2. For comparison appropriate peer group of universities are required. The peers may vary by region/climate (Middle East / Gulf), campus size, and energy system, as region matters a lot.

## VII) Mitigation Strategies

Based on the emission sources and trends, the following mitigation strategies can be considered:
To genuinely reduce its carbon footprint, the National University must implement a more holistic and systemic approach, moving beyond isolated measures. Integrating green building principles into all aspects of campus planning and operations offers a robust strategy for mitigating GHG emissions while simultaneously fostering healthier and more sustainable environment.

**Scope 2 Electricity:** Scope 2 Grid supplied electricity is observed as a high impact area as it leads to highest emission.

**Energy Efficiency Measures**: Conduct a comprehensive energy audit as per ASHRAE Level 02 to identify specific areas of high consumption and implement comprehensive energy efficiency measures, such as installing high efficiency lighting, upgrading to more efficient HVAC systems, and deploying smart building management systems to optimize energy use. For Smart HVAC Management Implement programmable thermostats (typical smart thermostat and thermostat setback guidance) and smart building controls to optimize heating (Optimistic 15% savings — advanced AI controls), ventilation, and air conditioning (HVAC) operation, especially since electricity consumption shows a consistent base load, implying continuous demand. Regular maintenance of HVAC systems is also crucial. Typical energy saving is as under.

**Renewable Energy Procurement**: Currently campus is not using any renewable energy source hence it needs to explore and initiate the purchase of renewable electricity or invest in on-site renewable energy projects, such as installing solar panels on campus rooftops to generate clean electricity.

**Behavioral Change Campaigns**: Promote energy-saving behaviors among the university community, including turning off lights and equipment when not in use, and setting thermostats optimally.

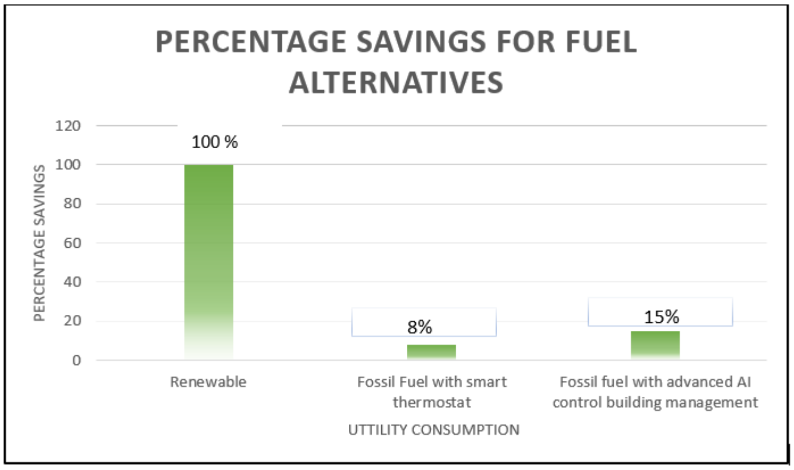


**Fig. 46 Scope 2 Percentage saving for fuel alternatives**

**Energy Efficiency Measures for Each Campuses: COLLEGE OF ENGINEERING (COE)**

## Pre-Call Site Survey Report

**Facility:** College of Engineering (COE)
**Working Hours:** 8:00 AM – 4:00 PM

### 1. Building Blocks & Purpose

**Main Block (MB):** Administrative office.
**CRI Block:** Classrooms, laboratories, and office rooms.
**R Block:** Offices, classrooms, laboratories, faculty rooms.
**A Block:** Classrooms, office rooms, assembly hall.
**L Block:** Staff offices, project lab, staff dining.
**D Block:** Student services, classrooms.
**G Block:** Cafeteria, incubation lab, store, technician room.
**Porta Cabin Block:** Classrooms, IT lab, store, bookstore.
**Porta Cabin Extension Block:** Classrooms.

### 2. Energy System

7 electrical energy meters.
2 transformers, 1000 kVA each, supplied by MEDC.
Diesel generator (capacity not specified).

### Energy Consumption

| | | |
|---|---|---|
| 2023(Jan-Dec) | 2,670,379 kWh | 85,452 OMR |
| 2024(Jan-Aug) | 1,348,984 kWh | 43,167 OMR |

### 3. Water System

3 water meters: MB (2), CRI (1) – rarely used.
3 wells: CRI (1), MB (1), outside parking (1 – not in use).

### 4. Equipment Summary

**Main Block (GF+1)**
DX Units: 79 Nos
Package Units: 02 Nos
Water Tanks: 4 Nos (3 from Well + 1 from Municipal, 800 gal each)

**D Block (GF+1)**

- DX Units: 5 + 12 Nos

**PC Block (GF)**

- DX Units: 59 Nos

**PC Block Extension (GF)**

- VRF Systems: 03 Nos (IDU: 40 Nos)

**G Block**
Pumps: 02 Nos (1 Well + 1 Service; UG to OH tank)
DX Units: 20 Nos

**CRI Block**
Thermal Lab: Diesel & Petrol Engine Lab (1 engine usable for one semester)
Workshop (Welding Lab): $CO_2$ Cylinders (2 Nos), Acetylene & Oxygen Cylinders (1 each) — Not used for 2 years
Exhaust Fans: 2 Nos
VRF Systems: 30 Nos
VRF Systems: 22 Nos
VRV Systems: 01 No
Water Tanks: 2 Nos (Well + Municipal) — Booster pump from well/municipal (rarely used)
Irrigation Water Pumps: 02 Nos

**L Block**

- DX Units: 30 Nos

**R Block**
Transfer Pumps: 2+2 UG to OH tank
VRF Systems: 03 Nos
DX Units: 13 Nos
Water Tanks: 2 Nos (600 US gal each)

**R Block (RE)**
DX Units: 03 Nos
VRF Systems: 04 Nos
VRV Systems: 06 + 04 Nos

**A Block**
DX Units: 25 Nos
Package Units: 05 Nos
Water Tanks: 4 Nos (800 US gal each)

## 5. Other Facility Details

**Parking:** 54 spaces in CRI Block basement, 150 along outside campus wall, 400 in outside

campus lot.
**VRF System Control:** Located in CRI Block for LG VRF system control.
**Energy Monitoring System:** Installed in CRI Block.

**Observation:**

1. Effective behavioral changes in the campus.
2. Monitoring and Management in place
3. The Package Unit fans are with conventional blower, and it is running at a constant full speed.
4. The HVAC is system is not optimally automated.
5. The lighting management system is not implemented
6. Older toilets have high water consumption per flush.
7. No Utilization of Renewable Energy

**Recommendations**

1. Conduct a Level 01 and then an opportunity to conduct an Investment grade assessment to lead to an energy Performance contract.
2. Replace the conventional belt-driven blowers with EC fans, thereby improving efficiency by 20–30% compared to conventional blowers. The fan speed can also be adjusted according to the load requirement, which will further reduce energy consumption.
3. Perform a leakage test to identify and quantify air leaks. Reduce air leakage in the air distribution system by sealing the ducts, which will improve cooling performance and enhance overall system efficiency. Aerosol based sealants make internal duct sealing with up to 99% reduction in air leakage.
4. Perform an infiltration test and seal the building or room envelope where leakage exceeds ideal levels. This will minimize air infiltration, improve indoor air quality, and reduce the cooling load.
5. Improve the air distribution system by implementing dynamic air balancing
6. Automate and optimize the HVAC system, including Package Units, VRF systems, and DX systems, by implementing smart thermostats and sensors.
7. Install a lighting management system equipped with adequate sensors and controls to optimize energy usage. Implement an energy management system to monitor, control, and optimize energy consumption across all building systems.
8. Older toilets consume 7–9 liters per flush, whereas modern vacuum-assisted WCs use only 1.5 liters per flush. Upgrading to these newer toilets can reduce water consumption by 80–85%.
9. Solar Feasibility Report is incorporated separately for National University Campuses.

## Energy Efficiency Measures for Each Campuses:
## SCHOOL OF FUNDAMENTAL STUDIES (SOFS)

**Facility:** School of Food Sciences (SoFS) – Built 2010
**Working Hours:** 8:00 AM – 4:00 PM

### 1. Building Information

- **Main Building** – divided into 3 parts:
    - **Part 1 – College:** Classrooms, laboratories, assembly hall, faculty rooms, admin office.
    - **Part 2 – Female Hostel:** 250 rooms.
    - **Part 3 – Cafeteria:** Dining hall, indoor sports area.

### 2. Energy System

Electrical Meters: 4 units.
Transformers: 4 units (supplied by MEDC).
Diesel Generator: 1 unit – 450 kVA / 360 kW.

### Energy Consumption

| | | |
|---|---|---|
| **2024 (Jan-Dec)** | 2,722,084 kWh | 87,106 OMR |
| **2024 (Jan-Aug)** | 1,753,588 kWh | 56,114 OMR |

### 3. Water System

- **Water Meters:** 1 unit.

### 4. Chiller & Pump System

- **Chillers:** 2 units, Trane, Model RTAC 350D UWOH NAGP HITY 2DDB NA57.

Capacity: 350 TR each.
Screw compressors: 4 (no VFD).
Condenser fans: 24.
Inlet temperature: 10.9°C.
Outlet temperature: 8.1°C.
Setpoint: 8°C.

- **Primary Pumps:** 3 (2 working + 1 standby), Grundfos.
    - Flow: 230 $m^3$/hr, Head: 12 m, Power: 11 kW.
- **Secondary Pumps:** 3 (2 working + 1 standby) with VFD, Grundfos.
    - Flow: 212.3 $m^3$/hr, Head: 38.8 m, Power: 37 kW.

### 5. Equipment Outline

- **Part 2 – Hostel:**

HRW: 4 units (never used).

Package units: 4 small units for lift shafts.
Water tanks: 2 units.
Booster pumps: 2 (connected to one tank).

- **Basement:**

Electric water heaters: 10 units (119 US gal, 4.5 kW, auto).
Pumps: 2 + 2 (College + Hostel).
Jet fans: 5.
Exhaust fans: 2.

- **Part 3 – Cafeteria:**
    - Exhaust and fresh air fans: 2 units.
- **Overall HVAC:**

FCUs: 280 units (chilled water type).
DX units: 20 units.

## 6. Other Details

**Parking:** Basement – 60 spaces; Inside campus wall – 50 spaces.
**BMS:** Standalone DDC controller for chiller plant.
**Gas Consumption:** Present in cafeteria and staff accommodation.

## Observation:

8. The HVAC is system is not optimally automated.
9. The lighting management system and Energy management system in not effective
10. Older toilets have high water consumption per flush.

## Recommendation and strategies:

1. Conduct a Level 01 Energy Survey and then an opportunity to conduct an Investment grade assessment to lead to an energy Performance contract.

2. Perform a leakage test to identify and quantify air leaks. Reduce air leakage in the air distribution system by sealing the ducts, which will improve cooling performance and enhance overall system efficiency. Aerosol based sealant makes internal duct sealing with up to 99% reduction in air leakage.

3. Perform an infiltration test and seal the building or room envelope where leakage exceeds ideal levels. This will minimize air infiltration, improve indoor air quality, and reduce the cooling load.

4. Perform a detail survey on chiller and provide the chiller additive which will help improve the overall efficiency of the chiller. It will improve the heat transfer by 8 to 15 %

5. Improve the air distribution system by implementing dynamic water balancing balancing

6. Automate and optimize the HVAC system, including FCUs and DX systems, by implementing smart thermostats and sensors.

7. Install a lighting management system equipped with adequate sensors and controls to optimize energy usage. Implement an energy management system to monitor, control, and optimize energy consumption across all building systems.

8. Older toilets consume 7–9 liters per flush, whereas modern vacuum-assisted WCs use only 1.5 liters per flush. Upgrading to these newer toilets can reduce water consumption by 80–85%.

**Energy Efficiency Measures for Each Campuses:**
**INTENATIONAL MARITIME COLLEGE (IMCO)**

**Facility:** IMCO
**Working Hours:** 8:00 AM – 4:00 PM

**Building Information**
**Main Building**: Classrooms, Offices, Labs, Admin, Library, Auditorium
**Simulation Building**: Classrooms, Bridge Simulator, Staff Room, Labs
**Workshop**: Mechanical & Chemical Labs, Classrooms, Staff Room
**Canteen & Restaurant**: Dining Hall, Kitchen
**Sports Complex**: Play Area, Gym, Swimming Pool
**Hostel**: Men's Hostel with 270+ rooms
**Working Hours**: 8:00 AM – 4:00 PM

**Energy System**
Main Electric Meters: 5 Nos.
Sub Meters: 4 Nos.
Transformers: 5 Nos – 1000 kVA Each
Total Connected Load: 4195 kW

**Energy Consumption**

| | | |
|---|---|---|
| **2021-2022** | 5,012,013 kWh | 196,920 OMR |
| **2022-2023** | 5,012,013 kWh | 162,944 OMR |
| **2023-2024** | 4,772,605 kWh | 1,52,723 OMR |

**Chillers**:
**Total:** 4 Nos. (2 Working + 1 Not in Use + 1 in Service)
**Make:** Carrier
**Capacity:** 313 TR, Electrical: 257 kW

3 Screw Compressors – No VFD
**Temperatures:** Inlet: 16°C, Outlet: 12°C, Setpoint: 9°C

**Chiller Pumps**:
**Primary**: 5 Nos. (2W+3S), 15 kW, In 4.5 bar / Out 5.5 bar.
**Secondary**: 5 Nos. (2W+3S) with VFD at 30 Hz, 30 kW, In 4.1 bar / Out 5.1 bar

**HVAC System:**
**Main Building (GF+2)**
AHU: 9 Nos.
FAHU: 2 Nos.
Toilet Exhaust: 11 Nos.
Pantry Exhaust: 2 Nos.

**Simulation Building (G+1)**
AHU: 5 Nos.
Exhaust: 3 Nos
**Workshop (G+1)**
AHU: 3 Nos.
FAHU: 1 No.
Toilet Exhaust: 5 Nos.
Workshop Exhaust: 2 Nos.
Workshop FA: 2 Nos.

**Canteen-Restaurant (G+1)**
AHU: 1 No.
Toilet Exhaust: 4 Nos.
Kitchen Exhaust: 1 No.
FA: 1 No.

**Sports Complex (G)**
AHU : 3 Nos.
Toilet Exhaust : 5 Nos.

**Men's Hostel (G+2)**
FAHU: 2 Nos.
Toilet Exhaust: 2 Nos.

**Other Equipment**
FCU (Chilled Water): 350+ Nos.
DX Units: 25 Nos.
VRF Systems: 4 Nos.

**Other Systems**

- **BMS**: Siemens (1 No.)
- **Drainage Pumps**: 3 Sets (Submersible)

- Hostel: 1 Set
- Masjid, SC, WS: 1 Set
- MB, SB, Cafeteria: 1 Set

**Major Observations**

1. The chilled water outlet temperature from chiller should be 6°C, but it is currently 12°C.
2. Due to insufficient cooling inside the building, most of the AHUs are operating for extended hours. During the site visit, the facility team also reported air leakage in the duct system
3. The AHU fans are with conventional blower, and it is running at a constant full speed even during non-peak hours.
4. During the discussion with the facility team, humidity issues were reported.
5. The chiller plant and chilled water system, including AHUs, FAHUs, and FCUs, are not optimally controlled.
6. The lighting management system and Energy management system is absent.
7. High water usages, toilets have high water consumption per flush.

**Recommendation**

1. Perform a Level 01 Energy Survey and then an opportunity to conduct an Investment grade Audit to lead to an energy Performance contract.
2. 
3. The faulty chillers need to be repaired. Additionally, using the chiller additive will help improve the overall efficiency of the chiller. It will improve the heat transfer by 8 to 15 %

4. Perform a leakage test to identify and quantify air leaks. Reduce air leakage in the air distribution system by sealing the ducts, which will improve cooling performance and enhance overall system efficiency. Aerosol based sealant makes internal duct sealing with up to 99% reduction in air leakage.

5. Replace the conventional belt-driven blowers with EC fans, thereby improving efficiency by 20–30% compared to conventional blowers. The fan speed can also be adjusted according to the load requirement, which will further reduce energy consumption.

6. By sealing the building or room envelope, air infiltration can be minimized, allowing better control of indoor humidity levels.

7. Optimize the chiller plant and pumping system based on load requirements.

8. Improve the air distribution system by implementing dynamic air balancing and enhance the chilled water system performance by adopting dynamic water balancing.

9. Install a lighting management system equipped with adequate sensors and controls to optimize energy usage. Implement an energy management system to monitor, control, and optimize energy consumption across all building systems.

10. Older toilets consume 7–9 liters per flush, whereas modern vacuum-assisted WCs use only 1.5 liters per flush. Upgrading to these newer toilets can reduce water consumption by 80–85%.

11. Survey the supplemental loads in the building and recommend solutions that will reduce internal heat gain and lower the energy required to cool the space.

12. Survey the lighting system, check the illumination levels, and optimize light intensity according to the relevant standards.

**Energy Efficiency Measures for Each Campuses:**
**COLLEGE OF MEDICINE, SOHAR (COM)**

**Facility:** College of Management (COM)
**Working Hours:** 8:00 AM – 4:00 PM

### 1. Building Blocks & Purpose

**Existing Main Block:** Admin offices, classrooms, faculty rooms, pantry.
**Main Block A & B:** Laboratories, classrooms, office spaces.
**Library Block:** Library, canteen, student services, laboratory.
**Hostel A:** Women's hostel.
**Hostel B:** Women's hostel.
**Hostels C, D, E:** Women's hostels.
**Hub:** Student activity center.

### 2. Energy System

**Electrical Meters:** 8 total (MB-3, MB Block A-1, MB Block B-1, Old Girls Hostel A-1, New Girls Hostel B-1, Dormitory C/D/E + Student Hub-1).
**Transformers:** 8 total (7 × 1000 kVA, 1 × 2000 kVA).
**Diesel Generator:** 1 unit (85 kVA) serving data center and server room.

#### Energy Consumption

| | | |
|---|---|---|
| **2022-2023** | 3,059,471 kWh | 97,903 OMR |
| **2023-2024** | 4,260,312 kWh | 136,329 OMR |

### 3. Water System

**Water Meter:** 1 common meter.
**Well:** 1 well (not used).

**Drainage:** 3 lifting points (managed by local contractor).

## 4. HVAC & Mechanical Equipment

- **Main Block Extension (GF+2):**

DX units
16 package units.
9 VRV systems (2 removed, 3 planned for removal and replacement with DX units).
Toilet exhaust fans.
1 water tank with small booster pump.
18 water heaters (50 liters, 1.5 kW).

- **Main Block A & B (GF+2):**

2 package units.
VRF systems: 25 and 36 units.
4 AHUs with HRW, each with VFD.
31 FAHUs (VRF type).
Laboratory exhaust fans.
Toilet exhaust fans.
Each block with 1 water tank and booster pump.
2 solar water heaters with electric backup (300 liters, 2.5 kW).

- **Library:**

DX units.
1 water tank with small booster pump.

- **Hostel A:**

DX units.
1 water tank with small booster pump.

- **Hostel B:**

DX units.
1 water tank with small booster pump.
64 water heaters (50 liters, 1.5 kW).
8 solar water heaters with electric backup (300 liters, 2.5 kW).

- **Hostels C, D, E:**

VRF system.
1 water tank with small booster pump.
170 water heaters (30 liters, 1.5 kW).

## 5. Other Facility Details

- **BMS Systems:**

Total: 2 systems.
Hub: Schneider Electric BMS (installation incomplete, not operational).
Hostels C, D, E: Schneider Electric BMS (operational, connected only to VRF systems).

- **Transfer Pumps:**

1 at Hub.
1 at Hostels C, D, E.

## Facility: NU COM Rustaq Training Centre – College of Medicine

### 1. Campus Overview

- **Campus Name:** NU Rustaq Training Centre – College of Medical (2012)
- **Campus Size:** Area ~525 sq.m, consisting of one small building.

### 2. Energy System

- Electricity: 1 Meter (Supplied via MOH submeter).

### 3. Energy Consumption

| | | |
|---|---|---|
| **2023-2024** | 497,246 kWh | 15,911 OMR |

### 4. Water System

- Water Supply: 1 Metre (Supplied from MOH).

### 5. Equipment Information

- Cooling Systems: 20 split AC units and 6 ACs in portacabin.
- Electric Heater : 2 Nos

### Observation:

1. The Package Unit fans are with conventional blower, and it is running at a constant full speed.
2. The HVAC is system is not optimally automated.
3. The lighting management system and Energy management system is absent.
4. Older toilets have high water consumption per flush.

### Recommendation and strategies:

1. Perform Level 01 Energy Assessment first and an Investment grade assessment for an Energy Performance Contract
2. Replace the conventional belt-driven blowers with EC fans, thereby improving efficiency by 20–30% compared to conventional blowers. The fan speed can also be adjusted according to the load requirement, which will further reduce energy consumption.
3. Perform a leakage test to identify and quantify air leaks. Reduce air leakage in the air distribution system by sealing the ducts, which will improve cooling performance and enhance overall system efficiency. Aerosol based sealant makes internal duct sealing with up to 99% reduction in air leakage.
4. Perform an infiltration test and seal the building or room envelope where leakage exceeds ideal levels. This will minimize air infiltration, improve indoor air quality, and reduce the cooling load.

5. Improve the air distribution system by implementing dynamic air balancing
6. Automate and optimize the HVAC system, including Package Units, VRF systems, and DX systems, by implementing smart thermostats and sensors.
7. Install a lighting management system equipped with adequate sensors and controls to optimize energy usage. Implement an energy management system to monitor, control, and optimize energy consumption across all building systems.
8. Older toilets consume 7–9 liters per flush, whereas modern vacuum-assisted WCs use only 1.5 liters per flush. Upgrading to these newer toilets can reduce water consumption by 80–85%.

## Energy Efficiency Measures for Each Campuses:
## COLLEGE OF PHARMACY & HQ, MUSCAT

**Working Hours:** 8:00 AM – 4:00 PM

### 1. Building Information

**Main Building (2000):** Admin office, classrooms, laboratories, faculty rooms, canteen.
**Hostel (2011):** 45 rooms – Girls Hostel.
**Staff Accommodation:** 7 rooms – facility staff housing.

### 2. Energy System

Electrical Meters: 1 unit.
Transformer: 1 unit (supplied by MEDC).
Diesel Generator: Not available.

#### Energy Consumption

| | | |
|---|---|---|
| **2023(Jan to Dec)** | 1,689,699 kWh | 54,070 OMR |
| **2025 (Jan to Sep)** | 1,301,035 kWh | 41,633 OMR |

### 3. Water System

**Water Meters:** 2 units (College + Hostel).
**Drainage Lifting Points:** 4 units.

### 4. Equipment Outline

- **Main Building (G+2):**

DX units: 70.
Package units: 26.
Exhaust & Fresh Air fan: 1 unit.
Toilet exhaust: Available.
Water tank: 1 unit with gravity supply.
Water heaters: 25 units (50 L – not in use).

- **Hostel (G+2):**

DX units: 60.
Toilet exhaust: Small unit.
Water tank: 1 unit with booster pump.

Water heaters: 17 units (20 L).
Kitchen exhaust: Available.

- **Staff Accommodation (G+1):**

DX units: 8.
Water tank: 1 unit with booster pump.
Water heaters: 5 units (40 L).

**5. Other Details**

**Parking:** Outside wall – 90 spaces and Inside campus wall – 120 spaces.
**BMS:** Not installed.
**Transfer Pump:** 1 set.
**Irrigation Pump:** 2 sets.

**Observation:**

The Package Unit fans are with conventional blower, and it is running at a constant full speed.
The HVAC is system is not optimally automated.
The lighting management system and Energy management system is absent.
Older toilets have high water consumption per flush.

**Recommendation and strategies:**

1. Perform an Energy Assessment to arrive an Energy Performance Contract
2. Replace the conventional belt-driven blowers with EC fans, thereby improving efficiency by 20–30% compared to conventional blowers. The fan speed can also be adjusted according to the load requirement, which will further reduce energy consumption.
3. Perform a leakage test to identify and quantify air leaks. Reduce air leakage in the air distribution system by sealing the ducts, which will improve cooling performance and enhance overall system efficiency. Aerosol based sealant makes internal duct sealing with up to 99% reduction in air leakage.
4. Perform an infiltration test and seal the building or room envelope where leakage exceeds ideal levels. This will minimize air infiltration, improve indoor air quality, and reduce the cooling load.
5. Improve the air distribution system by implementing dynamic air balancing
6. Automate and optimize the HVAC system, including Package Units and DX systems, by implementing smart thermostats and sensors.
7. Install a lighting management system equipped with adequate sensors and controls to optimize energy usage. Implement an energy management system to monitor, control, and optimize energy consumption across all building systems.
8. Older toilets consume 7–9 liters per flush, whereas modern vacuum-assisted WCs use only 1.5 liters per flush. Upgrading to these newer toilets can reduce water consumption by 80–85%.

### Renewable Energy – Feasibility

### Grid Connected Solar PV

The List of Campuses proposed for Solar Feasibility Study Are :

- **Head Quarters & College of Pharmacy (CoP) - Bousher Campus, Muscat**
- **College of Engineering (CoE), Al Hail Campus, Muscat**

- **College of Medicine and Health Sciences (CoM & HS), Sohar**
- **International Maritime College Oman (IMCO), Sohar**
- **School of Foundation Studies (SoFS), Airport Heights, Muscat**
- **Clinical Study Center, Rustaq**

**NU’s proposed Sustainability Strategy to be evaluated for feasibility:**

**Strategy to progressively implement 10% of Energy needs from Solar Energy every year for the next 5 years.**

1. Academic Year 2025-2026; 10%
2. Academic Year 2026-2027; 10%
3. Academic Year 2027-2028; 10%
4. Academic Year 2028-2029; 10%
5. Academic Year 2029-2030; 10%

## Utility Power Scenarios at Campuses:

| S N | Campuses / Details | HQ&COP Bousher | COE Al Hail | CoM Sohar | IMCO Sohar | SOFS Airport Heights | SHC (New) | CSC Rustaq |
|---|---|---|---|---|---|---|---|---|
| 1 | Number of NAMA Accounts | 1 | 7 | 8 | 5 | 4 | 2 | 3 |
| 2 | Connected Load (kW) | 900 | 2,509 | 7,200 | 3,736 | 2,195 | 3,090 | 1,200 |
| 3 | Annual Energy Consumption (KWHr) | 1,462,508 | 2,083,324 | 2,599,243 | 4,772,605 | 2,786,661 | TBA | TBA |
| 4 | Annual Electricity Bills (OMR) | 46,800 | 66,666 | 83,176 | 152,723 | 89,173 | TBA | TBA |
| 5 | Utility Tariff (Annual ) | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 |

| S N | Campuses / Details | HQ&COP Bousher | COE Al Hail | CoM Sohar | IMCO Sohar | SOFS Airport Heights | SHC (New) | CSC Rustaq | TOTAL NU |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Number of NAMA Accounts | 1 | 7 | 8 | 5 | 4 | 2 | 3 | **30** |
| 2 | Connected Load (kW) | 900 | 2,509 | 7,200 | 3,736 | 2,195 | 3,090 | 1,200 | **20,830** |
| 3 | Annual Energy Consumption (KWHr) | 1,462,508 | 2,083,324 | 2,599,243 | 4,772,605 | 2,786,661 | 3,090,000 | 1,200,000 | **17,994,341** |
| 4 | Annual Electricity Bills (OMR) | 46,800 | 66,666 | 83,176 | 152,723 | 89,173 | 98,880 | 38,400 | **575,818** |
| 5 | Utility Tariff (Annual ) | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 |

### Head Quarters & College of Pharmacy (CoP) - Muscat

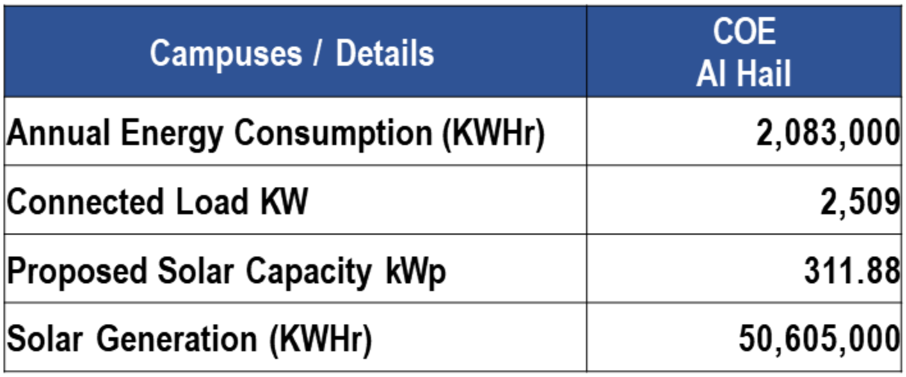
- Due to parapets and higher building portions nearby, all these roof areas are mostly shadow affected throughput the year.
- Roof areas 1,2,3 and 4 are to be treated as non-feasible due to limited Shadow Free Areas.
- In Shadow free roof area, the available capacity is very small with low energy production and high cost of installation.
- So proposal is AREA 1 for Solar Car Parking, where the solar modules can be shadow free through productive sun-hours

| Campuses / Details | HQ & COP |
|---|---|

| | |
|---|---|
| **Annual Energy Consumption (KWHr)** | **1,462,508** |
| **Connected Load KW** | **900** |
| **Proposed Solar Capacity kWp** | **53.20** |
| **Solar Generation (KWHr) / Yr** | **84,993** |

**College of Engineering (CoE), Al Hail Campus, Muscat**

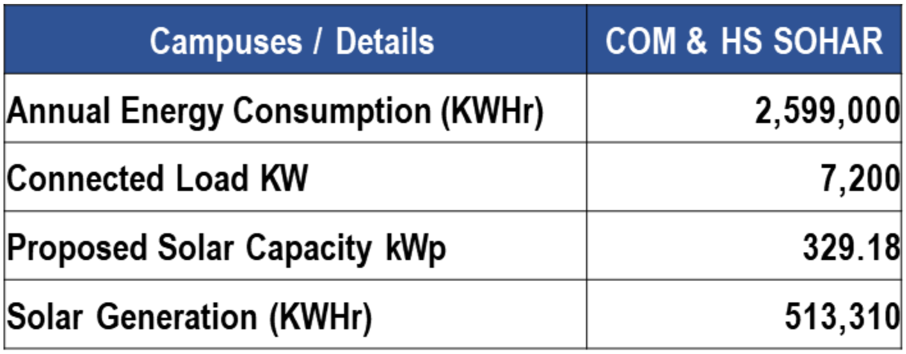
- The Campus is having given FOUR roofs that are shadow free and suitable for Solar Power Plants.
- Roof 1 and 2 are slope roofs primarily, where Tilt Angle and Azimuth of the Solar Power Plant shall follow the tilt of the Roof and orientation of the building.
- Roof 1 and 2 may be fully utilized and shadow free area only in other roofs are recommended.



| Campuses / Details | COE<br>Al Hail |
|---|---|
| Annual Energy Consumption (KWHr) | 2,083,000 |
| Connected Load KW | 2,509 |
| Proposed Solar Capacity kWp | 311.88 |
| Solar Generation (KWHr) | 50,605,000 |

## College of Medicine and Health Sciences (CoM & HS),

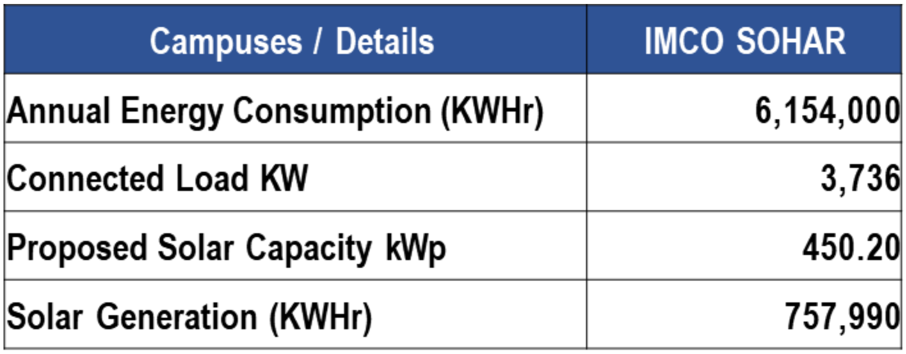
- The Campus is having academic blocks as well as accommodation blocks
- Roof 1, 2,3 and 4 among academic blocks are Flat roofs primarily, where Tilt Angle and Azimuth of the Solar Power Plant shall follow the ideal ones for the geocoordinate of the location.
- All the flat roofs among accommodation blocks are also considered for solar to maximize the potential.



| Campuses / Details | COM & HS SOHAR |
|---|---|
| Annual Energy Consumption (KWHr) | 2,599,000 |
| Connected Load KW | 7,200 |
| Proposed Solar Capacity kWp | 329.18 |
| Solar Generation (KWHr) | 513,310 |

**International Maritime College Oman (IMCO), Sohar**

- The Campus is having academic blocks as well as accommodation blocks.
- Roof 1, 2,3 and 4 are ideal Flat Roofs identified as shadow free in the primary investigation, where Tilt Angle and Azimuth of the Solar Power Plant shall follow the ideal ones for the geocoordinate of the location.
- Designer parapets in campus buildings are casting shadow over roofs excluded.



| Campuses / Details | IMCO SOHAR |
|---|---|
| Annual Energy Consumption (KWHr) | 6,154,000 |
| Connected Load KW | 3,736 |
| Proposed Solar Capacity kWp | 450.20 |
| Solar Generation (KWHr) | 757,990 |

**School of Foundation Studies (SoFS), Airport Heights, Muscat**

- The Campus is having academic block as well as accommodation block.
- Academic Block's Flat Roof is identified as shadow free in the primary investigation, where Tilt Angle and Azimuth of the Solar Power Plant shall follow the ideal ones for the geocoordinate of the location.
- Roofs above accommodation are uneven, fully occupied with services. The orientation is not ideal for a cost- effective elevated structure too.
- Even a secondary investigation resulted in non-feasibility of this roof for Solar.

| Campuses / Details | IMCO SOHAR |
|---|---|
| Annual Energy Consumption (KWHr) | 3,048,000 |
| Connected Load KW | 3,048 |
| Proposed Solar Capacity kWp | 540.00 |
| Solar Generation (KWHr) | 1,620,000 |

**Clinical Study Center, Rustaq**

- The Campus is having phased development plan of HUB+CTC Block and 2 Hostel blocks. This study primarily considered both phases.
- Flat Roofs in all THREE are identified as shadow free in the primary investigation.
- The Central Atrium at HUB_CTC spanning 193.21 M2 is proposed to be covered with Double Glass Solar Modules through light.
- Only a proposed connected load details are available and actual consumption and tariff are unclear. Since the project being in design stage, energy factors are assumed for feasibility.

| Campuses / Details | IMCO SOHAR |
|---|---|
| Annual Energy Consumption (KWHr) | 1,200,000 |
| Connected Load KW | 1,200 |
| Proposed Solar Capacity kWp | 361.10 |
| Solar Generation (KWHr) | 581,990 |

**Recommended GCPV Plants for all NU Campuses**

Subject to the Feasibility Study Conducted at all recommended Campuses as explained in the above slides, below is the abstract of the Proposal in Terms of FEASIBLE SOLAR CAPACITY and ESTIMATED SOLAR ENERGY for each Campus:

| S N | Campuses / Details | HQ&COP Bousher | COE Al Hail | CoM Sohar | IMCO Sohar | SOFS Airport Heights | SHC (New) | CSC Rustaq | TOTAL NU |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Number of NAMA Accounts | 1 | 7 | 8 | 5 | 4 | 2 | 3 | **30** |
| 2 | Connected Load (kW) | 900 | 2,509 | 7,200 | 3,736 | 2,195 | 3,090 | 1,200 | **20,830** |
| 3 | Annual Energy Consumption (KWHr) | 1,462,508 | 2,083,324 | 2,599,243 | 4,772,605 | 2,786,661 | 3,090,000 | 1,200,000 | **17,994,341** |
| 4 | Annual Electricity Bills (OMR) | 46,800 | 66,666 | 83,176 | 152,723 | 89,173 | 98,880 | 38,400 | **575,818** |
| 5 | Utility Tariff (Annual ) | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 |
| 6 | Feasible GCPV Capacity - kWp | 53.20 | 311.88 | 329.00 | 450.00 | 103.80 | 540.00 | 361.00 | **2,148.88** |
| 7 | Solar Energy in First Yr - kWhr | 84,993 | 506,050 | 513,302 | 757,956 | 184,657 | 879,950 | 581,990 | **3,508,898** |
| 8 | Solar Off-Set to Utility per Annum OMR | 2,720 | 16,194 | 16,426 | 24,255 | 5,909 | 28,158 | 18,624 | **112,285** |

- Recommended Maximum GCPV in kWp for each Campus to ensure 100% utilization of Solar Energy.
- Feasible Solar Plant Capacity are based on Sunpath, Solar Simulation and availability of Shadow free space
- Allowable Solar Capacity shall be sought from NAMA to ensure that Solar Plants are evacuated to the selected meters where 100% utilization is confirmed.
- Number of evacuations should ensure the solar energy through 119 nos of holidays are compensated by weekday consumption

**Scope 1 Transport Emissions:** Scope 1 Transportation emission is observed significant impact area which leads to moderate emissions.

Fleet Modernization and Electrification: Gradually replace the fossil fuel-powered transport fleet with electric vehicles (EVs) to eliminate direct tailpipe emissions. EVs don't emit directly at the tailpipe hence
CH4 and N2O are essentially 0 at vehicle level but electricity generation for charging an EV does produce emissions, depending on the grid emission factor of the country which goes under Scope 2 emission. By shifting to Electric vehicle, it reduces 12-15% emission. Hence Scope 1 emission become 0 and in scope 2 Grid supplied electricity consumption increase by 12-15% as for charging of EV grid supplied electricity is used.
If renewable energy source is used scope1 & 2 emission become zero. The life cycle emission for EV manufacturing is not covered in the emission.

Fuel Efficiency Programs: Implement regular maintenance for existing vehicles and provide eco-driving training to drivers to improve fuel efficiency.
Promote Sustainable Commuting: Encourage alternatives to single-occupancy vehicle use, such as carpooling, cycling, walking, or utilizing public transportation.

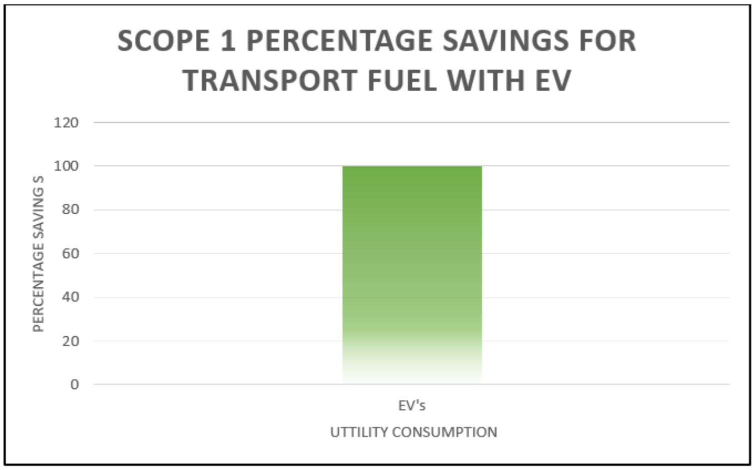


**Fig. 47 Scope 1 Percentage savings for transport fuel with EV**

**Scope 1 Stationary Emission (LPG):**
Scope 1 Stationery emission is observed lower impact area due to smaller emission.
LPG Alternatives: Investigate switching from LPG to electric appliances for cooking and heating where feasible, leveraging the grid (and potentially renewable electricity) for cleaner operations.

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https://www.iea.org/data-and-statistics/charts/comparative-life-cycle-greenhouse-gas-emissions-of-a-mid-size-bev-and-ice-vehicle?

**Scope 1 Fertilizers Emission (Organic & Synthetic):**

Scope 1 fertilizer emission is observed lower impact area due to smaller emission.

Optimized Fertilizer Management: Conduct regular soil testing to ensure precise fertilizer application, thereby reducing unnecessary use. Explore organic composting using campus waste to reduce reliance on purchased fertilizers and use native plant species in landscaping that require less input.

**Scope 1 Chemical & Refrigerant emission:**

It observed lower impact area due to smaller emission. The current, Ideal and Risk of inaction in the field of Stationary fuel consumption is as shown below:

Addressing Chemical (Refrigerant) Emissions - High Priority (due to high GWP):

Leak Detection and Repair Program: Establish a proactive and rigorous program for regular inspections and maintenance of all cooling systems to detect and promptly repair refrigerant leaks. The sporadic, large emission events suggest that leaks, when they occur, are substantial.

Transition to Low-GWP Refrigerants: When existing HFC134a systems require replacement or major servicing, prioritize systems that use refrigerants with significantly lower Global Warming Potential (GWP).

Proper End-of-Life Management: Ensure that refrigerants are recovered and either recycled or properly disposed of by certified technicians when equipment is decommissioned

**Emission Reduction Using Specific Strategies**

Based on the magnitude of emissions, it is evident that Scope 2 Electricity offers the greatest potential for overall GHG emission reduction for the College of Engineering and Al Hail. Emissions from electricity are significantly higher (e.g., over 200,000 kg CO2e per month) compared to Scope 1 transport (up to ~5,000 kg CO2e per month) and Scope 1 stationary/fertilizer sources (less than 10 kg CO2e per month). Therefore, strategies focusing on electricity consumption, such as investing in renewable energy sources and enhancing energy efficiency in buildings, would likely yield the most substantial percentage reductions in the university's carbon footprint. To determine specific percentage reductions, further analysis with detailed energy consumption models and impact assessments of proposed strategies would be required, which is beyond the scope of the work.

- **Reduction Roadmap (Mitigation Strategy)**

**Scope 2 Electricity:** The reduction strategies for the various sectors are as explained below. For Grid supplied / utility consumption electricity, the current, ideal and risk of inaction is as shown in the figure.

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https://www.energystar.gov/products/heating_cooling/smart_thermostats/smart_thermostat, Programmable Thermostats | Department of Energy

**Current State**: Grid supplied electricity is used which is high impact area as it leads to highest emission.

**Ideal State**: Needs to initiate the purchase of renewable electricity or invest in on-site renewable energy projects, such as installing solar panels on campus rooftops to generate clean electricity.

**Risk of Inaction**: Continued reliability on grid-based fossil fuel electricity will keep emissions at unsustainable levels.

**Fig. 48 Current, Ideal and Risk of inaction for Electricity Grid based sector**

The various strategies suggested to be implemented are as follows:

Next Step

1.

1. Conduct a comprehensive energy audit to identify specific areas of high consumption

2. implement comprehensive energy efficiency measures, such as installing LED lighting, upgrading to more efficient HVAC systems

3. deploying smart building management systems to optimize energy Implement programmable thermostats

4. smart building controls to optimize heating (Optimistic 15% savings — advanced AI controls ), ventilation, and air conditioning (HVAC) operation

5. Promote energy-saving behaviours among the university community, including turning off lights and equipment when not in use, and setting thermostats optimally

**Fig. 49 Suggested strategies for Electricity Grid based sector**

**Scope 1 Transport Emissions:** The reduction strategies for the transportation sector are as explained below. For various fuel consumption for transportation, the current, ideal and risk of inaction is as shown in the figure.

**Current State**

Transport emissions are moderate (up to ~5,000 kg $CO_2$e per month) due to fossil-fuel vehicles. Campus transport fleet is largely fossil fuel–powered.

**Ideal State**

Gradual electrification of the vehicle fleet (EVs), supported by renewable-powered charging.
Promote sustainable commuting (cycling, walking, carpooling, public transport).

**Risk of Inaction**

Failure to electrify transport will maintain direct Scope 1 emissions and expose the university to fuel price volatility.

**Fig. 50 Current, Ideal and Risk of inaction for transport sector**

The various strategies suggested to be implemented are as follows.

**Next Step**

1.

- Implement regular maintenance for existing vehicles and provide eco-driving training to drivers to improve fuel efficiency.
- Encourage alternatives to single-occupancy vehicle use, such as carpooling, cycling, walking, or utilizing public transportation.
- Gradually replace the fossil fuel-powered transport fleet with electric vehicles (EVs) to eliminate direct tailpipe emissions

**Fig. 51 Suggested strategies for transport sector**

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- https://www.iea.org/data-and-statistics/charts/comparative-life-cycle-greenhouse-gas-emissions-of-a-mid-size-bev-and-ice-vehicle?

**Scope 1 Stationary Source (LPG):** Scope 1 Stationery emission is observed lower impact area due to smaller emission. The current, Ideal and Risk of inaction in the field of Stationary fuel consumption is as shown below:

**Current State**

Stationary fuel cosmption rely on LPG and Diesel generator. though it is low impact area as it emits less CO2e.

**Ideal State**

Investigate switching from LPG to electric appliances for cooking and heating where feasible, leveraging the grid (and potentially renewable electricity) for cleaner operations.

**Risk of Inaction**

Failure to electrify LPG and Diesel use will Increased climate-related risks (e.g., heat stress in poorly managed buildings)

**Fig 52 Current, Ideal and risk of inaction for stationary fuel**

The various mitigation strategies suggested to be implemented are as follows:

Conduct audits of LPG-consuming equipment to identify opportunities for efficiency improvements or fuel switching.

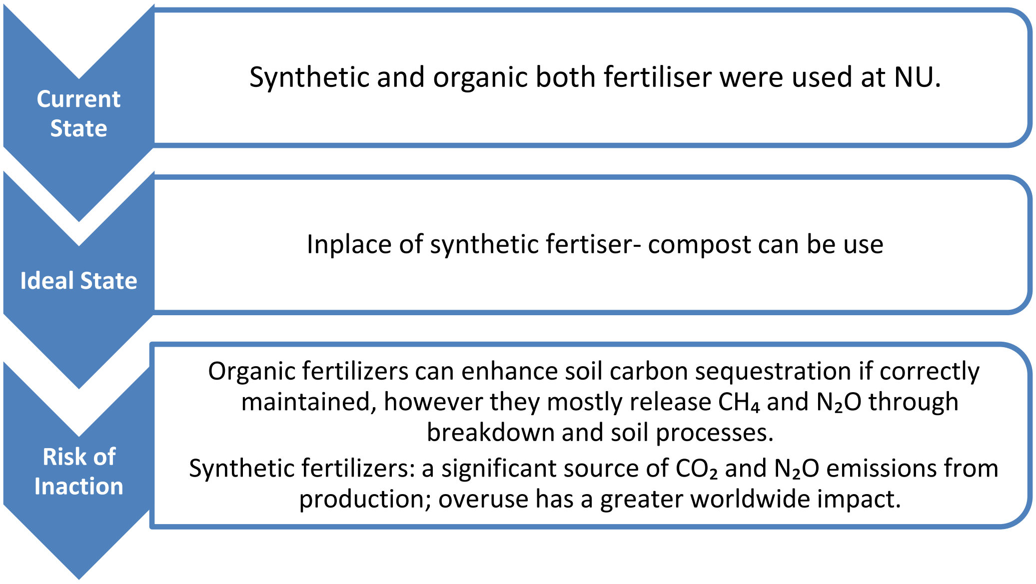
Investigate switching from LPG to electric appliances for cooking and heating where feasible

For specific applications, investigate the feasibility of switching from LPG to renewable energy sources, such as solar water heating where applicable.

Replace older, less efficient LPG appliances and equipment with newer, more energy-efficient models.

**Fig. 53 Suggested strategies for stationary fuel**

**Scope 1 Fertilizer (Organic & Synthetic):** Scope 1 Stationery emission is observed lower impact area due to smaller emission. The current, Ideal and Risk of inaction in the field of Stationary fuel consumption is as shown below:



**Current State**

Synthetic and organic both fertiliser were used at NU.

**Ideal State**

Inplace of synthetic fertiser- compost can be use

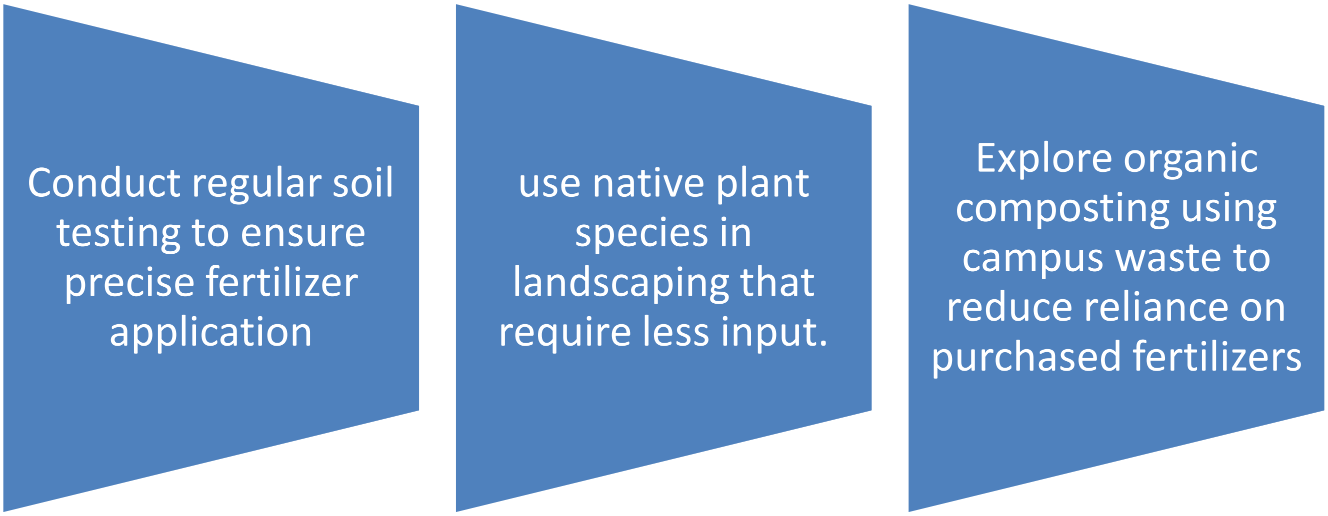
**Risk of Inaction**

Organic fertilizers can enhance soil carbon sequestration if correctly maintained, however they mostly release $CH_4$ and $N_2O$ through breakdown and soil processes.

Synthetic fertilizers: a significant source of $CO_2$ and $N_2O$ emissions from production; overuse has a greater worldwide impact.

**Fig. 54 Current, Ideal and risk of mitigation for fertilizer**

The various mitigation strategies suggested to be implemented are as follows:



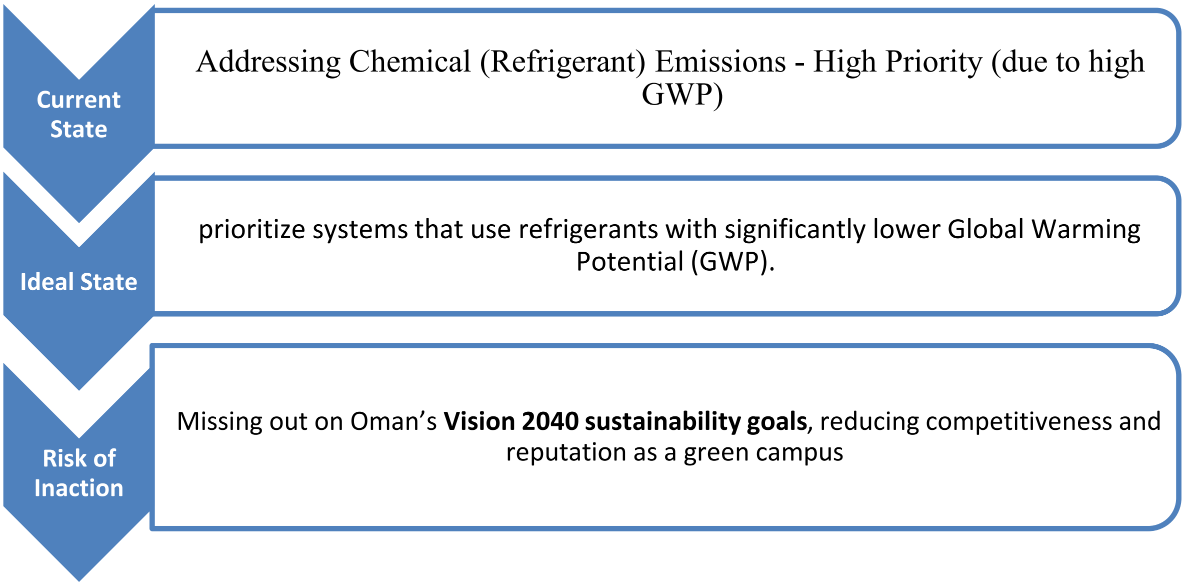
Conduct regular soil testing to ensure precise fertilizer application

use native plant species in landscaping that require less input.

Explore organic composting using campus waste to reduce reliance on purchased fertilizers

**Fig. 55 Mitigation strategies for fertilizer**

**Scope 1 Chemical & Refrigerant emission:** is observed lower impact area due to smaller emission. The current, Ideal and Risk of inaction in the field of Stationary fuel consumption is as shown below:



**Current State**

Addressing Chemical (Refrigerant) Emissions - High Priority (due to high GWP)

**Ideal State**

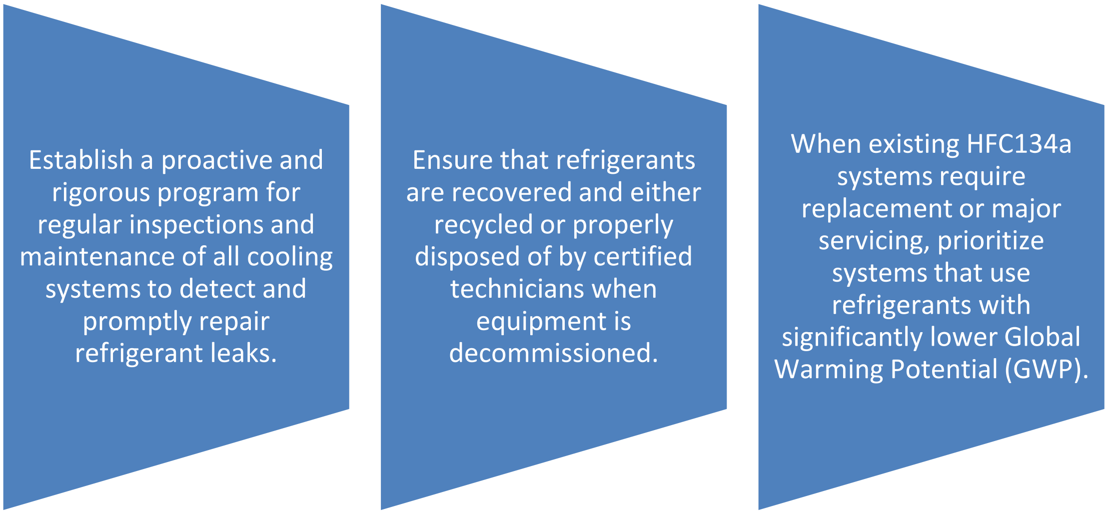
prioritize systems that use refrigerants with significantly lower Global Warming Potential (GWP).

**Risk of Inaction**

Missing out on Oman's **Vision 2040 sustainability goals**, reducing competitiveness and reputation as a green campus

**Fig. 56 Current, Ideal and risk of mitigation for chemicals and refrigerant**

The various mitigation strategies suggested to be implemented are as follows:



Establish a proactive and rigorous program for regular inspections and maintenance of all cooling systems to detect and promptly repair refrigerant leaks.

Ensure that refrigerants are recovered and either recycled or properly disposed of by certified technicians when equipment is decommissioned.

When existing HFC134a systems require replacement or major servicing, prioritize systems that use refrigerants with significantly lower Global Warming Potential (GWP).

**Fig. 57 Mitigation strategies for chemicals and refrigerant**

**Emission Reduction Using Specific Strategies**

The largest potential for GHG emission reduction at the College of Engineering and Al Hail lies in Scope 2 – Electricity consumption, which accounts for over 200,000 kg $CO_2e$ per month, far exceeding emissions from transport (~5,000 kg $CO_2e$/month) and stationary/fertilizer sources (<10 kg $CO_2e$/month). Targeted actions such as shifting to renewable energy supply and improving building energy efficiency would deliver the most impactful reductions in the university's carbon footprint.

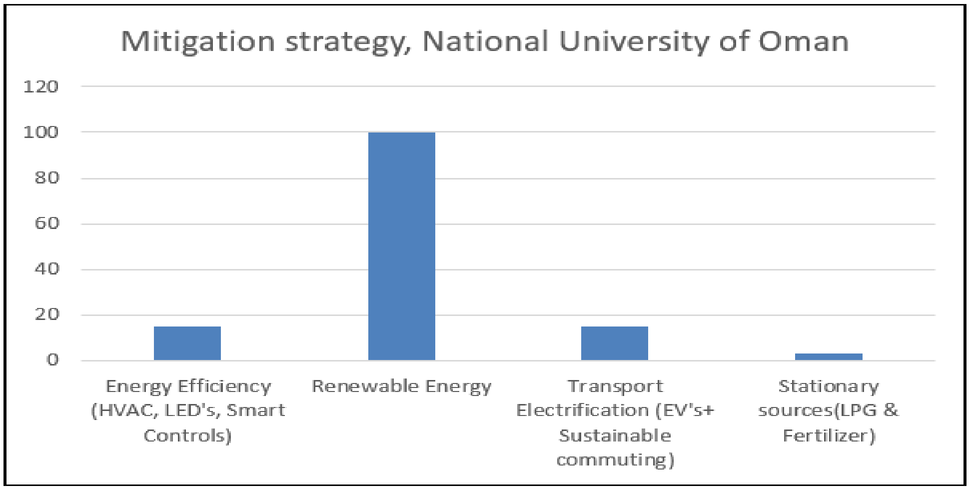


**Fig. 58 Mitigation strategies for National University of Oman**

## Key GHG Mitigation Strategy Flow for National University of Oman

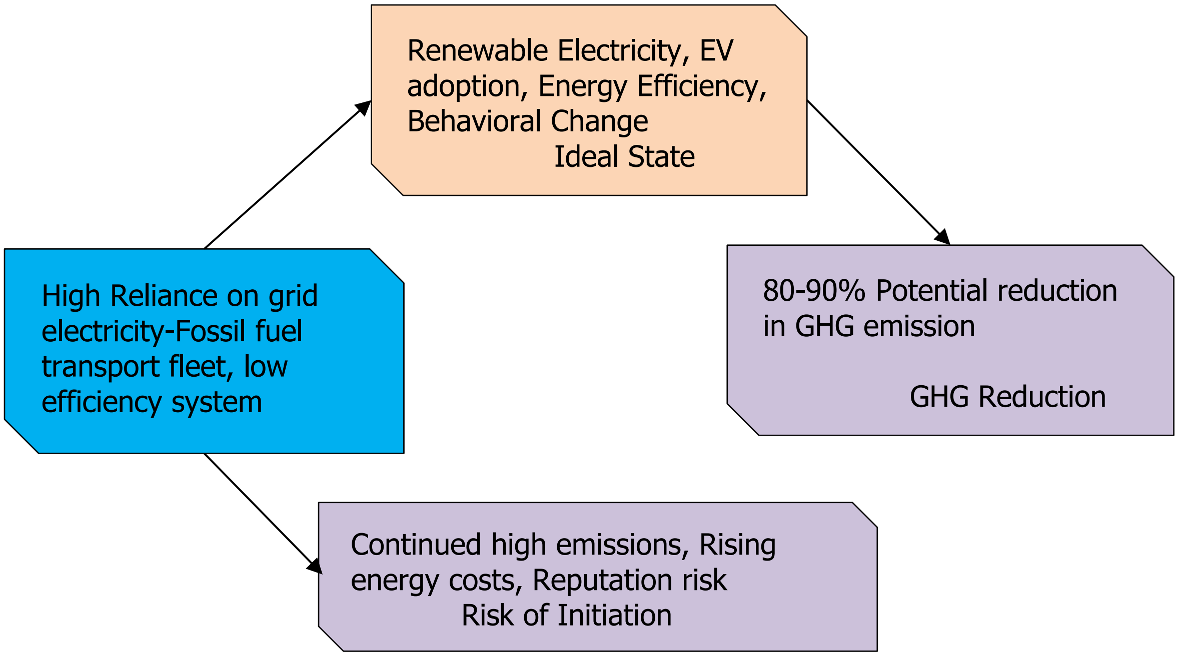


**Fig. 59 Key GHG Mitigation strategies for National University of Oman**

# VIII) Sustainable development goals and Mitigation Strategies

The Sustainable development goals and their corresponding mitigation strategies for the present study is as shown in the table

| Sr. No. | Sustainable development Goals | Mitigation strategy |
|---|---|---|
| 1 | **SDG 7 (Affordable and Clean Energy):** Promotes renewable energy and energy efficiency, which reduce GHG emissions. | ➢ Campus is not using any renewable energy source hence it needs to explore and initiate the purchase of renewable electricity or invest in on-site renewable energy projects, such as installing solar panels on campus rooftops to generate clean electricity. Conduct a comprehensive energy audit to identify specific areas of high consumption and implement comprehensive energy efficiency measures, such as installing LED lighting, upgrading to more efficient HVAC systems, and deploying smart building management systems to optimize energy use. |
| 2 | **SDG 11 (Sustainable Cities and Communities):** Encourages low-carbon transport, sustainable urban planning, and resilient infrastructure. | ➢ Replace the fossil fuel-powered transport fleet with electric vehicles (EVs) to eliminate direct tailpipe emissions. EVs don't emit directly at the tailpipe hence $CH_4$ and $N_2O$ are essentially 0 at vehicle level. |
| 3 | **SDG 13 (Climate Action):** Focuses on taking urgent action to combat climate change and its impacts by reducing GHG emissions, enhancing resilience, and integrating climate measures into national policies. | ➢ To genuinely reduce its carbon footprint, the National University must implement a more holistic and systemic approach, moving beyond isolated measures. Integrating green building principles into all aspects of campus planning and operations offers a robust strategy for mitigating GHG emissions while simultaneously fostering healthier and more sustainable environment. |

https://populationmatters.org/lp-population-and-the-sustainable-development-goals/?

# IX) Environmental Significance of the present study

Organizations are working harder to account for their carbon footprint in response to the need to lower greenhouse gas emissions. Although there are broad rules for calculating carbon footprints, they typically do not take into account unique organizational characteristics, such as those of higher education institutions. Then, case studies can serve as educational resources, and best practices can be developed by contrasting implemented techniques.

The present study extends the pool of accessible computation approaches proposed under real-life settings by offering a case study for various Institutions in Oman.

LPG, a stationary fuel, contributes to global emissions in a modest way. When burned, it produces less CO2 per kilogram than other fossil fuels like gasoline or heavy fuel oils. Despite being cleaner, LPG is still a fossil fuel, and as it burns, it releases CO2, one of the main greenhouse gases causing climate change.

Because universities are made up of people, their main goals are education and research, which puts an emphasis on its staff and students. This background would not be acknowledged if emissions thought to be personal choices were excluded. Additionally, even though a student or staff member chooses their own method of transportation, the university can have an impact by offering suitable facilities or encouraging the use of EV’s, bicycles etc. Employees and students may also frequently be obliged to attend mandatory activities or work from campus. As a result, their employment at the university directly affects their commute, and the university should bear the responsibility for the associated emissions.

Many chemical refrigerants contain hydrofluorocarbons (HFCs), which have a Global Warming Potential (GWP) hundreds to thousands of times higher than carbon dioxide (CO2) per unit mass, they are a major source of greenhouse gas (GHG) emissions. In the present study impact of chemicals and refrigerants have also been considered in GHG emission.

The power sector is the largest contributor to global GHG emissions, making it a critical focus for climate mitigation efforts. Since the energy industry is the biggest contributor to greenhouse gas emissions worldwide, utilities play a crucial role in GHG emissions since they supply the energy that drives society. The potential for utilities to reduce emissions through efficiency improvements, methane leakage from gas distribution, and renewable energy investments makes them significant.

Examining greenhouse gas (GHG) emissions in educational institutions is crucial because it offers information for creating efficient climate mitigation plans, identifies relevant sources such as energy use and student mobility, and sets a baseline for emission reduction targets. These studies help achieve carbon neutrality, increase institutional awareness, and facilitate the adoption of sustainable practices—all of which benefit larger initiatives to combat climate change.