

Our Carbon Footprint



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The Desert Development Center (DDC)

The DDC is a non-profit research center established by the American University in Cairo in 1979. The center's mission is the ecologically, socially, and economically sustainable development of Egypt's communities. The center conducts research and offers training and community services.

The Office of Sustainability

The Office of Sustainability, headed by a Sustainability Coordinator, was established in September, 2011. The Office is responsible for addressing AUC's environmental challenges, including climate change, pollution, waste management and resource conservation, in ways that improve the university's operations and strengthen its finances.

MESSAGE FROM THE PRESIDENT

With the establishment of its Office of Sustainability in September 2011, the American University in Cairo reaffirmed its commitment to environmentally-responsible economic growth and stewardship of the earth's resources. Since the creation of the Desert Development Center more than three decades ago, AUC has championed what would become known as sustainable development and today, with the publication of the first Carbon Footprint Report by a university in the Middle East and North Africa, we challenge ourselves and our communities to measure our impact and manage it responsibly.

Egypt's special vulnerability to the effects of climate change and its rising per capita carbon emissions make it a particularly opportune time to address this crucial component of sustainability. We at AUC believe that having a meaningful impact on climate change starts at home, with calculation of our own carbon footprint. This project represents the first attempt in the region to measure a university's impact on climate change. It not only enables AUC to work on the reduction of greenhouse gas emissions on its own campus, but to serve as a model and a challenge, encouraging others to address climate change as well.

Preparation of this report was an interdisciplinary effort, drawing on talent from across the university, including faculty in engineering, students in public policy and in science, and administrative staff from a variety of departments, from facilities and maintenance to institutional research. The report includes 17 specific recommendations for reducing AUC's carbon footprint; in the coming months, we will be developing community conversations about how to assess and apply those recommendations.

I would like to thank all those who worked with Marc Rauch, the Sustainability Coordinator and Richard Tutwiler, the Director of the Desert Development Center, in developing this ground-breaking report, and hope that it will be model for future efforts at AUC and universities across Egypt and the region to ensure that we all recognize our responsibilities to be trustworthy stewards of the Earth's resources.



Lisa Anderson

President

The American University in Cairo

September, 2012



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EXECUTIVE SUMMARY

Carbon footprints are a widely accepted method of measuring the impact of human activity on climate change. A university's carbon footprint is the annual total of carbon dioxide (CO₂) and other significant greenhouse gases emitted into the atmosphere as a result of daily activities and campus operations. Carbon footprints are commonly measured in metric tons of carbon dioxide equivalents (MTCO₂e). The impetus to calculate AUC's carbon footprint came from three overlapping concerns: first, the growing scientific consensus that climate change is real and potentially catastrophic; second, the University's commitment to innovative research in the field of sustainability; and third, the desire to make AUC's operations more sustainable.

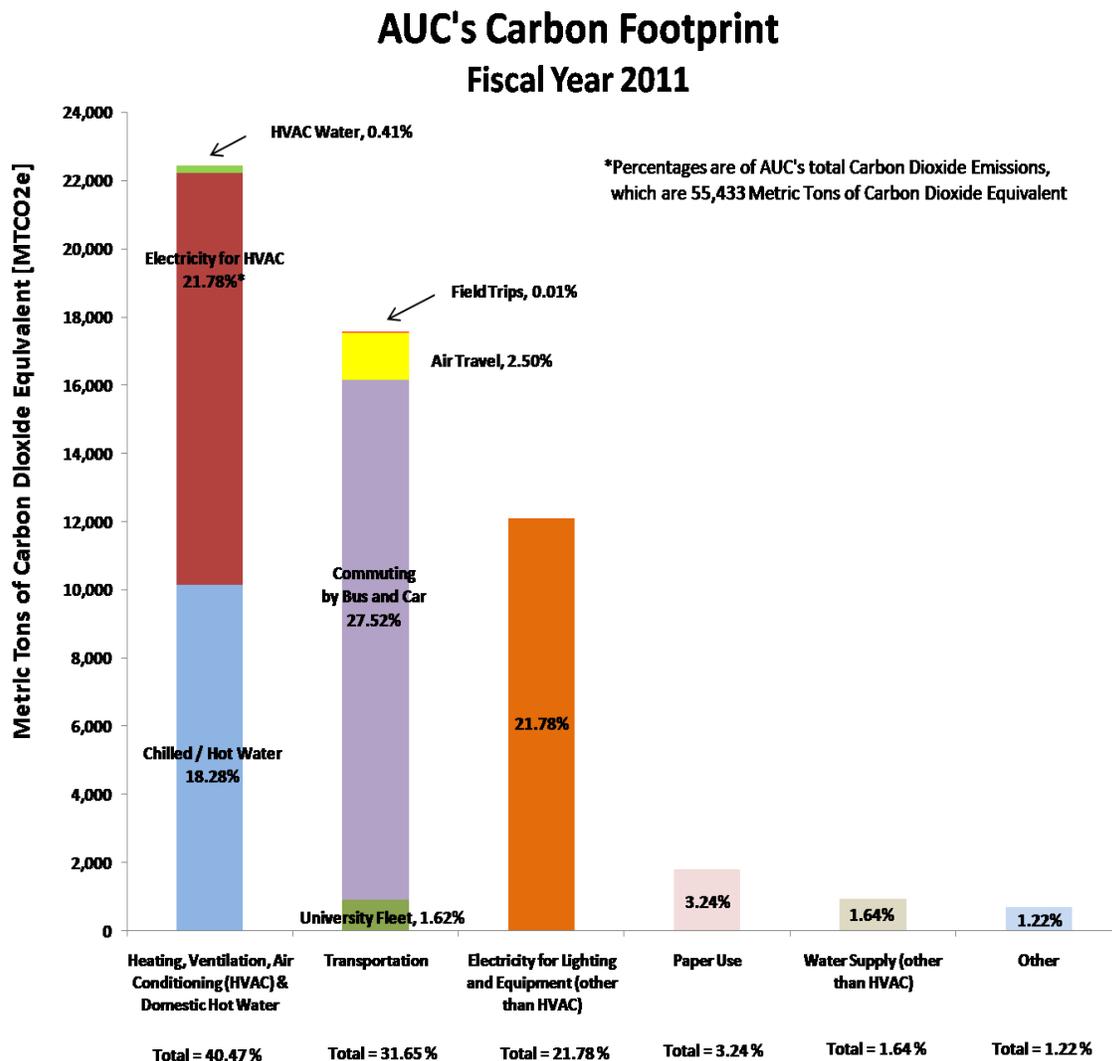


Figure 1: AUC's Carbon Footprint, Fiscal Year 2011.

This study calculates the carbon footprint for AUC's New Cairo campus, where the bulk of the University's activities now take place. It covers AUC's Fiscal Year 2011 (FY 2011), which ran from September 1, 2010 through August 31, 2011. FY 2011 will serve as the baseline from which all future changes to AUC's carbon footprint will be measured. The main activities contributing to AUC's carbon footprint (see Box 1), namely heating, ventilation and air conditioning (HVAC) and domestic hot water, transportation, lighting and use of electrical equipment, paper use and water supply, are shown in Figure 1, together with the percentage contribution of each to the carbon footprint.

Box 1: The Key Contributors to the Footprint

Nearly 90% of AUC's carbon footprint is attributable to three activities: (1) heating, ventilation and air conditioning (commonly known as "HVAC") and domestic hot water; (2) commuting; and (3) lighting and use of other electrical equipment (see Figure 1).

HVAC

More than 40% of the carbon footprint results from HVAC. Not surprisingly, given that the campus is located in a desert climate where air conditioning is needed more than half the year, the vast majority of these CO₂ emissions are caused by air conditioning. There is simply no way to significantly reduce AUC's carbon footprint unless we find more efficient ways to air condition the campus.

Commuting

More than 27% of the carbon footprint can be traced to commuting by bus and car. Again, this is hardly surprising since thousands of AUCians now commute daily from all over Greater Cairo to AUC's New Cairo campus 35 km east of Downtown. Developing more sustainable modes of commuting is a must if we are to significantly reduce our carbon footprint.

Lighting

More than 21.5% of the carbon footprint results from lighting and from the use of office and other electrical equipment on campus. Simply put, if we are serious about reducing our carbon footprint, we must learn to turn off the lights.

Paper

The use of paper contributes 3.24% to the carbon footprint. Unfortunately, recycled paper for office use is not yet locally available in Egypt. Although we have greatly reduced paper consumption since moving from Downtown, we need to cut our paper use further.

Water

Just over 2% of AUC's carbon footprint is caused by water use, 0.41% for HVAC and the remaining 1.64% for domestic use and irrigation. Given the unique geography of Egypt, where for millennia the very possibility of life has depended on proximity to the Nile, no study of AUC's carbon footprint would be complete without examining the CO₂ emissions resulting from transporting AUC's water from its source, the Ismailia Canal 54 km away, and up inclines totaling more than 300 meters to the New Cairo campus. Not only to reduce our carbon footprint but because water scarcity is a looming threat to Egypt, we must do a better job of conserving water.

The paths to reducing AUC's carbon footprint are clear. In the report that follows, we set forth the methodology, sources of data and assumptions that underlay our findings, and we propose specific, concrete steps that we can take to reduce our carbon footprint.

1. INTRODUCTION

1.1 Why Do a Carbon Footprint Study at AUC?¹

Of all the countries in the Arab world, Egypt is the most vulnerable to global warming. The rising sea level predicted by climate change models threatens to flood large swaths of the Delta, Egypt's breadbasket (see Figure 2), undermining Egypt's food security and threatening the livelihoods of millions of agricultural workers. Key population centers are also at risk, most notably the cities of Alexandria and Port Said. Additionally, rising mean temperatures will have a negative impact on Egypt's ability to grow enough food to feed its burgeoning population, causing further disruptions in the agricultural sector that presently employs over 30% of the workforce. Not least among the threats is the potential impact on rainfall patterns in highland Ethiopia, the source of over 80% of the Nile River flow reaching Egypt. Given Egypt's near total dependence on the Nile for its fresh water, either a reduction in average precipitation or a greater variation in annual rainfall in Ethiopia would seriously challenge the sustainability of Egyptian society.

Displaced population: 3,800 000
Lost cropland: 1,800 km²



Displaced population: 6,100 000
Lost cropland: 4,500 km²



Figure 2: Potential impact of sea level rise: Egypt's Nile Delta.

Sources: Simonett (UNEP/Grid), Sestini (Remote Sensing Center) and DIERCKE Weltwirtschaftsatlas.

The potentially stark consequences of climate change for Egypt led The American University in Cairo to undertake the first carbon footprint study of an institution of higher education in the Middle East and North Africa (MENA). The study also responds to a concern about the sustainability of AUC's own operations after the University moved most of its activities from a small 90-year-old campus in Downtown Cairo to a new 260-acre campus in the sprawling desert suburb of New Cairo, about 35 km to the southeast of the Downtown campus.

Carbon footprints are widely used as a measure of the impact of human activities on global warming.² A carbon footprint calculates net greenhouse gas (GHG) emissions over time, typically one or more years. The World Resources Institute describes the term as "a representation of the effect you, or your organization, have on the climate in terms of the total amount of greenhouse gases produced (measured in

¹ Portions of Section 1.1 appeared initially in Tutwiler, R. and Rauch, M., "Our Carbon Footprint", The Cairo Review of Global Affairs, Spring, 2012, pp. 12-15.

² A recent high-level survey of sustainability indicators concluded that carbon footprints remain a powerful tool, "capable of sending strong messages in terms of the overutilization of the planet's capacity for absorption" (Stiglitz et al., 2010, p.113-116).

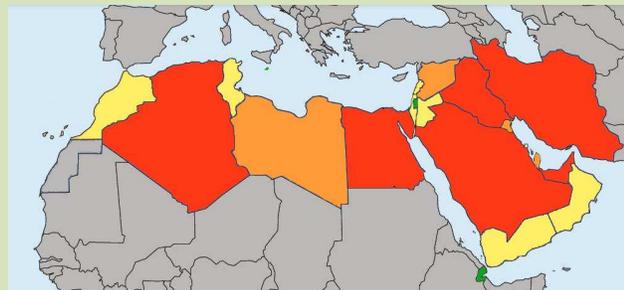
units of carbon dioxide)”.³ A carbon footprint offers a means to identify carbon emission sources, and to evaluate progress in the reduction of these emissions. In AUC’s case, a principal goal of the study is to develop information that can be used to mitigate climate change by reducing AUC’s own greenhouse gas emissions. A second important goal is to strengthen the University’s finances for the long term by permanently reducing its appetite for carbon-based energy sources like natural gas, electricity, gasoline and diesel fuel that must be purchased from third parties. Finally, our footprint study is designed to provide a replicable model and methods that can be adopted by other institutions of higher education in the MENA region to calculate and evaluate their own carbon emissions.

1.2 Greenhouse Gas Emissions in Egypt and the MENA Region

The principal activities generating Egypt’s carbon emissions on the macro level are broadly comparable to AUC’s, in that just over 40% of Egypt’s total emissions come from two sectors: power generation and road transport. This is comparable to other MENA countries (see Box 2), particularly those with a significant hydrocarbon (petroleum and natural gas) sector. In Egypt, the proportional shares of emissions from power, road transport, and basic industry are expected to increase, while the proportional contributions from agriculture, solid waste, and construction should decrease.⁴

Box 2: Carbon Emissions in the Middle East

Egypt’s national greenhouse gas (GHG), or carbon, emissions profile is broadly similar to those of its neighbors. With an estimated total emissions of around 318.2 million metric tons of CO₂e (carbon equivalent) in 2010, Egypt is among the highest in total emissions. However, its per capita emissions, given Egypt’s large population of more than 85 million inhabitants, are less than half the regional average. Qatar heads the list of the world’s highest per capita carbon emitters, while Kuwait, the Emirates and Bahrain occupy ranks three, four and five; Saudi Arabia ranks 14th on the same list, while Egypt, at about 2.8 tons per person, ranks 124th. Nevertheless, predictions are for Egypt’s emissions to increase at a faster pace than population growth: by the year 2030 Egypt’s total emissions will have more than doubled and Egypt’s share of world emissions will grow by 50%.



MENA annual CO₂ emissions per country (thousand metric tons).
 0-4,999; 5,000-49,999; 50,000-99,999;
 100,000-550,000

Source: United Nations Statistics Division. (2008).

Source: Carboun Group, 2011; EEAA, 2012.

The obstacles to reducing emissions in Egypt and the region include arid to hyper arid desert ecosystems, lengthy summers with extreme temperatures, rapid urbanization and the limits of prevailing technologies. In Egypt, the potential for lowering emissions or at least reducing the rate of growth in emissions is slightly lower than in comparable developing economies because gains have already been made in the power generation sector: Egypt already has a high proportion of natural gas-fired power plants and uses no coal-fired plants. Overall, the best strategy may be to lower consumer demand for electricity in buildings, while developing more power generating capacity from renewable sources, particularly wind and solar energy.⁵

³ World Resources Institute (WRI), SafeClimate, <http://www.safeclimate.net/calculator/>, viewed in November 2011.

⁴ Industrial Modernization Center (IMC, Egypt). 2010. “Egypt GHG emissions reduction strategy” www.imc-egypt.org/studies/Egypt_GHG_Emissions_Reduction_Strategy.pdf.

⁵ Ibid.

1.3 University Overview

The American University in Cairo (AUC) was founded in 1919 as a liberal arts college offering quality American-style education to Egyptians and other students in the MENA region. AUC is also dedicated to community service and promoting sustainable development. In September 2008, the University moved the bulk of its operations from its original five acre central Cairo campus on Tahrir Square to an all-new, state-of-the-art 260 acre campus in New Cairo. The amount of built space jumped from 68,000 m² to 203,000 m². In the past five years, the University's operating budget has more than doubled, and the student, faculty, and staff head counts have increased considerably. In short, the University's activities are expanding to capitalize on its new facilities and achieve its long-term strategic goals.

In Fiscal Year 2011 (September 1, 2010 – August 31, 2011), the University's operating budget was US\$160.5 million, including an energy budget of US\$6 million and a research budget of US\$8.7 million. Table 1 below shows the New Cairo campus population in FY 2011:

Table 1: AUC student body in FY 2011

Full-Time Students	5,321
Part-Time Students	1,232
Faculty	838
Staff	2,198
Total	9,589
Total Full-Time Equivalent (FTE) Students ⁶	5,937

1.4 AUC's Central Utility Plant and Co-Generation

Since nearly two thirds of AUC's greenhouse gas emissions can be traced to heating, ventilation and air conditioning (HVAC), domestic hot water, and use of lighting and other electrical equipment (See Figure 1), a basic understanding of how these vital services and utilities are delivered to the New Cairo campus is crucial for understanding AUC's carbon footprint. In 2006, as part of the construction of the New Cairo campus, AUC entered into a long-term contract with The Egyptian Company for Refrigeration by Natural Gas (GasCool) to build and operate an on-campus central utility plant.⁷ The plant, which has a floor area of some 5,781 m² (62,226 ft²) and is illustrated schematically in Figure 3, produces all of the chilled water used for air conditioning campus buildings⁸, all of the hot water used for heating, most of the domestic hot water⁹ and two thirds of the electricity¹⁰ used on campus.

The design of AUC's central utility plant is environmentally friendly in two important respects. First, the fuel used is natural gas, a relatively clean-burning (albeit hydrocarbon-based) fuel that is extracted domestically from abundant reserves in Egypt. Second, the plant uses co-generation, a process of capturing and recycling waste heat from generating electricity, to produce a significant portion of the hot water used on campus for heating and domestic hot water.

⁶ Includes full-time students and part-time students representing half of one full-time student.

⁷ GasCool later subcontracted operation of the electricity-generating portion of the plant to Kahraba, also known as the National Electricity Technology Co.

⁸ A few specialized areas, e.g. the rare books section of the library, are served by stand-alone air-cooled air conditioning units.

⁹ In locations where demand for domestic hot water is relatively light, e.g. hot water taps in bathrooms in campus office buildings, hot water is supplied by stand-alone electric hot water heaters.

¹⁰ The remaining electricity is obtained from the public utility (Egyptian Engineering Agencies or EEA), as discussed further below.

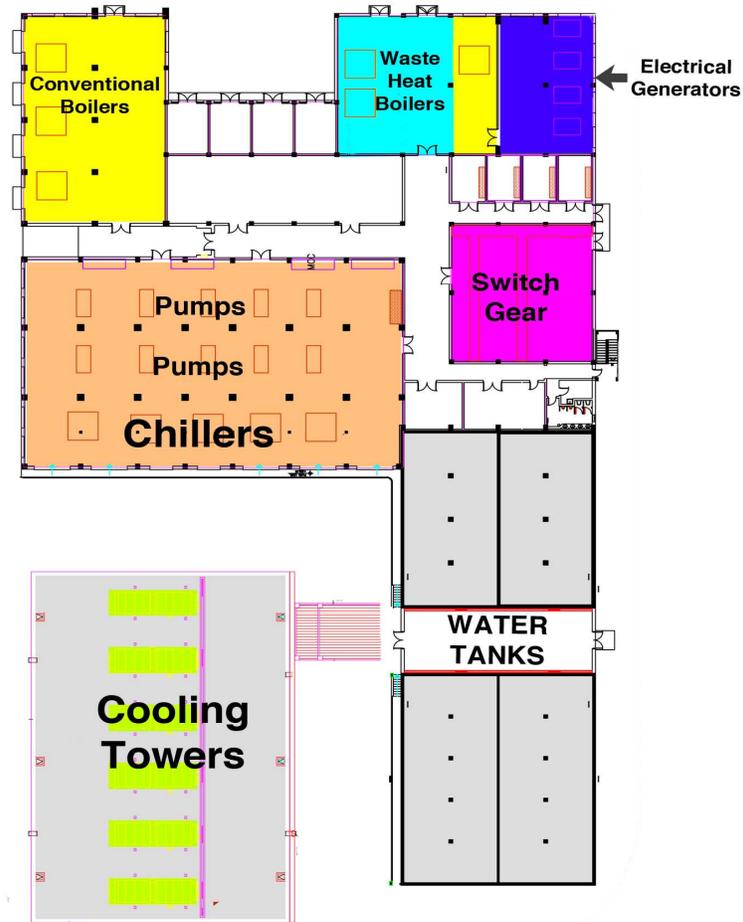


Figure 3: Schematic Diagram of the Central Utility Plant on the AUC Campus.

1.4.1 How the Utility Plant Works

Chilled Water for Air Conditioning

Chilled water is produced by five gas-fired absorption chillers, shown in Figure 3. Natural gas is burnt to drive compressors that remove accumulated heat from circulating water, in a process not unlike what occurs in a home refrigerator but on a larger scale. Waste heat produced by the gas-fired chillers is released through evaporation of water from six cooling towers shown adjacent to the gas-fired chillers in Figure 3. The cooling towers are shown in Figure 14.

Electric pumps (also shown in Figure 3) circulate the chilled water to a system of 150 electric-powered air handling units throughout the campus. The air handling units effectively convert chilled water to cool air, which is then circulated to air conditioned zones within campus facilities by a system of more than 1,200 electric-powered VAV (variable air volume) units.

Hot Water for Heating and Domestic Hot Water

Four conventional boilers (shown in yellow in Figure 3) and two waste heat boilers (shown adjacent to the electricity generators in Figure 3) produce hot water for heating and for domestic hot water. The four

conventional boilers heat water by burning natural gas. Each of the waste heat boilers, by contrast, heats water by using hot exhaust fumes from a gas-fired electricity generator. This is the co-generation process referred to previously. Hot water produced by the gas-fired boilers and the waste heat boilers is circulated to individual facilities throughout the campus by electric pumps, then converted to hot air for heating or used for domestic hot water, in each case by means of additional pumps and other electrical equipment.

Electricity – Principal Uses

It is presently estimated that half¹¹ of all electricity used on campus in FY 2011 was used for HVAC: electricity drives pumps circulating chilled water and hot water throughout the campus for air conditioning, heating and domestic hot water, and it also powers air handling units, VAV units, ventilation equipment and other electrical equipment that is part of the HVAC system. The balance of the electricity used on campus (i.e. the approximate half of all electricity not used for HVAC) is used for lighting, office equipment and many other types of electrical equipment.

Electricity – From Two Sources

Approximately two thirds of the electricity used on campus in FY 2011 was produced by three of the four gas-fired electricity generators shown in Figure 3¹². As noted above, two of these gas-fired electricity generators feed their exhaust fumes to waste heat boilers for co-generation.¹³ The remaining one third of the electricity used on campus in FY 2011 was obtained from EEA, the public utility. The decision whether to use electricity from the on-site electricity generators, from the public utility or from both simultaneously depends on the size of the demand for electricity on campus, on the amount of electricity then available from each source, and on the cost per kilowatt hour from each source. The electric switch gear shown in Figure 3 continually enables technicians to adjust the amount of electricity consumed by AUC from each source.

2. OVERALL METHODOLOGY AND ORGANIZATION OF REPORT

2.1 Reference Carbon Calculator

AUC's emission calculations are premised on the methodology used by the Clean Air – Cool Planet Carbon Calculator (CA-CPCC).¹⁴ CA-CPCC is widely used by other universities and time-tested. CA-CPCC is an Excel-based workbook capable of quantifying an annual aggregate carbon footprint. Once data is collected, verified and formatted into proper units for entry, the software calculates emissions of carbon dioxide, methane and nitrous oxide, the three most commonly reported GHG emissions. The CA-CPCC spreadsheets in turn are based on workbooks and protocols provided by the Intergovernmental Panel on Climate Change (IPCC), the GHG Protocol Initiative and the Climate Registry.

CA-CPCC had to be modified and supplemented for use at AUC. For example, as discussed more fully below, the AUC team had to identify and construct a number of emission factors specific to Egypt, to Cairo and even to processes occurring uniquely at AUC's central utility plant. Moreover, CA-CPCC does not account for carbon emissions attributable to water supply, an issue of significant concern in an arid

¹¹ The conclusion that approximately half of all electricity used on campus was used for HVAC is based on preliminary surveys, in selected buildings on campus, of electricity used for HVAC equipment as a proportion of electricity used for all purposes.

¹² The fourth generator was added at the start of FY 2012.

¹³ See discussion of co-generation as a carbon offset in Section 9.1 of this report.

¹⁴ Clean Air-Cool Planet was established in 1999 as a non-profit organization and has published several versions of its carbon calculator software. To date more than 1,000 universities in North America have used CA-CPCC to calculate their carbon footprints. CA-CPCC is also the calculator most commonly used by signatories to the American College and University Presidents Climate Commitment (ACUPCC). Additionally, most of AUC's peer institutions have relied on CA-CPCC.

country like Egypt. Ultimately, the AUC team used CA-CPCC as a guide for constructing AUC's own calculator based on methodologies substantially similar to CA-CPCC's, rather than using the CA-CPCC worksheets as such. Whenever possible, however, this carbon footprint report uses categories and methods of analysis similar to those used by CA-CPCC to facilitate comparisons with the other schools also relying on CA-CPCC.

2.2 Boundaries

This report focuses exclusively on the New Cairo campus where the bulk of the University's operations now take place.¹⁵ AUC's original historic campus in Tahrir Square, as well as smaller remote or satellite facilities, have accordingly been excluded from this analysis.

2.3 Calculations

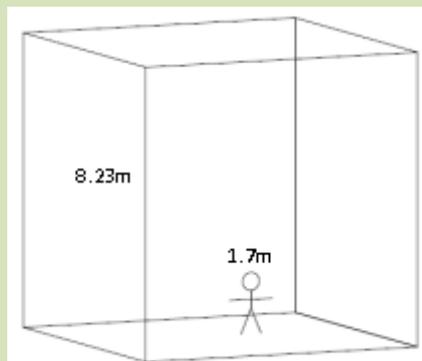
This report accounts for three of the six main greenhouse gases (GHGs): Carbon Dioxide (CO₂), Methane (CH₄) and Nitrous Oxide (N₂O). The main unit of measure is metric tons (MT) of carbon dioxide equivalents (CO₂e), which is the most widely used reporting method (see Box 3).¹⁶ Carbon dioxide equivalents of CH₄ and N₂O are based on the global warming potential (GWP) of each gas – which compares the amount of heat trapped by a similar mass of carbon dioxide. Methane has a GWP of 21 and nitrous oxide has a GWP of 310 over a 100 year interval.¹⁷ Carbon dioxide equivalents (CO₂e) are used here to express the relative global warming impact of each of the three greenhouse gases through a single unit of measure. The principal formula used in this report for calculating equivalents is as follows:

$$\text{Consumption of Energy (unit)} \times \text{Emission Factor (unit CO}_2\text{e/unit of energy)} = \text{Units of CO}_2\text{ Equivalent}$$

Box 3: What does 1 metric ton of carbon dioxide look like?

In order to visualize a metric ton (MT) of carbon dioxide (CO₂), see the box diagram below.

1 MT of CO₂ in its gaseous form as it is found in the atmosphere would amount to approximately 557 m³, represented here by a cube of 8.23 m length per side. The small stick figure was placed in the cube for scale comparison – it has the height of an average Egyptian adult male.



Sources:

Egypt – Demographic and Health Survey, 2008

Calabrese, 2010

World Bank, 2011

¹⁵ By way of example, in FY 2011 91% of the energy consumed by the university as a whole was consumed at the New Cairo campus.

¹⁶ See Box 1 for description.

¹⁷ Global Warming Potentials, http://unfccc.int/ghg_data/items/3825.php.

2.4 Organization of Balance of Report

Sections 3 through 7 of this report analyze the number of metric tons of carbon dioxide equivalent resulting from each of the principal activities at AUC giving rise to carbon emissions, in descending order by amount of emissions: (1) HVAC, (2) transportation, (3) electricity used for lighting and equipment, (4) paper use and (5) water supply. Section 8 analyzes the smaller, but still significant, carbon emissions resulting from miscellaneous other activities on campus. The detailed analysis of emissions in Sections 3 through 8 is followed in Section 9 by an analysis of AUC's carbon offsets resulting from co-generation and landscaping. The final two sections of the report, Sections 10 and 11, compare AUC's emissions to those of other universities and offer 17 specific recommendations for reducing AUC's carbon footprint.

3. HEATING, VENTILATION, AIR CONDITIONING (HVAC) AND DOMESTIC HOT WATER

3.1 Summary

As shown above in Figure 1, more than 40% of AUC's carbon emissions are attributable to heating, ventilation and air conditioning (HVAC), and domestic hot water. These vital services are produced by using electricity, natural gas and water in various processes occurring at the central utility plant.

Electricity is used to power pumps circulating chilled water throughout the campus for air conditioning and pumps circulating hot water throughout the campus for heating and domestic hot water. Electricity is also used to power air handling units, variable air volume (VAV) units and other equipment required to operate and regulate the HVAC system.

Chilled water for air conditioning (AUC's biggest energy user and source of carbon emissions given Cairo's hot climate¹⁸) is produced by gas-fired chillers at the central utility plant. The waste heat given off by the gas-fired chillers is removed by a circulating water system that releases the waste heat from six cooling towers through evaporation of water (see Figure 4). This process alone accounts for more than 20% of AUC's total water use during the hot summer months (see Section 3.4).

Hot water for heating and domestic hot water is produced in one of two ways. Whenever possible, exhaust fumes from gas-fired electricity generators are used to heat water in waste-heat boilers (a process known as co-generation). When the waste heat boilers are not sufficient for producing the volume of hot water required, additional hot water is produced in conventional, gas-driven boilers.



Figure 4: Cooling towers forming part of AUC's air conditioning system. Note the plainly visible water evaporation.

¹⁸A recent New York Times article reported that Cairo has nearly twice as many "cooling degree days" (a common measure of the need for air conditioning) as Tokyo and nearly three times as many cooling degree days as New York City (Rosenthal, 2012).

3.2 Electricity for HVAC

3.2.1 Emissions

In FY 2011, the University emitted an estimated 7,045.59 MT CO₂e through the consumption of electricity from the Cairo grid (Egyptian Engineering Agencies or EEA) and an estimated 17,104.38 MT CO₂e from electricity consumed from the central utility plant. Out of the total emissions from the consumption of electricity, 24,149.96 MT CO₂e, an estimated 50% or **12,074.98 MT CO₂e** resulted from operation of the HVAC system.¹⁹

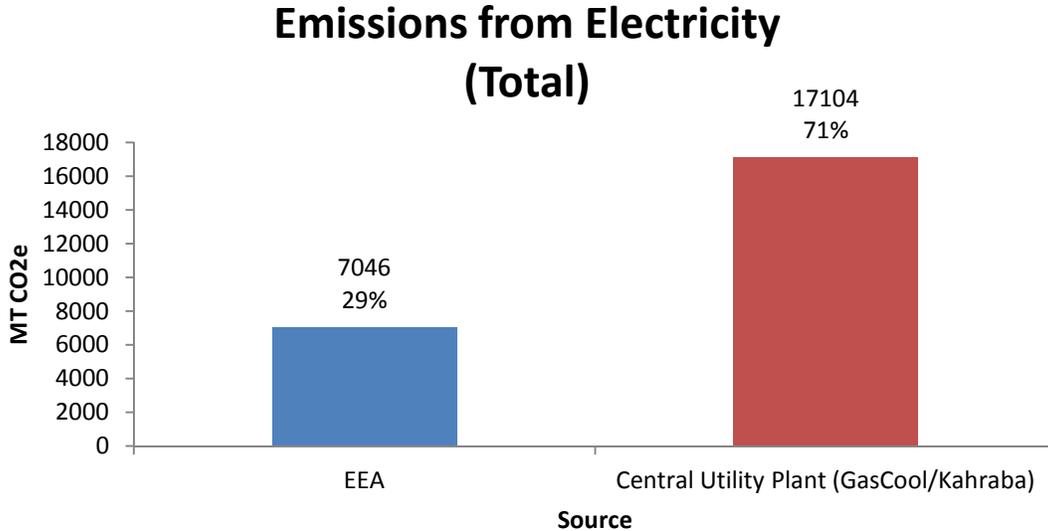


Figure 5: Emissions from electricity from the grid (EEA) and the central utility plant.

3.2.2 Consumption

The University consumed 14,005,600 kWh of electricity from EEA (Cairo electricity grid) and 27,900,000 kWh from its own central utility plant.

3.2.3 Methodology

In order to calculate the emission factor for the Cairo grid it was necessary to determine emission factors for the energy inputs used to create the electricity. In the Cairo Zone, the fuel mix is 83.8% natural gas and 16.2% *mazout* (high density fuel oil).²⁰ The efficiency of electricity production is 42.59% (weighted average among the seven Greater Cairo generating facilities). The central utility plant uses 100% natural gas and produces electricity at 32.98% efficiency. We calculated emission factors for the Cairo grid using the following formula:²¹

$$Emission\ Factor_{grid} = \frac{(Emission\ Factor_{Natural\ Gas} * \% Natural\ Gas) + (Emission\ Factor_{Mazout} * \% Mazout)}{Efficiency}$$

¹⁹ See Section 1.4.1.

²⁰ EEA Annual Report Fiscal Year 2011.

²¹ UNFCCC/CCNUCC, EB 61 Report, Annex 12, Version 02.2.0, 2011.

The formula was modified for the electricity coming from the central utility plant, since no *mazout* is used. We used the same formulas for CH₄ and N₂O emissions.²²

3.2.4 Data Sources

Data on electricity consumption was provided by AUC’s Office of Facilities and Operations/Maintenance and EEA.

3.2.5 Emission Factors²³

Source	Mass Emissions (kgCO ₂ e/kWh)
EEA	0.503055231
GasCool/Kahraba	0.613060036

3.3 Chilled / Hot Water

3.3.1 Emissions

The University emitted an estimated **10,135.56 MT CO₂e** from the production of chilled water for air conditioning and the production of hot water for heating and domestic hot water (see Figure 6). Most of these emissions result from air conditioning. Of the total emissions, 9,436.46 MT CO₂e can be attributed to chilled water consumption, the remaining 699.10 MT CO₂e to the consumption of hot water. Through co-generation, much of the hot water used for heating and domestic hot water is produced from waste heat in special waste heat boilers that do not generate additional carbon emissions. Without co-generation, production of hot water for heating and domestic hot water would have resulted in an additional 1,438.09 MT CO₂e of carbon emissions in Fiscal Year 2011.²⁴

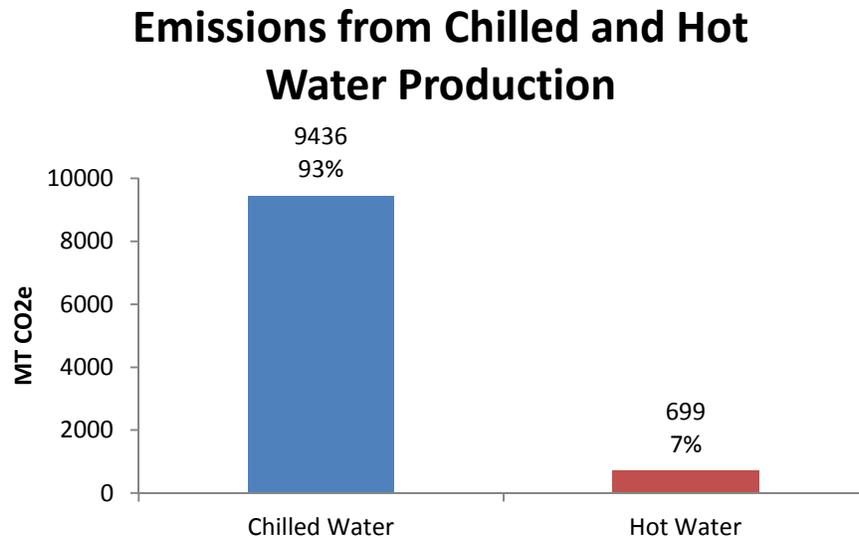


Figure 6: Emissions from chilled and hot water production.

²² See Appendix 2 for calculations.

²³ Constructed values, see Appendix 2.

²⁴ See discussions of co-generation in Sections 1.4.1 and 9.1.

3.3.2 Consumption

In total, the University consumed energy equivalent to 45,362,434.35 kWh for chilled and hot water produced by chillers and conventional boilers at the central utility plant. Of the total, 36,404,084.00 kWh are attributable to chilled water, the remaining 8,958,350.35 kWh to hot water.²⁵

3.3.3 Methodology

We constructed emission factors for the production of chilled water by gas-fired chillers and hot water by gas-fired (conventional) boilers at the central utility plant (see Appendix 3 for calculations).

3.3.4 Data Sources

We obtained data on chilled and hot water use from the Office of Facilities and Operations/Maintenance.

3.3.5 Emission Factors²⁶

Source	Mass Emissions (kgCO ₂ e/kWh)
GasCool (Chilled Water Production)	0.259214359
GasCool/Kahraba (Hot Water Production)	0.238568968

3.4 Water Consumption for HVAC

3.4.1 Summary

The gas-driven chillers that produce chilled water for air conditioning generate enormous amounts of waste heat. The waste heat is dissipated through a circulating water system that releases it from six cooling towers through the evaporation of water. The consumption of water for HVAC increases considerably during the summer months, exceeding, at times, 20% of the University's total monthly water use (see Figure 7).²⁷ We calculated²⁸ carbon emissions resulting from the consumption of water for air conditioning separately and added these emissions to the total for HVAC.

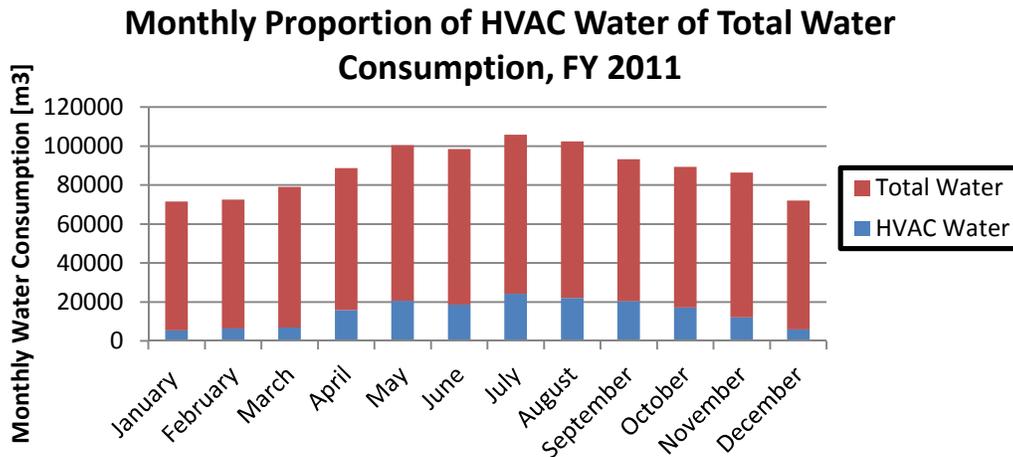


Figure 7: Monthly proportion of water used for HVAC of total water consumption in FY2011.

²⁵ Converted values from ton-hours (refrigeration), <http://www.unitconversion.org/energy/>. Because much of the hot water is produced through co-generation, these figures are not equivalent to the emissions figures presented in Figure 6.

²⁶ See Appendix 3 for calculations.

²⁷ In FY 2011, the university consumed a total of **175,731 m³** of water for HVAC. This amount represents an average of 20% of the campus's total water consumption, which amounts to **883,741 m³**.

²⁸ See Section 7 and Appendix 5.

3.4.2 Emissions

Out of a total of **1133.00 MT CO₂e** of emissions attributable to water supply, **225.30 MT CO₂e** of emissions, or 20%, are attributable to water use for HVAC. The remainder of the emissions related to water supply is attributable to other water uses such as consumption of domestic water and irrigation (see Figure 8).

For details on Non-HVAC water use, methodology, data sources and emission factors see Section 7.

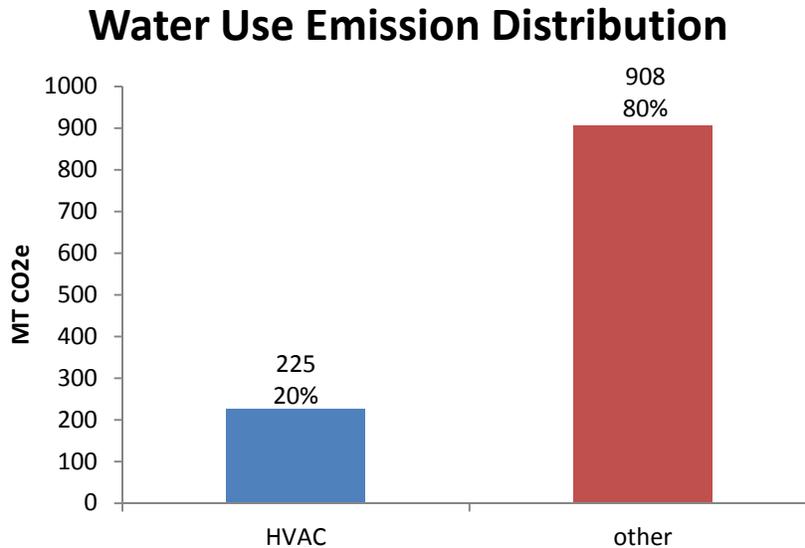


Figure 8: Distribution of water use emissions.

4. TRANSPORTATION

4.1 Summary

More than 27% of AUC's carbon emissions in FY 2011 can be attributed to commuting to the New Cairo campus by bus or car. By moving its main operations from Downtown Cairo to the satellite city of New Cairo, located approximately 35 km from the city center, AUC has significantly increased the distances traveled by its faculty, students and staff to reach its campus. Fewer than 8% of the 2,036 respondents to the online Transportation Sustainability and Safety Survey carried out in the spring of 2012 live in New Cairo. The largest contingents of AUCians live in Heliopolis and Maadi, followed by Nasr City, Zamalek, Mohandessin and Giza (see Figure 9). In order to reach the New Cairo campus and return home in the evening, AUCians travel an average of 65 km each day.

Commuting Locations & Distances for AUC Community

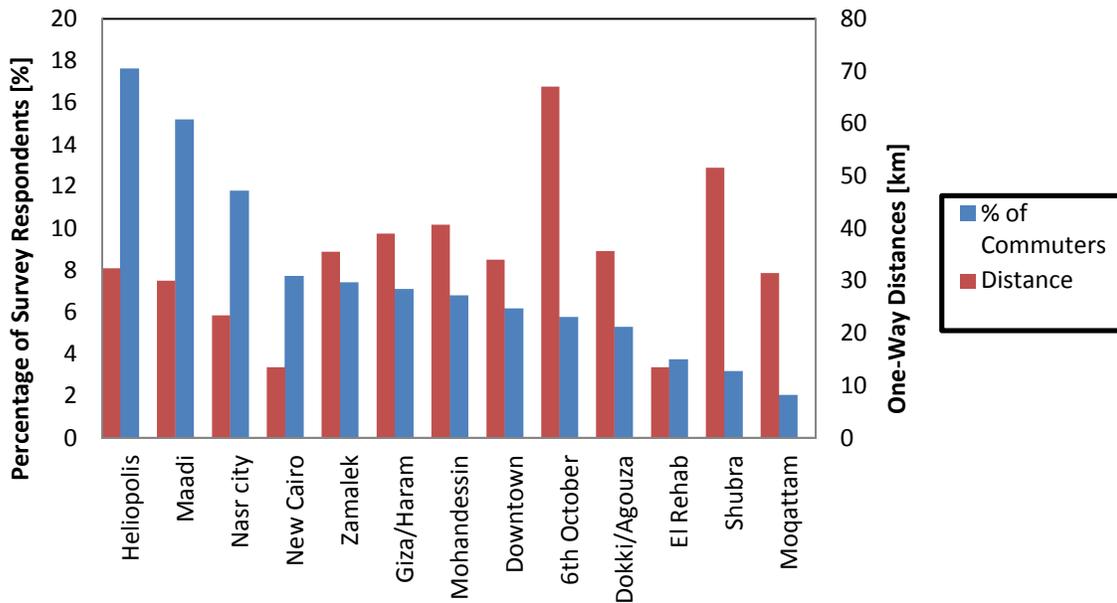


Figure 9: Commuting locations and distances for the AUC community.

In order to facilitate commuting, AUC offers its own bus service that is outsourced to two private transportation companies and connects the New Cairo campus to greater Cairo along 16 bus routes throughout the day and evening (see Figure 10). Apart from this bus service there is no public transport connecting the New Cairo campus to Cairo’s neighborhoods. Most commuters who do not make use of the bus service reach the New Cairo campus by private car.



Figure 10: AUC bus terminal with campus parking lot in rear.

While the bulk of AUC’s emissions from transportation are caused by daily commuting, the University also operates a fleet of cars, vans, minibuses and light duty trucks for use by AUC personnel. The operation of the fleet accounts for 1.62% of AUC’s overall carbon emissions in FY 2011 (see Figure 1).

Additionally, faculty and staff fly to destinations around the globe for meetings, conferences, research and other business purposes. This business air travel accounted for 2.50% of AUC’s overall carbon emissions (see Figure 1).

Finally, the University sponsors student field trips for educational purposes (generally by bus to destinations within Egypt). In FY 2011 (see Figure 1), these field trips accounted for 0.01% of AUC’s overall carbon emissions.

4.2 Commuting by Bus and Car

4.2.1 Emissions

In FY 2011, commuting to and from the New Cairo campus by AUCians contributed an estimated **15,252.52 MT CO₂e** of carbon emissions to the footprint.

Nearly 70% of AUCians and 80% of AUC students commuted by bus in FY 2011, while slightly more than 30% commuted by private car.²⁹ Bus service to and from the New Cairo campus amounted to an estimated 18,228,360 km traveled in FY 2011. Bus-related emissions are estimated to be 10,447.18 MT CO₂e. Of this total, the larger diesel coaches produced 6,504.41 MT CO₂e with the remaining 3,942.77 MT CO₂e produced by minibuses (see Figure 11).

Commuters by private car drove an estimated 20,301,388 km in FY 2011. 69% of the private car kilometers were traveled by students. We estimated that total emissions from private car commuting are 4,805.34 MT CO₂e (see Figure 11). Of this total, students account for 3,332.05MT CO₂e with the remaining 1,473.29 MT CO₂e attributable to faculty and staff commuting.

According to the transportation survey, to date only 19% of those who drive to the University have carpooled. However, without this car pooling activity, emissions from commuting by private car would have been even higher. Clearly, carpooling holds considerable potential for reducing AUC’s carbon footprint.

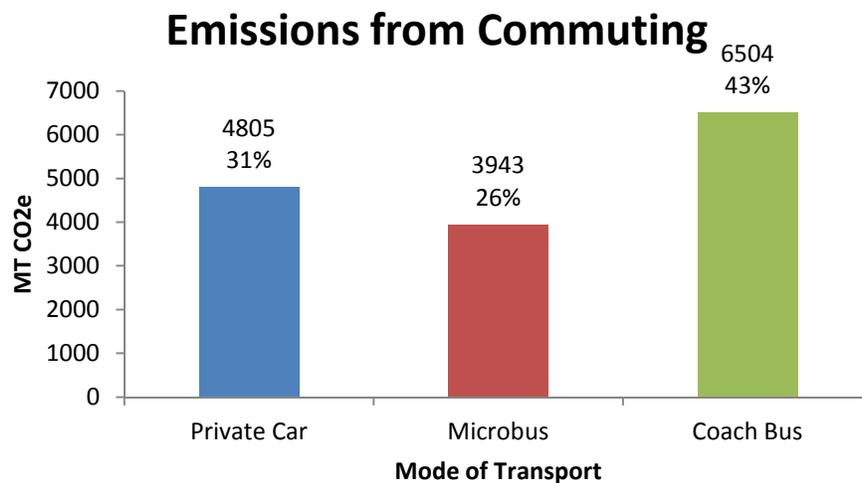


Figure 11: Emissions from commuting to and from AUC’s New Cairo campus.

²⁹ See 2012 AUC online transportation survey in Appendix 4. See also the AUC Transportation Committee’s “Transportation Service Report” dated November 30, 2011 at pp. 4, 25.

4.2.2 Methodology

The total distances traveled by AUC coach buses and minibuses were calculated by AUC's Department of Transportation Services using information regularly provided in the ordinary course of business by the private companies operating the bus system on AUC's behalf.

Regarding the distances traveled by those commuting in private cars, the DDC in partnership with AUC's Offices of Sustainability, Institutional Research, and Public Safety conducted the online Transportation Sustainability and Safety Survey.³⁰ The 2,036 responses were used to estimate total annual car commuting distances for the AUC community.

The survey shows how often, from where, and by what mode of transportation (bus, car, etc.) undergraduate students, graduate students, staff, and faculty commute to the New Cairo campus. To calculate total kilometers traveled for the entire AUC population, the survey data was scaled up to reflect the full size of the AUC community using 2011 enrollment data. A weekly kilometer total for each Cairo location was then calculated by multiplying the approximate roundtrip distance to campus by the number of trips made every week from that location. Carpooling was factored in by adjusting total distance traveled each week from each location to account for the average number of carpooling rides and riders.

The sum of weekly carpooling-adjusted distances traveled for each Cairo location and each demographic group approximates the total weekly roundtrip distance traveled by private car commuters during the fall and spring academic semesters. This weekly total was then further adjusted to reflect reduced commuting during University breaks and holidays, as well as lower enrollments during winter session. The estimated total distance traveled by private car commuters is simply the sum of these adjusted weekly totals over the course of the year.

The annual kilometers traveled by diesel buses (bus service) and average gasoline cars (car commuters) were then multiplied by the relevant emission factors provided below.

4.2.3 Data Sources

Data on bus commuting was provided by the AUC Department of Transportation Services and data on private automobile commuting was acquired through the University-wide online transportation survey.

4.2.4 Emission Factors³¹

Source	Mass Emissions (kgCO₂e/km traveled)
Average Gasoline Vehicle (Car)	0.2367
Average Diesel Vehicle (Van/Microbus/Light Duty Truck)	0.3636
Diesel Bus (Coach)	0.8808

4.3 University Fleet

4.3.1 Emissions

The University operates a fleet of 70 vehicles (54 gasoline cars, 14 diesel vans/microbuses/light duty trucks), used for transportation of University personnel and other daily operations, that consumed 260,381 liters of gasoline and 105,121 liters of diesel fuel in FY 2011. Emissions from the gasoline vehicle fleet

³⁰ A copy of the questionnaire used in the survey is attached to this report as Appendix 4. An Arabic version was also made available.

³¹ Converted values from EIA 2011 and EPA 2011, www.emissionfactors.com.

are 615.33 MT CO₂e; and from the diesel fleet 282.06 MT CO₂e (see Figure 12). The total emissions from the University vehicle fleet are **897.39 MT CO₂e**.

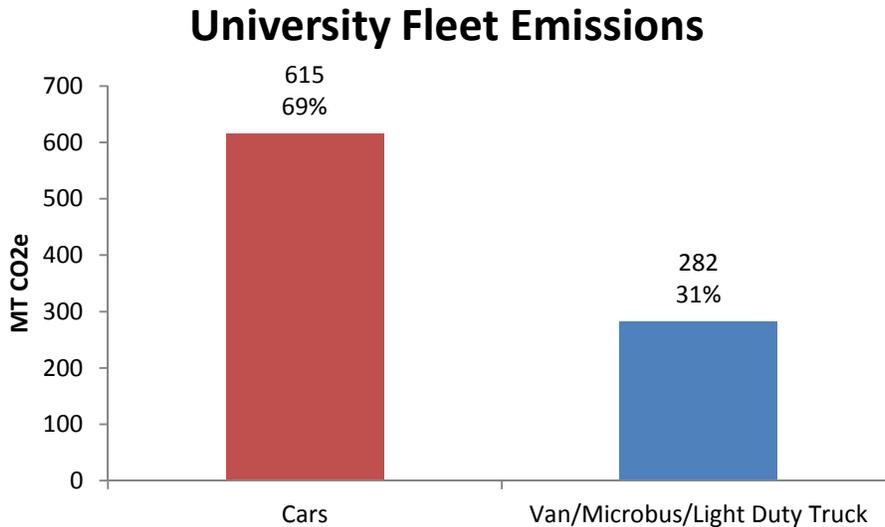


Figure 12: Carbon emissions caused by AUC’s fleet of vehicles.

4.3.2 Methodology

Emission factors were based on the vehicle composition of the fleet. For the gasoline fleet, consisting almost entirely of cars, an average emission factor for gasoline cars was used. For the diesel fleet, made up almost entirely of minibuses, an average emission factor for diesel light duty trucks (vans) was used. Total amounts of fuel used were multiplied by their respective emission factors.

4.3.3 Data Sources

We obtained data for the University fleet from the AUC Department of Transportation Services.

4.3.4 Emission Factors³²

Source	Mass Emissions (kgCO ₂ e/Liter of fuel used)
Average Gasoline Vehicle (Car)	2.3631787
Average Diesel Vehicle (Van/Microbus/Light Duty Truck)	2.683210969

4.4 Air Travel

4.4.1 Emissions

Air travel by faculty and staff for business amounted to a total of 11,521,285.9 passenger kilometers (pass. km) traveled in FY 2011 resulting in an estimated **1,385.88 MT CO₂e** emissions. Long haul air travel accounted for 87% of the km traveled and 88% (1,214.81 MT CO₂e) of the total GHG emissions (see Figures 13 and 14). Medium and short haul travel accounted for only 13% of the kilometers traveled and 12% of the emissions or 171.06 MT CO₂e.

³² Converted values from EIA 2011 and EPA 2011, www.emissionfactors.com.

Air Distance Traveled

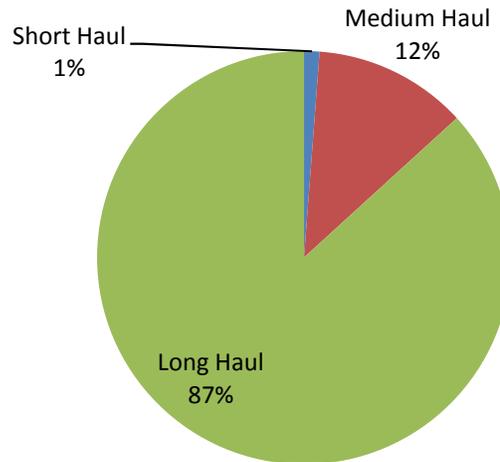


Figure 13: Short, medium and long haul business-related flights taken by the AUC community.

Emissions from Air Travel

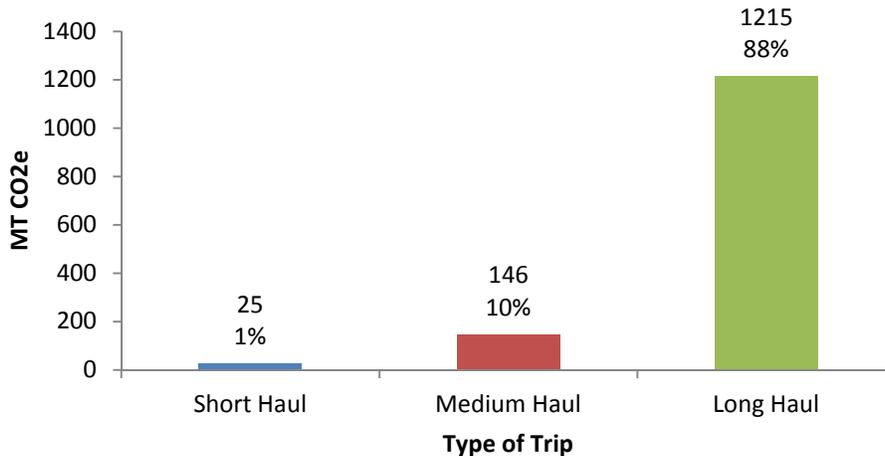


Figure 14: Carbon emissions caused by air travel.

4.4.2 Methodology

The University Travel Office coordinates official University (business) travel as well as personal travel requests from the University community. All flights booked through the travel office are compiled in a database. However, it was not until the start of FY 2012 (i.e. September 1, 2011) that business travel could be differentiated from personal travel in the database. Accordingly, the proportion of business flights to personal flights recorded between September 2011 and April 2012 was used to estimate the number of kilometers traveled for business purposes in FY 2011. Flight distances were calculated using www.webflyer.com. Given that business class flights cause significantly more CO₂ emissions than economy class flights, a weighted emission factor for business/economy was used. For emission factor

purposes flights were subdivided into short haul (≤ 785 km), medium haul (between 785 km and 3,700 km) and long haul ($\geq 3,700$ km).³³

4.4.3 Data Sources

Data provided by the AUC Travel Office.

4.4.4 Emission Factors³⁴

Source	Mass Emissions (kgCO ₂ e/passenger km traveled)
Short Haul ³⁵	0.1796639
Medium Haul (Average Class)	0.105535449
Long Haul (Average Class)	0.121499129

4.5 Sponsored Field Trips

4.5.1 Emissions

The University sponsored a number of field trips within Egypt in FY 11, resulting in an estimated 5,687 km of road travel by bus. Total emissions caused by these field trips are **5.01 MT CO₂e**.

4.5.2 Methodology

Distances to destinations were estimated using Google Maps with the departure point assumed to be AUC's New Cairo campus. Where the final destination was a city, distance was measured to the city center. It is assumed that travel was undertaken by diesel fuel bus, given that this is the most commonly used method of transportation for field trips.

4.5.3 Data Sources

We obtained data on field trip transport from the AUC's Office of Public Safety.

4.5.4 Emission Factors³⁶

Source	Mass Emissions (kgCO ₂ e/km traveled)
Diesel Bus (Coach)	0.8808

5. ELECTRICITY FOR LIGHTING AND EQUIPMENT (OTHER THAN HVAC)

5.1 Summary

As discussed in Sections 3.1 and 3.2, it is presently estimated that half of all electricity consumed by AUC in FY 2011 was used to operate the HVAC system. The remaining half was used for lighting and for operation of office equipment and other electrical equipment. The electricity used to power lighting and other electrical equipment accounted for nearly 22% of AUC's carbon emissions in FY 11 (see Figure 1).

³³ Air Travel Definitions, www.emissionfactors.com.

³⁴ Converted values from Defra/DECC 2011, www.emissionfactors.com.

³⁵ Source does not list differentiated emission factors by class for short haul flight.

³⁶ Converted value from EIA 2011 and EPA 2011, www.emissionfactors.com.

5.2 Emissions

The University emitted an estimated 7,045.59 MT CO₂e through the consumption of electricity from the Cairo grid (Egyptian Engineering Agencies or EEA) and an estimated 17,104.38 MT CO₂e from electricity consumed from AUC's central utility plant. In total, AUC emitted **24,149.96 MTCO₂e** into the atmosphere from use of electricity in FY 2011, out of which approximately **12,074.98 MT CO₂e** resulted from the use of lighting and other electrical equipment.

For the methodology, assumptions, data sources and emission factors for electricity, please see Section 3.2.

6. PAPER USE

6.1 Emissions

The University purchased an estimated 631,373.96 kg of paper in FY 2011. The emissions from paper purchases for the New Cairo campus total **1,796.28 MT CO₂e**.

6.2 Methodology

The research team reviewed all paper purchase invoices, categorized paper by coated and uncoated paper, and weighed the paper packages. More than 99% of the paper AUC purchases is uncoated, as opposed to only 1% of coated paper, which is used, for example, for glossy brochures.

All paper is 0% recycled, as recycled paper for office use is not yet available in Egypt. Recycled office paper would have to be imported, which is not only costly but would indirectly increase the University's carbon footprint.

6.3 Data Sources

We obtained information on paper purchases from the Office of Supply Chain Management and Business Support.

6.4 Emission Factors³⁷

Source	Mass Emissions (MT CO ₂ e/kg of paper)
Uncoated Paper	0.0028451
Coated Paper	0.0027417

7. WATER SUPPLY (OTHER THAN WATER USED FOR HVAC)

7.1 Summary

Egypt is an arid country with minimal rainfall. It has less water per capita than the global scarcity benchmark of 1,000 m³ per capita per annum. Simply put, Egypt is in a situation of constant water scarcity and sustainable water management is one of the most important issues Egypt will face in the coming years.

Energy and water supply at AUC are intimately connected. The New Cairo campus is located on an elevated desert plain east of central Cairo. In order to supply water to AUC from the Ismailiya Canal northeast of Cairo, water must be pumped across a distance of 54.45 km, and up inclines totaling 308 m.

³⁷Accounts for entire paper life-cycle, <http://calculator.environmentalpaper.org/home>.

Reducing water consumption, whether for the central utility plant, for irrigation of campus landscaping, or for domestic use, would reduce our carbon footprint in addition to saving scarce water resources.

7.2 Emissions

The University consumed 883,750 m³ of water during the 2011 fiscal year resulting in GHG emissions that amount to **1,133.00 MT CO₂e**. Of this total, **225.30 MT CO₂e** can be attributed to HVAC, the remaining **907.71 MT CO₂e** to Non-HVAC water uses such as domestic use and irrigation.

7.3 Methodology

Chemonics Egypt graciously assisted the carbon footprint team by mapping the water supply route from the original water source at the Ismailiya Canal through a number of treatment and pumping stations to the perimeter of the New Cairo campus, then calculating the electricity used to move the water along each leg of the trip from source to final destination. A sample of the Chemonics Egypt calculations, covering the 8-kilometer leg of the trip from pumping station 4 to pumping station 5, is attached to this report as Appendix 5.

Chemonics Egypt concluded that 2.55 kilowatt hours (kWh) of electricity are required to bring each cubic meter of water from the Ismailiya Canal to the New Cairo campus, given a system pumping efficiency of 65%. It is worth noting that, as Hani Sewilam, AUC Professor of Sustainable Development and Water Resources Management has observed, 2.55 kWh/ m³ is nearly as much energy as is needed to produce fresh water from sea water by desalination.

The total consumption of water by the University was taken from meter readings and estimates of all water used on campus, including domestic use, irrigation, and the production of electricity and hot and chilled water.

7.4 Data Sources

We obtained energy consumption for water delivery to the New Cairo campus from Chemonics Egypt and data on University water consumption from AUC's Office of Facilities and Operations/Maintenance and the Desert Development Center.

7.5 Emission Factors

Source	Mass Emissions (CO ₂ e/kWh)
Cairo Grid (Electricity)	0.50276612

8. MISCELLANEOUS OTHER SOURCES

8.1 Summary

Significant but comparatively minor sources of AUC's carbon emissions (see Figure 15) are solid waste disposal, fertilizer use, refrigerant leakage and the burning of natural gas for domestic and lab purposes. Together, these represent less than 1.5% of AUC's total carbon emissions.

Breakdown of Category "Other" Metric Tons of Carbon Dioxide Equivalent [MTCO₂e]

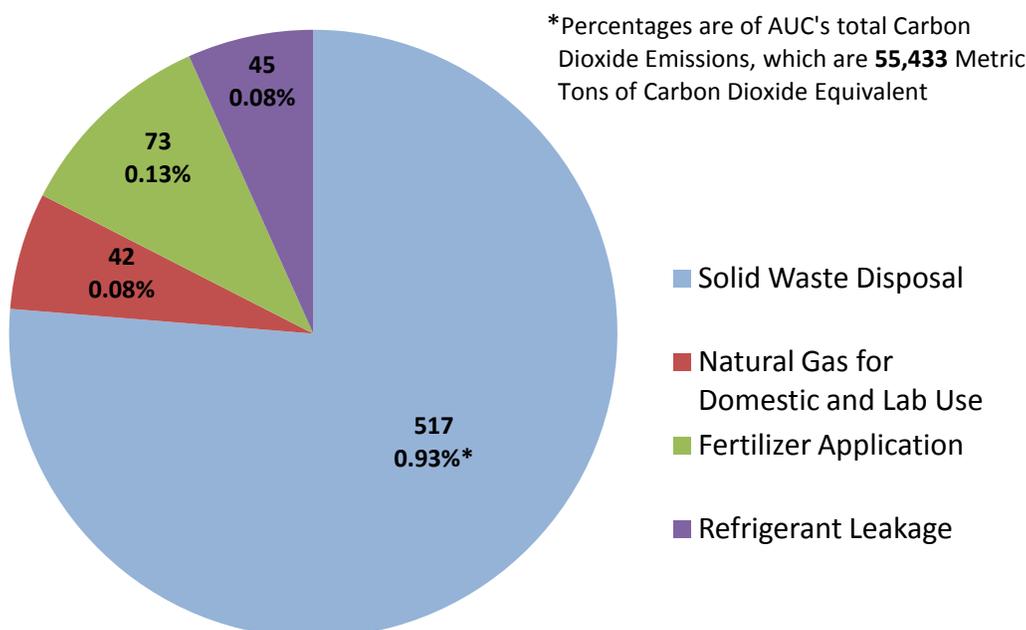


Figure 15: Emission types falling into the category “other” in Figure 1 due to their minor share of the total emissions.

8.2 Solid Waste Disposal

8.2.1 Emissions

We estimate that the University produced 614 MT of solid waste over FY 2011. As the only emission from solid waste is methane (CH₄), this amount of waste created 24.62 MT CH₄. Taking into account the global warming potential (GWP) of methane, **517.05 MT CO₂e** were emitted into the atmosphere.

8.2.2 Methodology

In order to estimate the total amount of solid waste produced in FY 2011, two one-week assessments were conducted. All waste leaving campus was weighed every day for one week during non-peak time (winter term) and then again every day for one week during peak time (spring semester). Solid waste weights were measured by weighing the trash trucks when fully loaded and then again when empty.

Throughout the year, and even throughout the week, there are days of low population density on campus (approximately less than half the student body and fluctuating amounts of staff and faculty) and days of high population (most students, staff, and faculty are present). We estimate that the New Cairo campus is relatively lightly populated 30.96% of the time and relatively densely populated 69.04% of the time. This fluctuation causes variation in the amount of solid waste produced per day. To account for this difference, a yearly average was calculated.

The emissions factor we chose assumes that there is no CH₄ recovery from the waste and that the total amount of waste is land-filled. However, the trash collector community in Cairo – referred to as the Zabaleen – is very efficient at sorting and recycling, and it has been estimated that 75 % of all solid waste

collected by the Zabaleen is recycled.³⁸ Consequently, the figure of 517.05 MT CO₂e used here for AUC’s emissions from solid waste is likely overstated.

8.2.3 Data Sources

Data on the amounts of solid waste produced were provided by AUC’s Department of Environmental Services in collaboration with the Zabaleen who pick up solid waste from AUC’s New Cairo Campus once or twice a day, as needed. Estimates of the proportion of waste recycled by the Zabaleen are provided by the Spirit of Youth Association, a local NGO that works in collaboration with the Zabaleen.

8.2.4 Emission Factors³⁹

Source	Mass Emissions (kgCO ₂ e/MT)
Solid Waste (No CH ₄ Recovery, e.g. methane bio-gas production)	842.1

8.3 Fertilizer Application

8.3.1 Emissions

For New Cairo campus landscaping, AUC used 67,476.25 kg of synthetic fertilizer in FY 2011 with a nitrogen content of 10.68% and 300,000 kg of organic fertilizer with a nitrogen content of 0.16%. We estimated that emissions from synthetic fertilizer application were 68.44 MT CO₂e and from organic fertilizer application 4.62 MT CO₂e. In total, **73.06 MT CO₂e** were emitted as a result of fertilizer application on the New Cairo campus (see Figure 16).

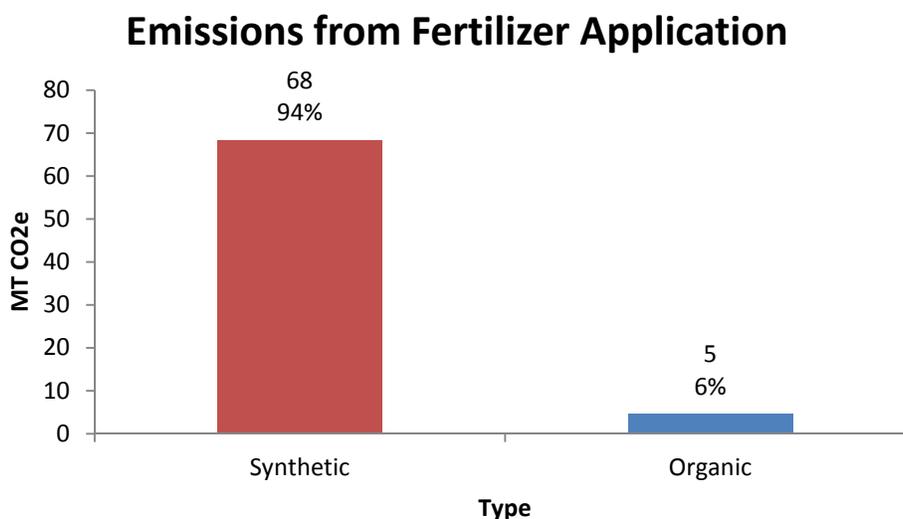


Figure 16: Emissions from the application of synthetic and organic fertilizers.

8.3.2 Methodology

The total amounts of synthetic and organic fertilizer used were multiplied by the respective percentages of nitrogen to obtain the amount of nitrogen applied. These values were then multiplied by each source’s

³⁸ Interview with Ezzat N. Guindy, Executive Director, Spirit of the Youth Foundation.

³⁹ Converted value from IPCC 2006 and Smith et al. 2001, www.emissionfactors.com.

emission factor in order to obtain the amount of N₂O. The amount of N₂O emissions from each source was multiplied by 310, the global warming potential (GWP) of nitrous oxide, to determine the CO₂ equivalent emissions. Information regarding nitrogen content was taken from information provided on the fertilizer packages.

8.3.3 Data Sources

Data on fertilizer use was obtained from the Desert Development Center, which is responsible for the landscaping of AUC’s New Cairo campus.

8.3.4 Emission Factors⁴⁰

Source	Mass Emissions (kgCO ₂ e/kg of Nitrogen)
Synthetic Fertilizer	9.49749418
Organic Fertilizer	9.61925691

8.4 Refrigerant Leakage

8.4.1 Emissions

The University uses two types of refrigerants for refrigerators and stand-alone air conditioning units (see Footnote 8): R22 (HCFC-22), amounting to 13.5 kg and R407c, amounting to 13 kg. Total emissions from leakage of refrigerants (see Figure 16) were **45.37 MT CO₂e** in FY 2011, i.e. the sum of emissions from R22 (24.44 MT CO₂e) and emissions from R407c (20.93 MT CO₂e).

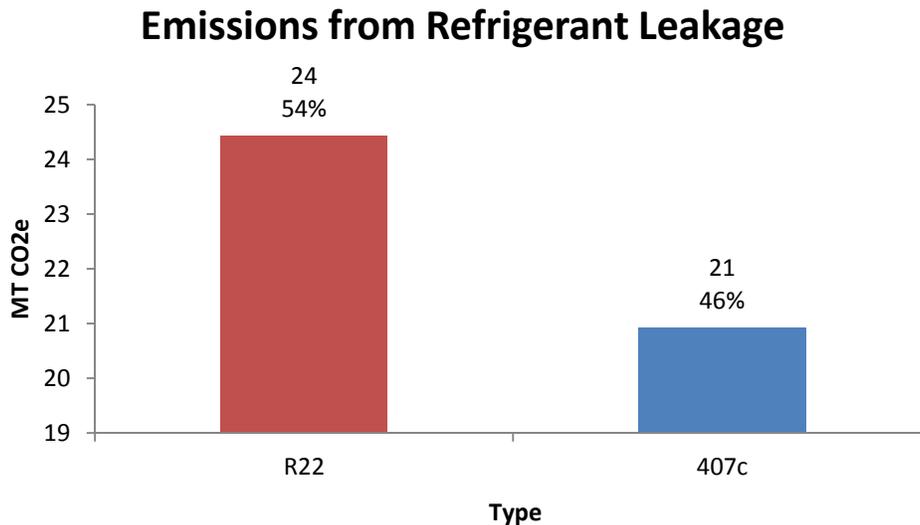


Figure 17: Emissions from the leakage of refrigerants R22 and 407c.

8.4.2 Methodology

The amount of refrigerants lost to leakage or unintended releases were calculated by determining the amount of refrigerants added to “top-up” the refrigerants in FY 2011.

⁴⁰ Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001 (April 2003) EPA 430-R-03-004; Annex N.

8.4.3 Data Sources

We obtained information on refrigerants from AUC's Office of Facilities and Operations/Maintenance.

8.4.4 Emission Factors

Source	Mass Emissions (MT CO ₂ e/kg)
R22 ⁴¹	1.81
R407c ⁴²	1.61

8.5 Natural Gas for Domestic and Lab Use

8.5.1 Emissions

The total natural gas consumption for the New Cairo campus for domestic and lab use was 21,000 m³ or 21, 000,000 liters in FY 2011. The University emitted **42.23MT CO₂e** from this type of natural gas combustion.

8.5.2 Methodology

The amount of natural gas for domestic and lab use was determined by calculating the difference between total natural gas consumption on campus and consumption by the central utility plant.

8.5.2 Data Sources

We obtained data on total natural gas consumption and consumption by the central utility plant from AUC's Office of Facilities and Operations/Maintenance.

8.5.3 Emission Factors⁴³

Source	Mass Emissions (kgCO ₂ e/L)
Natural Gas	0.002010862

9. CARBON OFFSETS

According to Goodward and Kelly (2010), a carbon offset is a reduction in emissions of carbon dioxide or greenhouse gases made in order to compensate for or to offset an emission made elsewhere.⁴⁴ Carbon offsetting can play an important role in reducing AUC's carbon footprint. Current emission offsets are achieved through energy co-generation and campus landscaping (see Figure 18).

⁴¹ IPCC 4th Assessment Report, http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html.

⁴² <http://www.comfort.uk.com/refrigerants.htm>.

⁴³ Converted value from IPCC 2006, www.emissionfactors.com.

⁴⁴ Goodward, Jenna; Kelly, Alexia (August 2010). "Bottom Line on Offsets". World Resources Institute. Retrieved May 8, 2012.

Emission Offsets

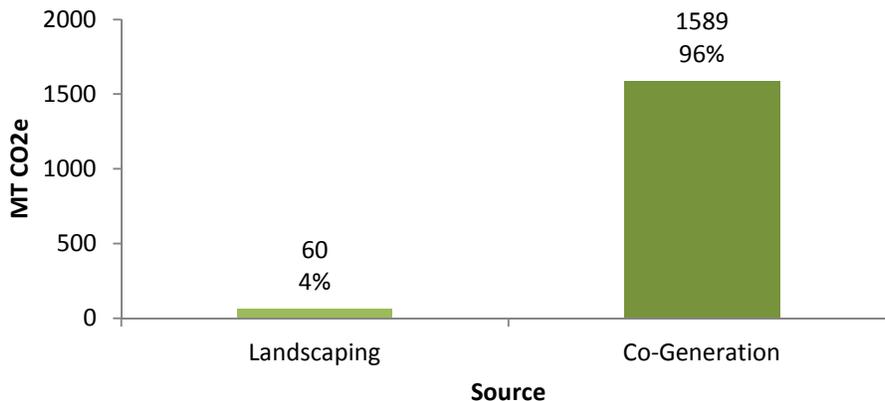


Figure 18: Carbon emission offsets at AUC through energy co-generation and landscaping.

9.1 Reducing CO₂ Emissions through Co-Generation

Co-generation is the design, construction and operation of a power plant simultaneously to generate both electricity and waste heat that can be used elsewhere, e.g. to produce hot water for heating and domestic hot water. The two main benefits of co-generation are reduced energy costs and reduced carbon emissions compared to using conventional electricity generators and conventional (e.g. gas-fired) boilers.⁴⁵

As discussed in Section 1.4.1, at AUC’s central utility plant two of the four gas-fired electricity generators feed hot exhaust fumes to waste heat boilers which produce hot water for heating and domestic hot water. In FY 2011, approximately 40% of the hot water produced for heating and domestic hot water was produced by co-generation. This saved 6,027,980.44 kWh of energy,⁴⁶ which in turn would have resulted in an additional 1438.09 MT of CO₂e emissions had the same amount of hot water been produced by conventional gas-fired boilers. Thus, co-generation saved – or “offset” approximately 39% of the carbon emissions that would have resulted had all of AUC’s hot water for heating and domestic hot water been produced by conventional gas-fired boilers in FY 2011.

AUC’s total carbon footprint in FY 2011 was approximately 2.5% smaller than it would otherwise have been thanks to co-generation. Since at AUC the potential for co-generation exists only if electricity is produced at the central utility plant (as opposed to consumed from EEA, the public utility), a long-term strategy for reducing AUC’s carbon footprint is to increase the proportion of AUC’s electricity produced by the on-site generators at the central utility plant (about two thirds of all electricity consumed in FY 2011), and to decrease the proportion consumed from EEA (about one third in FY 2011) in order to capture all possible benefits from co-generation.

⁴⁵ Cogeneration and Cogeneration Schematic, <http://www.clarke-energy.com/chp-cogeneration/>.

⁴⁶ Converted value from ton-hours (refrigeration), <http://www.unitconversion.org/energy/>.

9.2 Sequestering CO₂ through Landscaping



Figures 19, 20 and 21: AUC campus landscaping.

Carbon sequestration means capturing and removing CO₂ from the atmosphere and depositing it in a stable, long-term reservoir, in this case, the soil.⁴⁷ In FY 2011 landscaping at the New Cairo campus (see Figures 19-21) sequestered **60.16 MT CO₂e**.

The New Cairo campus, built on 260 acres of land, boasts extensive areas of green. In keeping with the desert environment, campus landscaping was designed to be as water-efficient as possible, using local plant varieties whenever possible, minimizing the planting of lawns (which consume relatively large amounts of water) and making extensive use of drip irrigation.

A variety of trees, including citrus and palm, covers approximately 50 acres (20.23 hectares) of the New Cairo campus.⁴⁸ The emission factor we used to estimate the amount of carbon dioxide sequestered by trees is 0.875 MT CO₂/acre/year.⁴⁹ As a result, 43.75 MT CO₂ were sequestered in FY 2011 from trees on the New Cairo campus.

The remainder of the landscaped area is planted with lawns, bushes and flowering plants. Lawns, including those in the gardens and the athletic fields, cover approximately five acres. Lawns also act as a carbon sink in that they sequester carbon dioxide from the atmosphere. Common turf grass, similar to the variety used at the New Cairo campus, sequesters an estimated 1.172 MT CO₂/acre/year.⁵⁰ Thus we estimate that the lawns on the New Cairo campus sequestered approximately 5.86 MT of CO₂ in FY 2011.

Lastly, ground cover such as flowering plants covers approximately nine acres, bringing the total of the landscaped areas on campus to approximately 64 acres. Applying the sequestration rate we used for lawns to areas planted with flowering plants and other ground cover, we estimate that approximately 10.55 MT of CO₂ were sequestered by flowering plants and other ground cover in FY 2011.

⁴⁷ Glossary of Climate Change Acronyms, UNFCC 2012.

⁴⁸ The campus's carbon sequestration potential was estimated on the basis of tree coverage of the landscaped area. We rely on the definition of a forest as having at least 10% crown cover of trees with a height at maturity of at least 2m, in an area of at least 0.05 ha (FAO 2006).

⁴⁹ Edinburgh Centre for Carbon Management. 2000. Technical Document 1: Estimation of Carbon Offset by Trees.

⁵⁰ Converted value, <http://www.thelawninstitute.org/environment/?t=3150&st=5043&c=186438>.

10. AUC's CARBON FOOTPRINT COMPARED TO OTHER UNIVERSITIES

In total, emissions produced by the University in FY 2011 amounted to **55,433.30 MT CO₂e**. This amount is roughly equivalent to the CO₂ emissions resulting from consuming 128,882 barrels of oil, or the amount of carbon sequestered by 1,421,365 tree seedlings grown for 10 years.⁵¹

A useful way for AUC to compare itself to other universities is by greenhouse gases emitted per Full-Time Equivalent Student (FTE). The table below (see Table 2) ranks AUC in comparison with a sample of higher education institutions that are similar in physical size, climate and/or institutional characteristics (e.g. size and level of programs offered):⁵²

Table 2: Rankings of selected institutions of higher education by greenhouse gas emissions per full time equivalent student

Institution	Report Year	Total Student Enrollment (FTE)	Total Emissions (MT CO ₂ e)	Total Emissions / FTE Student
Pomona College (California)	2011	1,549	24,684	15.9
Tulane University (Louisiana)	2010	10,958	152,230	13.9
Rice University (Texas)	2009	4,993	53,084	10.6
University of California – San Diego	2010	29,899	282,453	9.4
The American University in Cairo (AUC)	2011	5,937	55,433	9.3
University of New Mexico, Main Campus	2009	25,820	199,960	7.7
Brandeis University (Massachusetts)	2010	5,310	39,145	7.4
University of Arizona	2010	38,076	253,723	6.7
Arizona State University	2010	66,988	269,364	4.0
University of Cape Town	2007	21,231	84,926	4.0
University of Nevada – Las Vegas	2008	21,841	85,878	3.9
Santa Clara University (California)	2010	7,917	23,464	3.0

⁵¹ Greenhouse Gas Equivalencies Calculator, <http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results>.

⁵² ACUPCC Reporting System, http://rs.acupcc.org/search/?institution_name=tufts&carnegie_class=%3F%3F&state_or_province=%3F%3F.

11. RECOMMENDATIONS FOR REDUCING OUR CARBON FOOTPRINT

The seventeen measures recommended below were developed jointly by AUC's Office of Sustainability and the Desert Development Center, with assistance from many other members of the AUC community. The list below is not intended to be exhaustive, but the recommended measures address each of the five activities contributing most significantly to AUC's carbon footprint, in descending order by amount of emissions. Implementing these recommendations will go a long way towards reducing our carbon footprint.

Box 4: Summary of Recommendations

1. Air Conditioning, Heating and Ventilation (HVAC)

- Adjust temperature settings for air conditioning and heating to eliminate overcooling and overheating.
- Reduce the need for air conditioning and heating by ventilating with outside air whenever possible to reach desired temperatures.
- Don't cool or heat space at all if it is not being used, e.g. during nonworking hours, summer and winter terms and school vacations.
- Consolidate activities and consciously plan space utilization with an eye to reducing the need for cooling and heating.

2. Transportation

- Encourage more students, faculty and staff to commute by bus rather than private car. Buses have a much bigger carrying capacity, operate more efficiently and emit less carbon per passenger-kilometer.
- Encourage car-pooling by structuring parking fees to reward car-pooling and by creating a car-pooling website.
- Consider converting the university's commuter buses and its fleet from diesel and gasoline to natural gas, a more carbon-efficient fuel.

3. Lighting and Electrical Equipment

- Install a computerized and centralized lighting control system to turn off lights whenever and wherever they are not needed.
- Encourage "day lighting" – the use of natural light to illuminate interiors during daylight hours.
- Consider replacing stand-alone office equipment (e.g. copiers, printers, scanners) with networked equipment to reduce the amount of equipment needed.
- Install motion sensors in classrooms, meeting rooms, computer labs and group study rooms to turn off lighting and equipment when no one is present.

4. Paper Use

- Make two-sided printing and copying the "default option", and move towards entirely paperless operation by phasing out use of hard copies.
- Use "smart" (networked) office equipment to discourage excessive printing and copying.
- Find local sources of affordable, high-quality recycled paper to reduce the net carbon footprint of purchased paper.

5. Water Supply

- Use recycled water for campus landscape irrigation.
- Encourage water conservation by maintaining kitchen and bathroom fixtures and monitoring and reporting leaks and malfunctions.

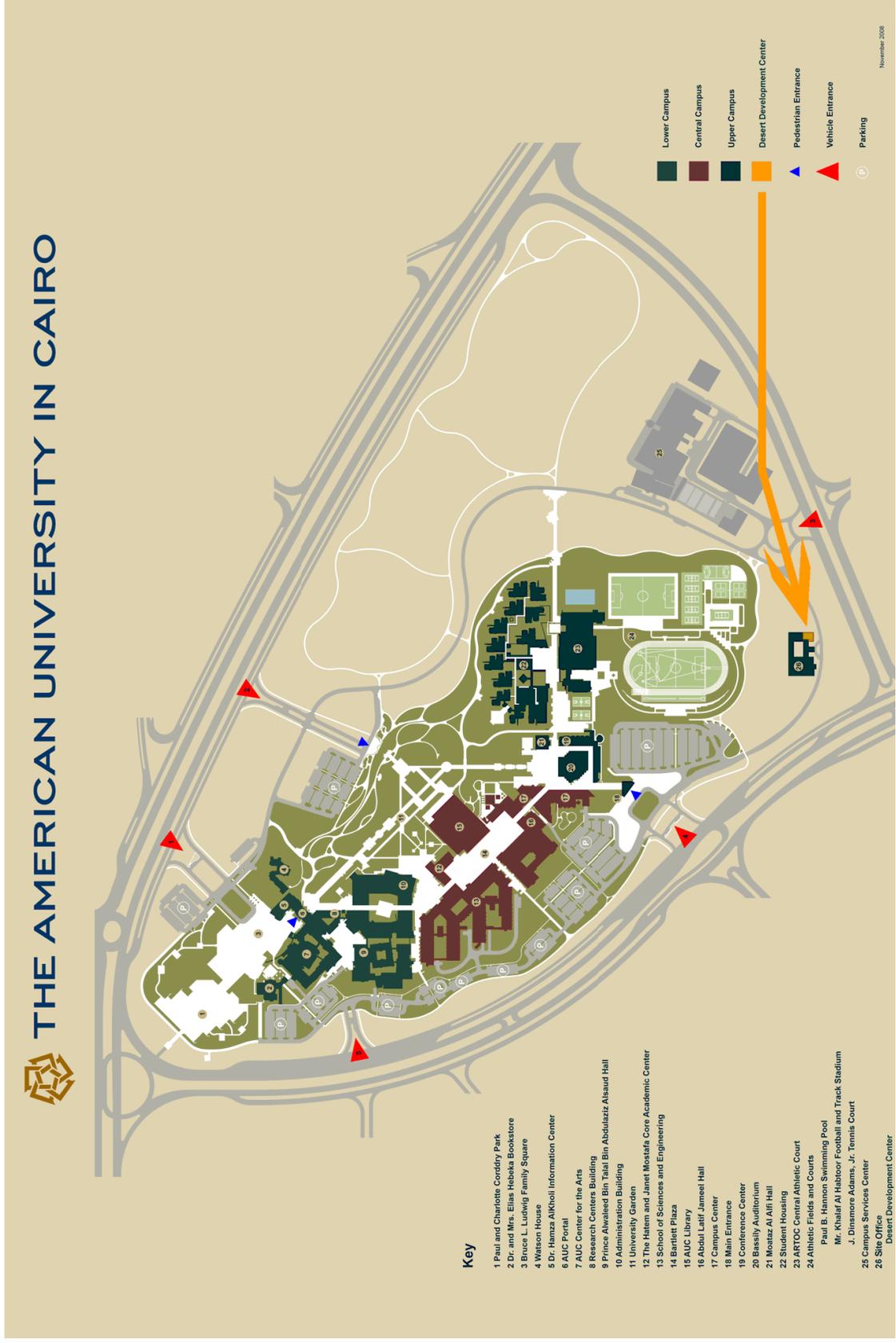
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APPENDIX 1: Campus Maps
1a. Campus Map: Aerial Photo



1b. Campus Map: Schematic Overview



APPENDIX 2: Electricity Emission Factor Calculations

Base Factors

Natural Gas

- 0.202 kgCO₂/kWh (Source: IPCC 2006, www.emissionfactors.com)
- 0.0000036 kgCH₄/kWh (Source: IPCC 2006, www.emissionfactors.com)
- 3.600e-7 kgN₂O/kWh (Source: IPCC 2006, www.emissionfactors.com)

High Density Fuel Oil #6 or Residual Fuel #6 (*mazout*)

- 0.275760077 kgCO₂/kWh (Source: Project Design Document Form, CDM PDD, Helwan Cement Plant, Version 3 UNFCCC, 2006)
 - Conversion: 76.6 tCO₂/TJ * 1TJ/277777.7 kWh = 0.000275 tCO₂/kWh* 1000 = 0.27576007721282161959005348521498 kgCO₂/kWh
- 0.0000108 kgCH₄/kWh (Source: IPCC 2006 via emissionfactors.com)
- 0.00000216 kgN₂O/kWh (Source: IPCC 2006 via emissionfactors.com)

Calculating an Electrical Grid Emission Factor:

$$\text{Emission Factor}_{\text{grid}} = \frac{(\text{Emission Factor}_{\text{Natural Gas}} * \% \text{ Natural Gas}) + (\text{Emission Factor}_{\text{Mazout}} * \% \text{ Mazout})}{\text{Efficiency}}$$

(Source: UNFCCC/CCNUCC, EB 61 Report, Annex 12, Version 02.2.0, 2011.)

Note: For CH₄ and N₂O, must multiply the emission factor made from base factor by 21 and 310 (Global Warming Potentials, GWP) respectively to convert to carbon dioxide equivalents (CO₂e). (Source: IPCC 4th Assessment Report, http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html)

EEA Cairo Zone (source: EEA Annual Report 2011)

EEA 2011 Annual Report (Cairo Zone)

Fuel Mix and Efficiency Data:

- 83.8% Natural Gas
- 16.2% High Density Fuel Oil
- 42.59% Efficiency of Electricity Production (weighted average among 7 Greater Cairo station production levels)

Custom Emission Factors for EEA Cairo Zone Production:

CO₂: EF_{EEA} = [(0.202*0.838)+(0.275760077*0.162)]/0.4259 = 0.502345932 kgCO₂/kWh

CH₄: EF_{EEA} = [(0.0000036*0.838) + (0.00001080*0.162)]/.4259 = 0.000011191*21 = 0.00023502 kgCO₂e/kWh

$N_2O: EF_{EEA} = [(0.00000036*0.838) + (0.00002160*0.162)]/.4259 = 1.52994E-06*310 = 0.00047428$
kgCO₂e/kWh

CO₂e: EF_{EEA} = 0.503055231 kgCO₂e/kWh

GasCool/Kahraba

Fuel Mix and Efficiency Data:

- 100% Natural Gas
- 32.98% Efficiency of Electricity Production

Custom Emission Factors for GasCool/Kahraba Production:

$CO_2: EF_{GasCool} = [(0.202*1)]/0.3298 = 0.61249242$ kgCO₂/kWh

$CH_4: EF_{GasCool} = [(0.0000036*1)]/0.3298 = 1.09157E-05*21 = 0.00022923$ kgCO₂e/kWh

$N_2O: EF_{GasCool} = [(0.00000036*1)]/0.3298 = 1.09157E-06*310 = 0.000338387$ kgCO₂e/kWh

CO₂e: EF_{GasCool} = 0.613060036 kgCO₂e/kWh

APPENDIX 3: Heated and Chilled Water Emission Factor Calculations

We used the same methodology and base factors as used above to calculate the emission factor for an electrical grid:

$$\text{Emission Factor}_{\text{hot/chilled water}} = \frac{(\text{Emission Factor}_{\text{Natural Gas}} * \% \text{Natural Gas})}{\text{Efficiency}}$$

(Source: UNFCCC/CCNUCC, EB 61 Report, Annex 12, Version 02.2.0, 2011.)

Note: For CH₄ and N₂O, must multiply the emission factor made from base factor by 21 and 310 (Global Warming Potentials, GWP) respectively to convert to carbon dioxide equivalents (CO₂e). (Source: IPCC 4th Assessment Report, http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html)

Efficiency of Hot Water Production: 84.75%

Efficiency of Chilled Water Production: 78%

(Source: AUC's Office of Facilities and Operations/Maintenance)

APPENDIX 4: AUC Transportation Safety and Sustainability Survey 2012

For the **New Campus** only

Please do not fill out this survey more than once

1. You are....

Male

Female

2. You are...

Faculty

Student – Freshman

Staff

Student – Sophomore

Alumni

Student – Junior

Other

Student – Senior / Graduating

Graduate

3. How do you usually get to AUC? (Check all that apply)

Bus

Bicycle

Car / Taxi

Walking

Motor Bike / Motor Cycle

4. How many days a week do you usually come to campus?

1 day

5 days

2 days

6 days

3 days

4 days

5. Where do you live during the school year?

New Cairo / Rehab

Giza / Haram

Heliopolis

Maadi

Boulaq / Imbaba

Moqattam

Helwan / 15 May

6th October

Sherouq

Downtown / Garden City / Zamalek

Shoubra

Other:

Menyal

Nasr City

Dokki / Agouza/ Mohandessin

Ramsis / Abasseya

6. Have you ever been in a road accident while commuting to/from AUC?
- Once
 - Twice
 - Three times
 - More than three times
 - Never
7. Do you personally know someone who has been in a road accident while commuting to/from AUC?
- Yes
 - No

If you drive to campus by car(Bus riders can skip this entire last section of the survey. Thanks!)

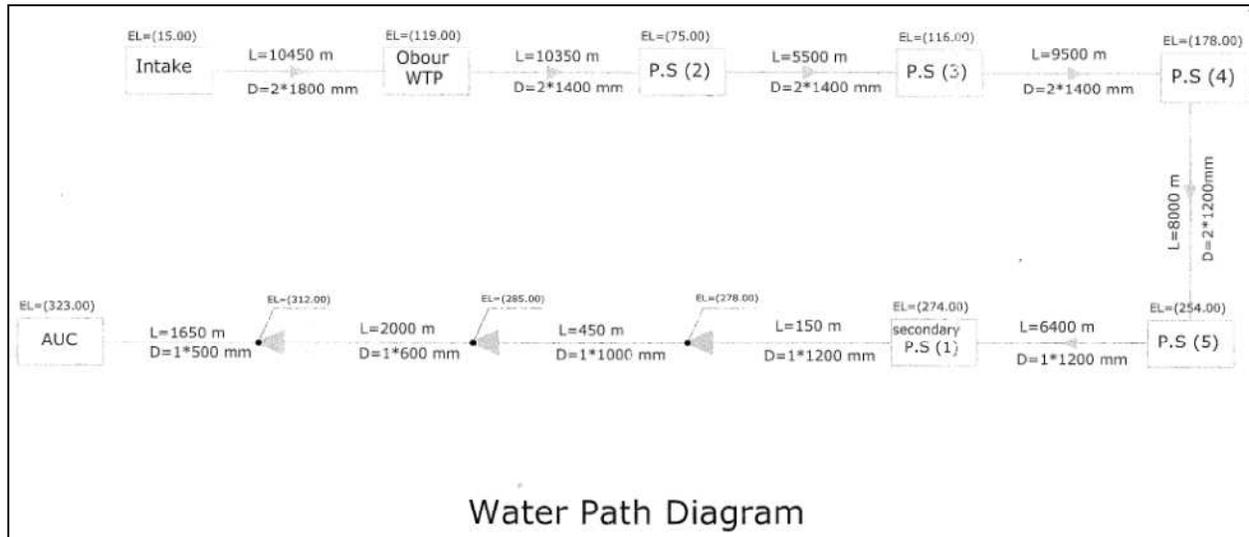
8. Where do you park?
- Inside campus gates
 - Driver drops me off
 - Outside campus gates
9. When you drive yourself, do you ever use your phone while commuting to/from AUC?
(People being driven to campus can jump straight to question 11)
- Often
 - Occasionally
 - Never
 - I use a hands-free device
10. When you drive and use your phone, what kind of device do you use?
- Smart Phone – Full Keyboard or Touch Screen (Blackberry, iPhone, Android, etc.)
 - Other – Basic Phone Model
11. If you carpool, how many AUCians are in the car?
- | Faculty | Staff | Students |
|---------------------------------|---------------------------------|---------------------------------|
| <input type="radio"/> 1 | <input type="radio"/> 1 | <input type="radio"/> 1 |
| <input type="radio"/> 2 | <input type="radio"/> 2 | <input type="radio"/> 2 |
| <input type="radio"/> 3 | <input type="radio"/> 3 | <input type="radio"/> 3 |
| <input type="radio"/> 4 or more | <input type="radio"/> 4 or more | <input type="radio"/> 4 or more |

12. If you drive to campus, would you consider...

- Taking the bus
- Car pooling
- Neither of the above

What could encourage you to take the bus or to carpool?

APPENDIX 5: Water Supply Delivery Path and Energy Calculation Example



Link from P.S(4) to P.S(5), D1200 mm

Power Calculations:

Pressure head (H) = Static Head + Friction Losses * 1.15 + Residual pressure

$$\begin{aligned} \text{Static Head} &= (254 - 178) \\ &= 76 \text{ m} \end{aligned}$$

Assume $V = 1.15 \text{ m/sec}$

Friction Losses

$$\begin{aligned} H_f &= \frac{6.78 * L * (V/C)^{1.85}}{(D^{1.165})} \\ &= 8.089 \text{ m} \end{aligned}$$

$$\begin{aligned} H &= 76 + (8.089 * 1.15) + 7 \\ &= 92.30 \text{ m} \end{aligned}$$

Power Consumed for each 1L/sec

$$P = \frac{H \text{ (m)}}{75 * \eta * 1.34 * 0.85}$$

$$P = 1.662 \quad (\text{kw/1L/sec})$$

Energy Consumption (kw.hr) to let through 1m³

$$\begin{aligned} &= P * (1000/3600) \\ &= 1.662 * (1000/3600) \\ &= 0.461743 \quad \text{kw.hr /m}^3 \end{aligned}$$