

Carbon footprint of the University of Cape Town

Thapelo C M Letete

Energy Research Centre, University of Cape Town

Nothando Wandile Mungwe

Energy Research Centre, University of Cape Town

Mondli Guma

Anglo Coal Global, Johannesburg

Andrew Marquard

Energy Research Centre, University of Cape Town

Abstract

Since signing the Talloires Declaration in 1990, the University of Cape Town (UCT) has been striving to set an example of environmental responsibility by establishing environmentally sound policies and practices, and by developing curricula and research initiatives to support an environmentally sustainable future. One of the most recent efforts in this quest was the release of a Green Campus Action Plan for the University of Cape Town by the Properties and Services Department in 2008. While the Plan proposed a number of carbon emission mitigation interventions for the University, it also stressed the need to conduct a detailed and comprehensive carbon footprint analysis for the whole University.

The aim of this analysis was to determine the carbon footprint of UCT, not only to give a tangible number with which the University's carbon sustainability level can be compared with other academic institutions, but also to provide the much needed baseline against which future mitigation efforts on the university campus can be measured.

UCT's carbon footprint for the year 2007 was found to be about 83 400 tons CO₂-eq, with campus energy consumption, Transportation and Goods and Services contributing about 81%, 18% and 1% the footprint respectively. Electricity consumption alone contributes about 80% of all the emissions associated with university activities. UCT's per-capita emissions for 2007 amount to about 4.0 tons CO₂-eq emissions per student. For comparison only, South Africa's 2007 per capita emissions were estimated at 10.4 tons CO₂-eq.

In terms of energy consumption only, UCT's footprint is about 3.2 tons CO₂-eq per student, higher than the National University of Lesotho's value of 0.1 and much lower than Massachusetts Institute of Technology's value of 33.1.

Keywords: greenhouse gas emissions, carbon footprint, University of Cape Town

1 Introduction

A carbon footprint can broadly be defined as a measure of the greenhouse gas emissions that are directly and indirectly caused by an activity or are accumulated over the life stages of a product or service, expressed in carbon dioxide equivalents (Wiedmann and Minx, 2007). According to the Intergovernmental Panel on Climate Change (IPCC), there are a total of 18 greenhouse gases with different global warming potentials, but under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, only Carbon dioxide (CO₂), Methane (CH₄), Nitrous Oxide (N₂O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF₆) are considered for the purposes of carbon accounting, with others being regulated elsewhere (IPCC 1990; UNFCCC 1997).

The determination of the carbon footprint of the University of Cape Town has truly been long overdue. In 1990 it became a signatory to the Talloires Declaration, wherein the University was committed to setting an example of environmental responsibility by establishing environmentally sound policies and practices, and by developing curricula, research initiatives and operational systems to support an environmentally sustainable future (Hall and Murray 2008). In the quest to coordinate the implementation of the declaration, the university management has since formed a university-wide Environmental Management Working Group and published a Green Campus Policy Framework for

the University, which was adopted by the university Senate and Council in May 2008. The latest effort in advancing the implementation of the declaration was the release of a Green Campus Action Plan for the University of Cape Town in 2008. This Action Plan presented a list of prioritized sustainability actions classified into the following categories: energy, water, indoor environmental quality, solid waste, carbon emissions, transport, emissions (to water and land), construction, institutional changes, landscaping and biodiversity. While the Plan proposed a number of carbon emission reduction interventions for the University, it also stressed the need to conduct a detailed and comprehensive carbon footprint analysis for the entire university (Rippon, 2008).

Determining the University's carbon footprint is seen as a critical step in achieving the goal of sustainability at it. Knowing the University's carbon footprint will not only give a tangible value with which its carbon footprint can be compared with other academic institutions, but will also provide a much needed baseline against which future mitigation efforts on campus will be measured.

This paper presents the results of the University of Cape Town's carbon footprint analysis, showing all significant contributing activities. The paper also compares the University's carbon footprint with that of other academic institutions, both regionally and internationally.

2 Methodology

In the scoping phase of this project, a carbon footprint conceptual framework was developed with the aim of comprehensively characterising all activities, products and services within the University that are envisaged to contribute significantly to its carbon footprint. A secondary objective was to also improve the resolution of boundary definitions

through a consistent and clear grouping of all components of the carbon footprint. In the analysis phase of the project, this conceptual framework evolved into a methodological framework through which the University's carbon footprint was finally determined. Figure 1 presents this methodological framework.

2.1 Basis and emission factors

The initial estimation of the University of Cape Town's carbon footprint was carried out in 2007 using available data for that year, and it only covered direct emissions and vehicle fleet emissions. In the two subsequent years of this project, the task was then to update the categories that had already been covered and to analyse the rest of the categories using, as far as possible, data for the year 2007. Where data for 2007 was unavailable, various estimation methods were employed to extrapolate the results to the year 2007, and whenever data for other years was also available it was used to carve an emissions time series for that category.

As much as possible South Africa specific emission factors were used in this analysis and in cases where such data was unavailable, standard IPCC emission factors and methods were then prioritized. Where emission factors could not be obtained from these two sources, other relevant publications were used.

Specific methodologies and data gathering processes for each category are presented below.

2.2 Campus energy emissions

This section encapsulates all GHG emissions that originate from direct energy consumption within the university campuses. This is primarily divided into contributions from the consumption of electricity and other fuels.

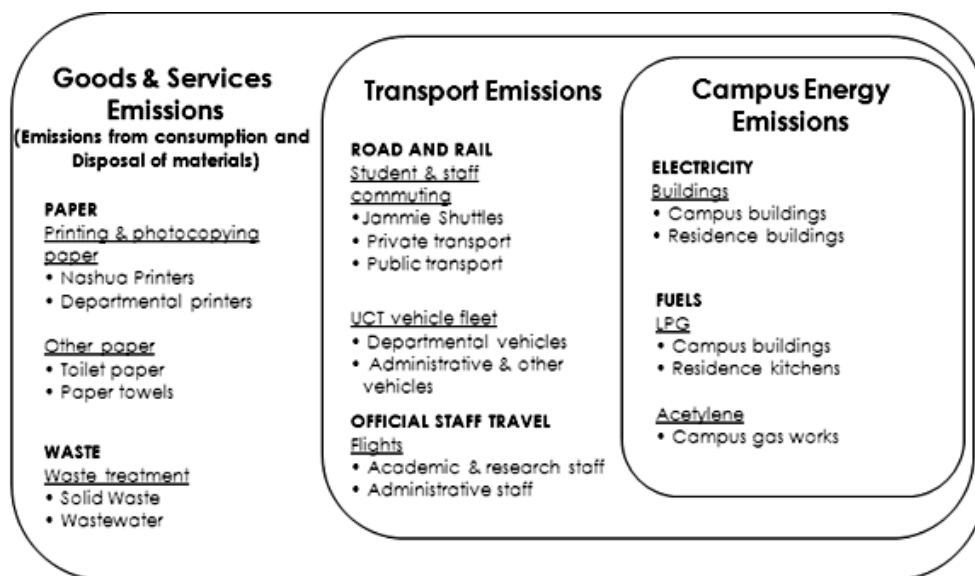


Figure 1: UCT carbon footprint methodological framework

2.2.1 Electricity

There are two distinct methods by which electricity is supplied to UCT:

- UCT Substations – There are two UCT substations that are directly fed by Eskom. The first and biggest is located on lower campus, and it services the whole of the lower, middle and upper campuses of the University, including the residences within these campuses. The second is located in the Medical School campus and it services that campus and the residences in it.
- Directly by the municipality – These are all ‘satellite’ buildings and campuses of UCT. They include the Hiddingh and Breakwater campuses and all residences and administrative buildings which are neither located on lower, middle, upper and medical campuses.

Electricity data for each of the two substations from 2003 to 2008 and for the Graduate School of Business (GSB) from 2008 to October 2009 was obtained from UCT’s Properties and Services Department, while electricity consumption data for satellite residential buildings was obtained from the Finance Office of the University’s Student Housing Department.

Data for electricity supplied directly by the municipality was only available for the Breakwater campus, while electricity consumption data for Hiddingh campus and all non-residential satellite campuses could not be obtained. UCT’s Breakwater campus houses both the Graduate School of Business (GSB) and the university-owned Breakwater Lodge which offers accommodation for tourists. As of 2010, the University has been receiving a single electricity bill for both the GSB and the Lodge. But since the Lodge activities are not university-related, the Breakwater campus finance manager suggested allocating only 46% of this electricity consumption to UCT’s carbon footprint.

Electricity consumption for satellite residences was only available in monetary terms from January 2007 to October 2007 for all flats, thus consumption for the months of November and December had to be estimated. Consumption for November was then assumed to be equal to the average consumption for all the preceding months, while consumption for December was assumed to equal that of December 2006. Also, to convert the monetary data to energy consumption, it was assumed that all flats were eligible for municipality’s free basic electricity of 50kWh per flat per month.

To determine the carbon footprint associated with the use of electricity on campus, the amount of electricity in kWh was multiplied by the CO₂ emissions factor obtained from Eskom’s 2006 report (Eskom, 2007). A transmission loss factor of 5.58%, specific for the Western Cape, and a distribution loss factor of 1.74% (Engineering News, 2007; Eskom, 2007) were used to account for the losses

from generation plants to UCT. The resulting electricity emission factor used in this analysis was 1.054 kg CO₂/kWh.

2.2.2 Liquefied petroleum gas

Liquefied petroleum gas (LPG) at UCT is used for cooking in residence kitchens and for academic research purposes (e.g. fuelling laboratory burners and heaters).

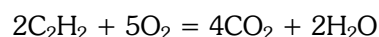
For its LPG needs, the University is currently serviced through two means:

- Bulk LPG delivery to four storage tanks on the University campus
- Portable LPG cylinder deliveries, primarily on an ad-hoc or emergency basis

AFROX Ltd is the University’s LPG vendor. For each of these two types of deliveries, quantities of LPG ordered for the period of January – October 2007 were obtained from the UCT Finance Department. The net calorific value (OECD-IEA 2004) was used to determine the amount of energy released at combustion. Using the IPCC 2006 guidelines emission factor (IPCC, 2006), the amount of CO₂ released could therefore be calculated. Average figures were used for November and December as calculated based on the average monthly consumption between January and October.

2.2.3 Acetylene

Acetylene at UCT is used for laboratory work and maintenance (e.g. welding, etc). Air Liquid (Pty) Ltd is the UCT vendor for acetylene. Quantities of acetylene ordered for the period of January – October 2007 were obtained from the UCT Finance Department. The amount of CO₂ released was thereafter calculated based on reaction stoichiometry for the combustion reaction for acetylene in air:



The reaction was assumed to occur to completion, and kinetic effects were not considered. Average consumption values for the period of January to October were assumed for the last two months of the year.

2.3 Transport emissions

All emissions that emanate from UCT-related student and staff travelling fall under this category. This covers emissions from commuting to and from UCT, and also emissions from vehicles owned by the various University departments and student bodies. Emissions from the university-owned Jammie Shuttle fleet, which provides commuting services for UCT students and staff between campuses and within areas close to the main campus, are also included this category. All emissions from

medium and long-haul staff flights (e.g. travel to conferences, symposia and workshops outside the city of Cape Town) are classified under this category as well.

2.3.1 Jammie Shuttle

Jammie Shuttle fuel data for the period of September 2007 to June 2009 was obtained from the Production Manager in the University's Properties and Services Department. It was given as diesel consumption quantities on a daily basis, and extracted from the computer emailing system records of the diesel supplier. Shuttle diesel consumption for the period of January – August 2007 was estimated based on an average ratio of September – December 2007 consumption to consumption over the same period in 2008. IPCC inventory methodology and emission factors were then used to determine the resulting carbon emissions (IPCC, 2006).

2.3.2 Students and staff commuting

A transport survey was conducted for University staff and students in 2009 to determine the distribution of modes of transport used for commuting daily to the campus campus and the distribution of areas of residence. In the survey, the various residential areas were grouped together based on their relative distance from the University, and the resulting distribution was applied to the University's 2007 student and staff statistics (University of Cape Town, 2009). The distances were then converted to CO₂ emissions using the emission factors associated with the relevant transport modes.

In the analysis it was assumed that buses carry 60 passengers while taxis carry 15 passengers. Fuel consumption was assumed to be 9.5 L/100km of petrol for all private cars and taxis, 4.0L/100km of petrol for motorbikes and scooters and 40.0L/100km of diesel for public buses (Landy on Line, 2008; SACAN, 2008). It was also assumed that there are 21 working days per month. Standard IPCC emission factors for diesel and petrol were used for cars, taxis and buses, while a per capita emission factor of 30 gC per passenger-km was assumed for passenger trains (Penner, Lister et al., 1999).

2.3.3 UCT vehicle fleet

UCT vehicle fleet fuel payments are facilitated through the Bankfin petrol card system in which vehicle users purchase fuel at filling stations on the card and then submit their receipts at the end of each month. Each card is linked to a university account and cost centre (affiliated to the department to which the car pool is issued) which then gets debited with the claimed amount.

Claimed and processed monetary payment data for fuel ordered from January to August 2007 was

obtained from the UCT Finance Department, and the average fuel price in Rands per Litre for coastal conditions was used (DME, 2007) to calculate the volume of fuel consumed. The density of the fuel (OECD-IEA, 2004) was used to convert these figures to a mass basis for each fuel type, after which the net calorific value (OECD-IEA, 2004) was used to determine the amount of energy released at combustion. Using the IPCC emission factor (IPCC, 2006), the amount of CO₂ released could therefore be calculated. Average figures were used for September to December as calculated based on the average monthly consumption between January and August.

2.3.4 Official flights

Flights for official UCT business are not booked through a single travel agent or administered centrally by a single University department, instead each department, sometimes even each person within one department, uses a different travel agent, and hence obtaining flight data for the entire university is an impossible task. Travel insurance for official international trips, however, is administered centrally by the UCT Travel Insurance Office, and this is the office that provided data on the international trips taken for official UCT business for the year 2007.

To estimate the emissions associated with each international trip, flight distances obtained from Travel Math were used, together with a long haul flight emission factor of 0.15 ton CO₂-eq per passenger per 1000 km (SACAN, 2008; Travel Math, 2009).

2.4 Goods and services emissions

This section captures GHG emissions associated with goods and services consumed by the University. In the scoping stages of this project, this category included emissions from a range of products and services delivered to the University (e.g. packaging, paper products, chemicals, equipment, waste disposal services etc.), but as the project evolved it was found that only emissions associated with the consumption of various types of paper and the treatment of waste were significantly large enough to be included in the analysis (Letete and Guma, 2007).

2.4.1 Paper

Three types of paper were covered in this analysis: Printing and photocopying paper, toilet paper and paper towels.

Printing and photocopying paper

At UCT printing and photocopying services are managed in two different ways: The most common is the use of Nashua-owned machines and paper, while the other is through department-owned

machinery and consumables. The former contributes a much larger portion compared to the latter because it is used by all undergraduate students and most departments have reverted to it, and also centrally managed hence activity data was relatively simpler to obtain. Because it is not managed at any one point, data on the latter could not be obtained, hence was not included in the carbon footprint analysis.

It was not possible to obtain data on the consumption of printing paper for the year 2007 from Nashua, instead 2009 data was used for analysis, with the assumption that printing paper consumption has not increased significantly since 2007. This data, however, was only available for the period of January 2009 – July 2009, and therefore the consumption rate for the rest of the year (August-December 2009) was assumed to be the average of the seven preceding months. Here a mass of 5 grams was assumed for each sheet of A4 paper.

Toilet paper and paper towels

Consumption data on toilet paper and paper towels was obtained from Supercare Cleaning Services – A company responsible for procuring cleaning materials and carrying out all cleaning services on campus. For both items, data was only available for the period of January 2007 – October 2007; hence consumption for the rest of the year had to be assumed. For toilet paper a weight of 227 g/roll was used, while a size of 240 mm x 330 mm and a specific gravity of 38.18 gsm were used in the analysis for paper towels (3PIN 2009; WIPO, 2009).

To obtain the carbon emissions associated with all types of paper, a life-cycle emission factor of 1200 kg CO₂-eq per tonne of paper was applied to the mass consumption data.

2.4.2 Solid waste

As with printing paper, there was no record of the quantities and types of solid waste removed from the University for the year 2007. Only starting in 2009 was a recycling company called Wasteman recycling contracted by the Properties and Services Department to remove waste from UCT premises, recycle all recyclables and to keep record of all quantities involved. Even then, only data for the months of April, May and June was available, and an average quantity for these months was assumed for all other months.

The IPCC 2006 method for estimating the generation potential of CH₄ emissions from solid waste was used and converted to CO₂ emissions using a global warming potential of 25 for methane (IPCC, 2006).

2.4.3 Wastewater

Only sewerage disposal data for the period of January – August 2007 was available from the

University's Department of Properties and Services, hence extrapolation using the monthly average was necessary to estimate sewerage data for the last four months of the year.

The IPCC 2006 method for estimating CH₄ emissions from wastewater was used, together with an average Chemical Oxygen Demand (COD) of 58 mg/l for all Western Cape wastewater treatment plants in 2007 (City of Cape Town, 2009). Anaerobic treatment of wastewater with no methane recovery and a global warming potential of 25 for methane were also assumed.

3 Results and discussions

3.1 Campus energy emissions

Figures 2 and 3 show the annual electricity consumption and the associated carbon emissions for different UCT campuses. For the Main (lower, middle and upper) and Medical campuses these have been shown from 2003 to 2008, while for GSB campus and satellite residences, values for the periods 2007-2008 and 2007 only respectively are presented.

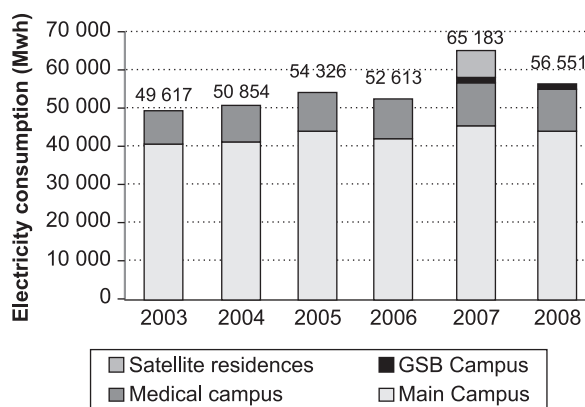


Figure 2: trend of electricity consumption on Main, Medical and GSB campuses

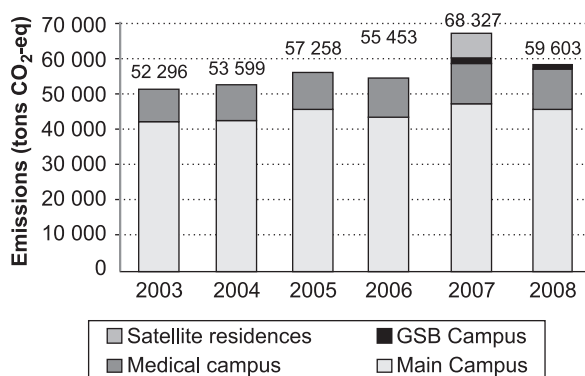


Figure 3: Carbon emissions trend from electricity consumption on Main, Medical and GSB campuses

GHG emissions from electricity consumed on Main and Medical School campuses range from

about 52 300 tonnes CO₂-eq in 2003 to about 59 900 tonnes CO₂-eq in 2007, while CO₂ emissions from electricity consumed at the GSB and in satellite campuses for the year 2007 were estimated at 1 500 and 6 900 tonnes CO₂-eq respectively.

Electricity consumption contributed a total of 68 300 tons to the University's carbon footprint in 2007, 35% of which was from the Main Campus, 9% from Medical School Campus, 1% from the GSB and the rest from satellite residential buildings (Figure 4).

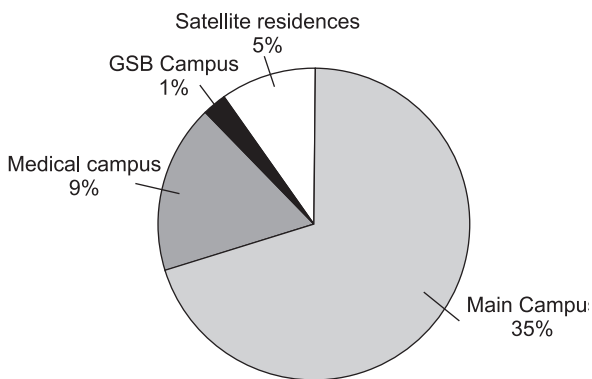


Figure 4: Distribution of carbon emissions from electricity usage at UCT

A total of 259.3 tonnes of LPG was consumed at UCT in 2007, contributing about 755.2 tonnes of CO₂-eq emissions to the University's carbon footprint in that year. Bulk gas and handigas made up about 97% and 3% of the emissions respectively. The analysis also showed that a total of 205 kg of acetylene was used on all campuses in 2007, contributing about 0.693 tonnes of CO₂-eq emissions to the University's 2007 emissions (Table 1).

Table 1: LPG and acetylene consumption and emissions for 2007

Fuel	Consumption (tons)	Emissions (tons CO ₂ -eq)
LPG	259.3	755.2
Acetylene	0.205	0.694

3.2 Transport emissions

A total of 2 077 students and members of staff responded to the UCT commuting survey, and Figure 5 shows the distribution of the major modes of transport used daily for commuting to and from the University campuses.

Only about 16% of the UCT community commute to campus carbon-free, while about 33% use the Jammie Shuttle. More than 40% of the UCT community drive to campus daily.

Figure 6 shows the emissions profile of the Jammie Shuttles for the period of January 2007 to June 2009. The total emissions from the Jammie Shuttles for the year 2007 and 2008 were estimated

at 802.8 and 1,013.3 tons of CO₂-eq respectively, while for the period of January to June 2009 the emissions were about 553.3 tons CO₂-eq. The expected trend is observed in CO₂ emissions per annum for all the years showing less emissions in January, June and July, November and December due to reduction of the number of shuttles operating in this period due to vacation.

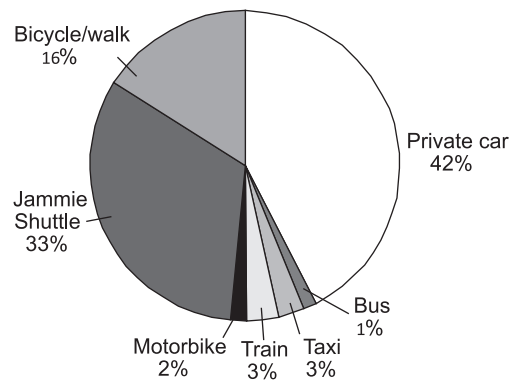


Figure 5: Distribution of daily commuting modes by students and staff

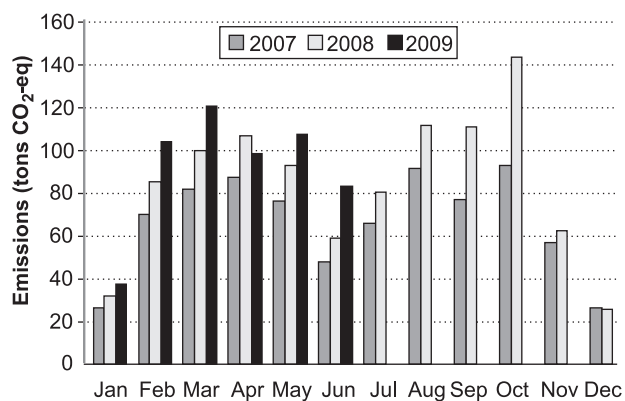


Figure 6: Carbon dioxide emissions from diesel consumption in Jammie Shuttles

The total emissions resulting from commuting of students and staff for 2007 were found to be about 12,640 tonnes of CO₂-eq, of which about 95% are attributable to the use of private vehicles and the Jammie shuttles, with motorcycles and public transportation making up the rest (Figure 7).

The UCT vehicle fleet was found to contribute a total of 424.8 tonnes of CO₂-eq to the University's emissions, with petrol and diesel amounting to about 333 or 78% and 92 or 22% respectively (Figure 8).

A total of about 11.9 million passenger-kilometres were flown internationally for UCT official business in 2007, resulting in CO₂ emissions of about 1 800 tonnes. As can be seen from Figure 9, trips to Europe and North America made up about 76% of these emissions while trips within Africa only contributed about 8.6%.

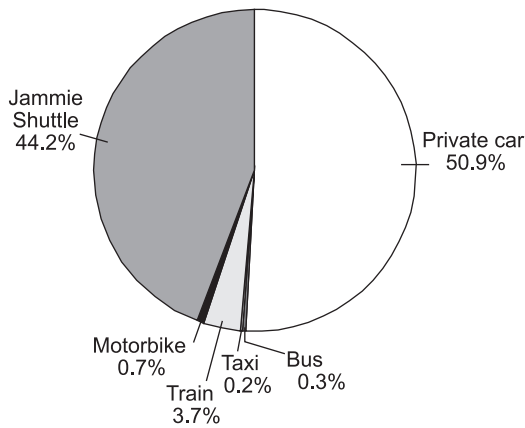


Figure 7: Distribution of GHG emissions due to daily commuting to UCT campuses

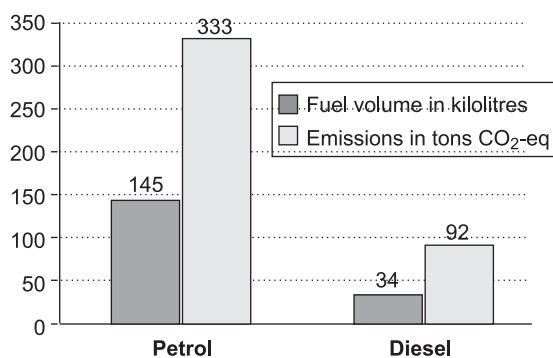


Figure 8: Fuel quantities and resulting emissions from UCT vehicle fleet for year 2007

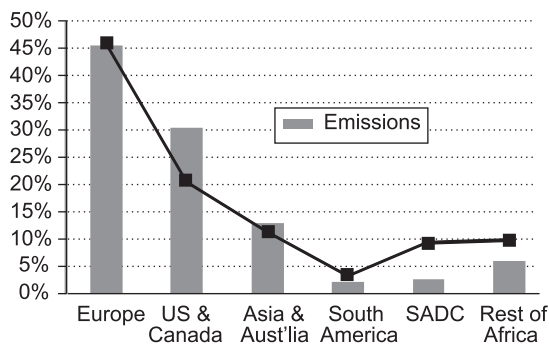


Figure 9: Distribution of trips and emissions from international official flights in 2007

It must be noted that because of unavailability of data on domestic flights for official UCT business, the emission value reported in this section is an underestimation of the actual UCT carbon footprint resulting from official flights.

3.3 Emissions from goods and services

Paper

Figure 10 shows the emission contribution of each type of paper to the university's carbon footprint for the year 2007.

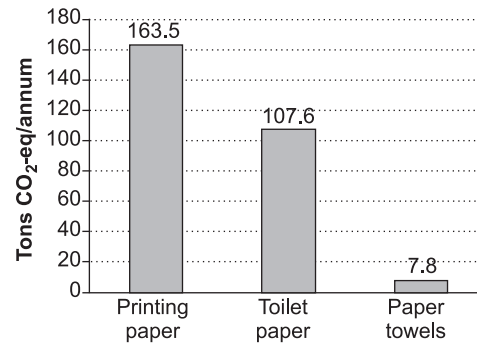


Figure 10: Life-cycle emissions from the use of paper on UCT campuses in 2007

Solid waste and wastewater

The results showed that solid waste contributes about 595.1 tonnes of CO₂-eq emissions per annum to the University's total carbon footprint. These are only emissions associated with the wet waste that is taken to the landfill, and assumes that all the recyclables are actually recycled and do not contribute to UCT's carbon footprint.

The contribution of wastewater to the total carbon footprint of the University was found to be about 113.1 tonnes of CO₂-eq per annum for 2007.

3.4 Total carbon footprint of UCT

Table 2 shows the total carbon footprint of the University of Cape Town for the year 2007. University activities for the year of 2007 led to the release of about 85 000 tons of CO₂-eq emissions into the atmosphere, with about 80% of those emissions coming from the consumption of electricity alone. Daily commuting to campus and official international flights were the second and third most carbon-intensive activities at the University in 2007 with contributions of 14% and 2% respectively.

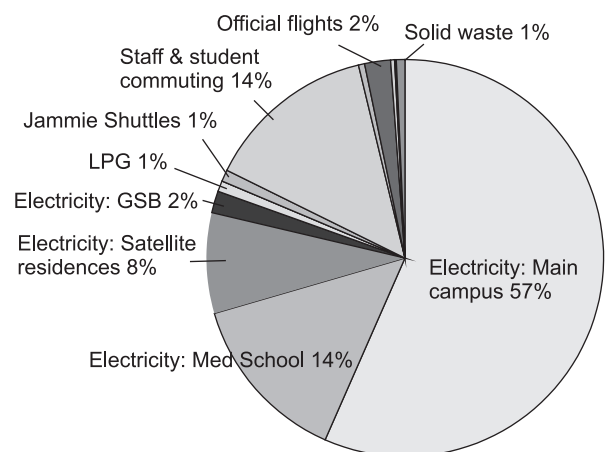


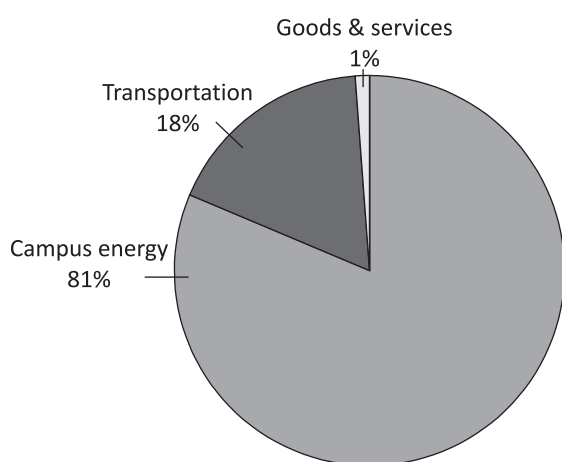
Figure 11: Overall UCT CO₂ emissions

Figure 11 is an overview of the carbon footprint of the University of Cape Town, highlighting only the most significant contributors (greater than 0.5%)

Table 2: UCT's carbon emissions for the year 2007

Category	Emissions source	Emissions [tons CO ₂ -eq/yr]	% contribution
Campus energy	Electricity: Main Campus	48 061.7	56.59%
	Electricity: Medical School Campus	11 810.5	13.91%
	Electricity: Graduate School of Business	1 518.4	1.79%
	Electricity: Satellite residences	6 936.6	8.17%
	LPG	755.2	0.89%
	Acetylene	0.7	0.001%
Transportation	Jammie Shuttles	802.8	0.95%
	Staff and student commuting	11 837.2	13.94%
	UCT vehicle fleet	424.8	0.50%
	Official flights	1 790.4	2.11%
Goods & Services	Printing paper, toilet paper, paper towels	278.9	0.33%
	Wastewater	113.1	0.13%
	Solid waste	595.1	0.70%
TOTAL		84 925.5	100%

contribution). Of the three emission categories, Campus energy has the largest share of GHG emissions at 81%, followed by Transport at 18% and lastly Goods and services with 1% (Figure 12).

**Figure 12: Distribution of UCT's carbon footprint by emission category**

4 Benchmarking against other universities

Information on the carbon footprints of other South African universities could not be found; instead the carbon footprint of UCT was compared to those of international universities, which have published such studies.

Figures 13, 14 and 15 (overleaf) compare UCT's carbon footprint with that of other academic institutions around the world. Specifically, Figure 9 compares the emissions per capita from direct energy consumption (excluding transport emissions) of the different universities, and UCT is found to be at 3.2 tons CO₂-eq per student, well below the average of 8.4. What seems interesting in the Figure is that all

American universities have higher per capita emission values than UCT while the two British universities and the National University of Lesotho perform better than UCT.

Of the universities compared in Figure 13, only nine could further be compared in terms of emissions from sectors other than direct energy use. Figure 14 compares UCT's emissions from Transportation, Waste and Other sources with those of other universities, while Figure 11 compares the total annual carbon footprints of these universities per student.

It is clear from both Figures 14 and 15 that UCT outperforms all the other universities included in the analyses in terms of emissions intensity.

It is worth noting that UCT's value of 4.0 Tons CO₂-eq/student is rightfully lower than the country's 2007 per capita emissions estimate of 10.4 Tons CO₂-eq/capita (Appendix) because the former only reflects the student's carbon footprint associated with the University activities.

5 Conclusions and recommendations

- The total carbon emissions for the University of Cape Town for the year 2007 were estimated at 84 900 CO₂-eqt. Although this value is an underestimation because of unavailability of some of the activity data, it is the best estimation that was possible with the data available, and it gives a good idea of the size of the University's annual carbon footprint.
- Electricity usage on UCT campuses is the largest sole contributor to the University's carbon footprint. In 2007, about 80.5% of UCT's carbon footprint resulted from the use of electricity.
- The unavailability of data was the biggest problem to determining a complete and comprehensive carbon footprint for the University of Cape

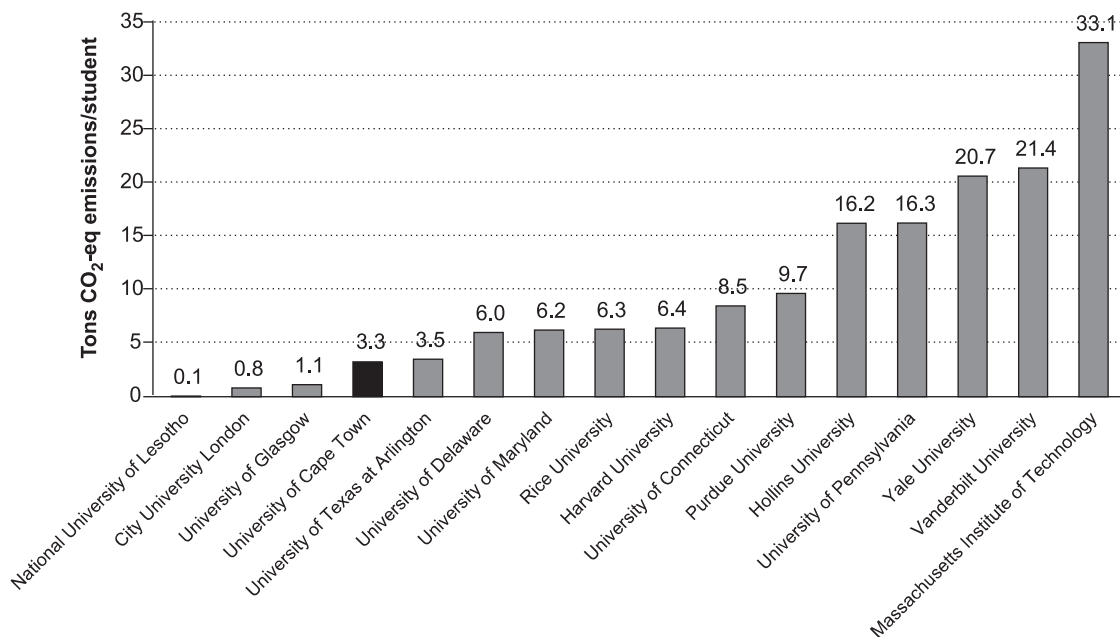


Figure 13: Per capita emissions from energy consumption of different universities

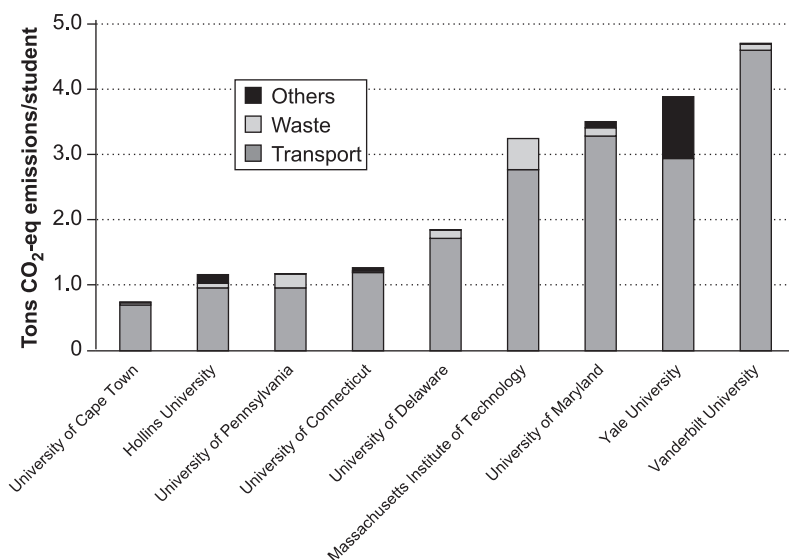


Figure 14: Per capita emissions from transport, waste and other sources for different universities

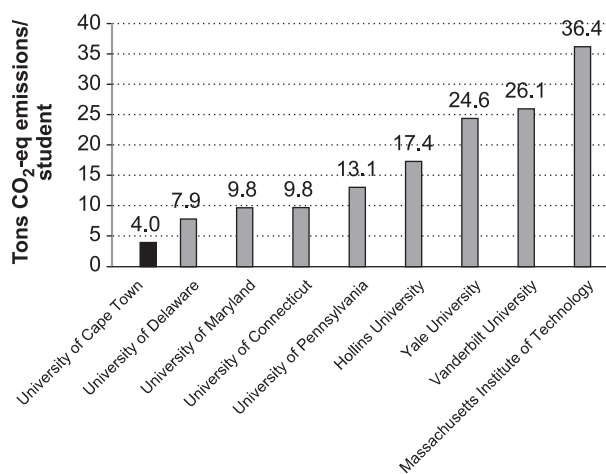


Figure 15: Comparing the total per capita emissions of the different universities

Town. It is recommended that all activity data – electricity consumption in all UCT campuses, LPG consumption data, Acetylene consumption data, UCT fleet data, Jammie Shuttle diesel consumption and waste data – should constantly be monitored and updated, at least on a yearly basis.

Note

1. All data for year 2007 with the exception of University of Glasgow (2006), University of Texas Arlington (2005), Yale University (2002) and Massachusetts Institute of Technology (2003).

References

- 3PIN. (2009). Nampak Twinsaver M-Fold folded Paper Towels – 2000 Towels. 2009, from www.3pin.co.za/ecommerce/product?product_id=22955&category_id=21&subcategory_id=198&subsubcategory_id=0.
- City of Cape Town. (2009). Cape Town Wastewater Treatment: Effluent Mean Values – Year to December 2007 (Excel spreadsheet). 2009.
- Dias, A. C., L. Arroja, et al. (2007). Life Cycle Assessment of Printing and Writing paper produced in Portugal. *International Journal of Life Cycle Assessment* 12(7).
- DME. (2007). Fuel Prices 2007, from www.dme.gov.za/energy/liquid_prices.stm.
- Engineering News. (2007). SA's electricity supply still at risk. Retrieved 18 May 2007, 2007, from www.engineeringnews.co.za/article/sarsquos-electricity-supply-still-at-risk-2007-05-18.
- Eskom (2007). *Annual Report 2006*.
- Hall, M. and N. Murray (2008). Green Campus Policy Framework for the University of Cape Town. University of Cape Town, Cape Town.
- IPCC (1990). *Climate change: The IPCC scientific assessment*. Cambridge, Cambridge University Press.
- IPCC (2006). *IPCC guidelines for national greenhouse gas inventories*. Prepared by the National Greenhouse Gas Inventories Programme. Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Kanagawa, Japan, Institute for Global Environmental Strategies.
- Landy on Line. (2008). Land Rover – Engine Conversions. from www.landyonline.co.za/techtalk/engine_conversions%20.htm.
- Letete, T., N.W. Mungwe and M. Guma (2010). Report: University of Cape Town carbon footprint. University of Cape Town, Cape Town.
- Letete, T. and M. Guma (2007). Scoping Study: The Carbon footprint of the University of Cape Town. University of Cape Town, Cape Town.
- OECD-IEA (2004). *Energy Statistics Manual*. Paris, International Energy Agency.
- Penner, E. J., D. H. Lister, et al. (1999). *Aviation and the Global Atmosphere*, IPCC.
- Rippon, S. (2008). *Green Campus Action Plan*. University of Cape Town, Cape Town.
- SACAN. (2008). *Project 90x2030: Personal Household*

Carbon Footprint Calculator: Assumptions. Retrieved 12 August 2009, 2009, from www.90x2030.org.za/frame_index1.html.

- Travel Math. (2009). *Travel Calculator*. 2009, from www.travelmath.com.
- UNFCCC (1997). *The Kyoto Protocol to the Convention on Climate Change*. Bonn, UNFCCC Secretariat.
- University of Cape Town. (2009). *About the University: Green Campus Initiative*. 2009, from www.uct.ac.za/about/greencampus/.
- University of Cape Town. (2009). *About the University: Introducing UCT – Statistics*. Retrieved 12 Nov 2009, 2009, from www.uct.ac.za/about/intro/statistics/.
- Wiedmann, T. and J. Minx (2007). *A definition of 'Carbon footprint'*. Durham, ISA-Research and Consulting.
- WIPO. (2009). *Tissue products having enhanced cross-machine directional properties*. Retrieved 12 Dec 2009, 2009, from www.wipo.int/pctdb/ja/wo.jsp?WO=2007070124&IA=US2006032204&DISPLAY=DESC.

See appendices overleaf

Appendices

A. Data for other universities

University	No of students 2008 ^a	Emissions [Tons CO ₂ -eq]				Total emissions	Total emis- sions/capita Tons CO ₂ eq /student	Year	Source ^b
		Energy	Transportation	Waste	Others				
National Univ. of Lesotho	8 566	573					2007	1	
City Univ. London	12 861	10 686	-		1 597	12 283	2007	2	
University of Glasgow	23 590	27 000					2006	3	
University of Cape Town	21 175	69 083	14 855	708	279	84 925	2007		
Univ. of Texas at Arlington	25 297	88 830				98 700	2005	4	
University of Delaware	19 359	116 614	33 336	2 538	54	152 542	2007	5	
University of Maryland	36 014	224 733	118 466	4 560	3 386	351 145	2007	6	
Rice University	5 061	31 986				69 032	2007	7	
Harvard University	29 900	192 230					2007	8	
University of Connecticut	20 229	171 993	24 248	487	1 025	197 753	2007	9	
Purdue University	39 102	378 400				668 800	2007	10	
Hollins University	1 039	16 874	1 000	75	137	18 086	2007	11	
Univ. of Pennsylvania	26 537	317 000	25 548	5 750	0.48	348 298	2007	12	
Yale University	11 851	244 814	34 904		11 236	290 954	2002	13	
Vanderbilt University	11 577	247 877	53 308	1 098	134	302 417	2007	14	
Massachusetts IT	5 909	195 861	16 407	2 807	0	215 075	2003	15	

Notes

a. Obtained from: Top Universities. University Profiles: Statistics. 2009 [Available from: www.topuniversities.com.]

b. Most of the reports are available on the following website: www.aashe.org/resources/ghg_inventories.php

Sources:

1. Mpholo, M., Electricity consumption of the National University of Lesotho, T. Letete, Editor. 2009: Maseru.
2. City University London. University carbon footprint calculated – City University London. 2007 16 August 2007 [cited 2009; Available from: www.city.ac.uk/news/archive/2007/08_august/16082007_4.html].
3. Young, A. Carbon footprint. 2008 [cited 2009; Available from: <http://www.gla.ac.uk/events/energy/carbonfootprint/>].
4. Howard, J., et al., University of Texas at Arlington Carbon footprint Analysis: Beginning a conversation on responsible growth in the face of climate change 2005-2020. 2008, University of Arlington at Texas: Arlington
5. Zhang, X., et al., A Sustainable University of Delaware: Carbon footprint – Greenhouse Gas Emissions Inventory. 2008, University of Delaware: Delaware.
6. Tilley, D., et al., Carbon footprint of the University of Maryland, College Park: An inventory of Greenhouse Gas emissions (2002-2007). 2007: Maryland.
7. Caves, J., et al., Leaving Tracks: The Carbon footprint of Rice University. 2007, Rice University.
8. Harvard University, Harvard University Fact Book 2007-08, The Office of Institutional Research, Editor. 2008, Harvard University: Cambridge.
9. University of Connecticut. UConn Emissions Inventory Summaries. 2008 [cited 2009; Available from: www.ecohusky.uconn.edu/pcc/emissionresults.html].
10. Gardner, E. Purdue's carbon footprint measured by students. 2007 [cited 2009; Available from: <http://news.uns.purdue.edu/x/2007a/070423ShepsonResults.html>].
11. Godard, R. and E. Latty, The Carbon Footprint of Hollins University 2003 – 2007. 2007, Hollins University.
12. Braham, W., et al., University of Pennsylvania Carbon Footprint. 2007, University of Pennsylvania: Pennsylvania.
13. Buttazzoni, M., et al., Inventory and Analysis of Yale University's Greenhouse Gas Emissions, J. Coppock, Editor. 2005, Yale School of Forestry and Environmental Studies.
14. George, A., S. Gild, and K. Abkowitz, Baseline Inventory of Greenhouse Gas Emissions 2005-2007. 2009, Vanderbilt University.
15. Groode, T. and J. Heywood, A Methodology for Assessing MIT's Energy Use and Greenhouse Gas Emissions. 2004: Cambridge.

B. Estimating South Africa's 2007 per capita emissions

Information	Value	Units	Source
2007 country emissions	498.5	MTons CO ₂	Winkler, H., ed. Long Term Mitigation Scenarios: Technical Report. 2007, Prepared by the Energy Research Centre for Department of Environment Affairs and Tourism, Pretoria, October 2007.
2007 mid-year population estimate	47.9	Million people	www.southafrica.info/about/people/population.htm

Received 4 November 2010