*This is a research paper prepared by Jennifer Zhu, ANU, as part on IARU exchange with the Yale Office of Sustainability. It provides useful background on development of Greenhouse Inventory and the challenges in standardizing greenhouse emissions calculations within an international framework.*

# Standardising Greenhouse Calculators

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For the institutions in the International Alliance of Research Universities (IARU), the key goal is to become leaders in addressing global challenges. The issue of long term campus sustainability is at the heart of the challenge, and an essential aspect towards achieving this is the compilation of data that quantifies the amounts and sources of emissions of greenhouse gases attributable to the existence and operations of the institutions. Conducting a greenhouse gas (GHG) emissions inventory is the first and crucial step for effective management and mitigation options.

## *The Need for an Inventory Standard*

The quickest and most efficient way of calculating a GHG inventory is using one of the many online emissions calculators. However, when comparing results for institutions around the world, the computation method for deriving the emissions is primarily dependent upon the characteristics of the country's, and sometimes the local region's, energy supply. The output metrics of weight of emitted carbon dioxide equivalent (eCO2) can also vary from country to country. When it comes down to comparing between universities in the IARU, two factors need to be accounted for

- *The unit in which the metric for the emissions is stated*: setting a standard for SI units of kilograms eCO2 will enable valid cross campus comparisons, and this can be achieved by a simple numerical conversion.

- *The way the metric for the emissions is calculated*: this is later analysed in detail for a few greenhouse calculators. Some points to note

- there are many calculators available on the internet, however only those that detailed the conversion factors and their sources were examined

- the emitted carbon coefficients are usually obtained from a nationally standard value, sometimes region-specific, and are constantly being updated

- the calculators are predominantly for the counties of US, UK and Australia, calculators in other countries were very hard to find, and only the most relevant one from each country was investigated

## *Principles and Scope of GHG Emissions Reporting*

The World Business Council for Sustainable Development and the World Resource Institute (WBCSD/WRI) jointly established a set of accounting standards. GHG accounting and reporting should be based upon the principles

- *Relevance*: define boundaries that reflect decision making needs of all stakeholders

- *Completeness*: account for all sources within chosen organizational and operational boundaries

- *Consistency*: allow meaningful comparison of performance over time and within other contexts

- *Transparency*: disclosure of assumptions and clear references to computational methodology

- *Accuracy*: address all relevant issues with precision to ensure validity and reliability

The scope of the reporting for an institutional context is comprised of three categories

- Direct sources of GHG owned and/or controlled by the institution
- Indirect GHG emissions associated with generation of imported sources of energy
- All other indirect sources of GHG emissions resulting from institution activities and community members

These categories can be further subdivided to cover the entire scope for data collection and entry. Clean Air – Cool Planet utilises the following sections designed specifically for a campus inventory

- Energy
    - Purchased electricity
    - Purchased steam/hot water
    - On campus cogeneration
    - On campus stationary energy use

- Transportation
    - University Fleet
    - Air travel
    - Student, faculty and staff commuting

- Agriculture
    - Fertiliser
    - Animals

- Solid Waste
    - Incineration
    - Landfill

- Refrigeration and other Chemicals
    - All other GHGs

- Offsets
    - Actions taken to offset emissions

In addition to emission source data, institution data including demography, budget and physical size, is also important to include in the analysis for distributions of emissions among the various sources. This allows scaling for a meaningful global comparison. Data needs to be collected on a yearly basis to examine trends and projections, and to provide a context for the effects and impacts over time.

## *Global Standards: Greenhouse Gases (GHGs), Carbon Dioxide Equivalents (eCO2) and Global Warming Potential (GWP)*

The gases that should be included in a GHG emissions inventory are those that are GHGs and these have been specified by the Kyoto Protocol to the UN Framework Convention on Climate Change

- Carbon dioxide (C02)
- Methane (CH4)
- Nitrous oxide (N20)

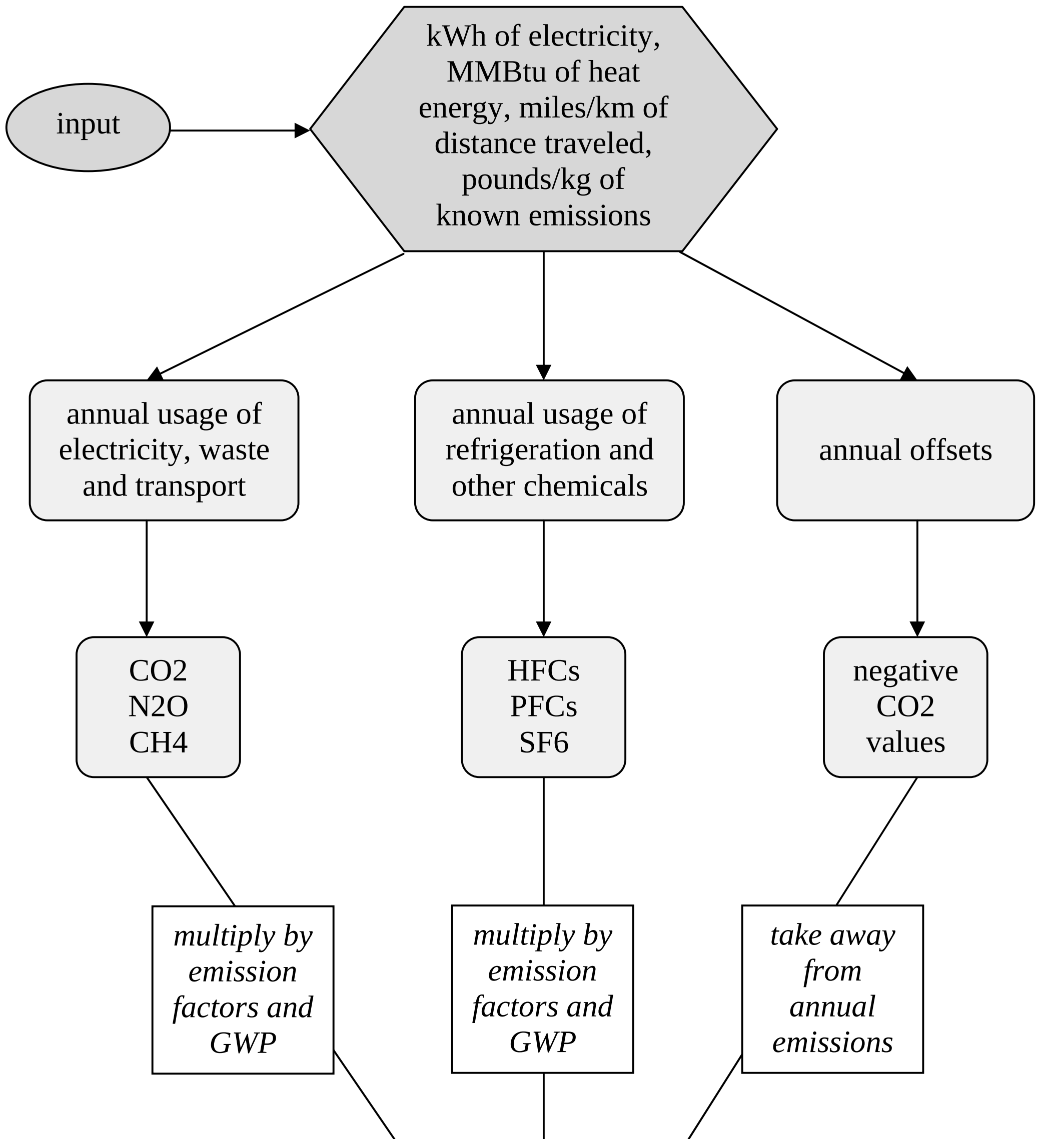
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF6)

The International Emissions Trading Association (IETA) has provided a universal standard of measurement against which the impact of releasing different GHGs can be evaluated. The units are yearly carbon dioxide equivalents (eCO2), and the figure is given in terms of weight which can be standadised to the SI unit of kg per annum.

Every GHG has a Global Warming Potential (GWP) specified by the Intergovernmental Panel on Climate Change (IPCC) which describes the effect of the particular gas on climate change relative to an equivalent amount of CO2 calculated over a specific time interval.

## *Variations in Computation Methodology*

The eCO2 is found through applying a standard series of calculations to generate a value that represents the annual weight of eCO2 released into the atmosphere. There are many online calculators, and the variations in emission factors are examined.



## US: Clean Air – Cool Planet

This carbon calculator is specifically designed for the constitution of an inventory of greenhouse gases emitted by a university campus, and hence is very relevant to the institutions in the IARU. Its main objective is to provide a very useful, if not vital, foundation for a discussion on the issue of climate change and methods of management and mitigation.

The calculator is a Microsoft Excel spreadsheet that consists of three steps: collection of data, calculating GHG emissions and analysing/summarising the results. It includes the GHG specified by the Kyoto Protocol and covers a range of time from 1990-2020, producing charts and graphs for presentation. The spreadsheets are based on workbooks provided by the Intergovernmental Panel on Climate Change (IPCC) with a few modifications for campus specific analysis.

This calculator can seem quite complex, with multiple worksheets, formulae and cell references. However, all that is required of the user is to enter in collected data, with the rigorous maths and science behind the calculations being already set up. Conversion factors and relevant formulae are built into the calculator so the output is automatically calculated. In addition to the resulting numerical values, it will generate graphs and charts to create an emissions profile.

The emissions factors used in this calculator were obtained from the US Environmental Protection Agency, the US Department of Energy and the US Department of Transportation, with the published data ranging from 2002 through to 2006. This can be adjusted in the data entry worksheet for different states in the country.

## Australia: Australian Greenhouse Office

There does not seem to be a GHG emissions calculator specifically designed for a university campus, many focus on household and personal emissions. Upon request from the Australian Greenhouse Office (AGO), an emissions calculator was supplied from the “Greenhouse Challenge Plus” members section.

The input information includes energy fuels and processes, petroleum products transport, waste synthetic gases, fugitive emissions and offsets. This covers the main aspects of a university campus. The input format is straightforward, data entry is in consumption units which are converted to basic units and multiplied by the emission factor to obtain eCO2 per annum. Compared to the Clean Air – Cool Planet calculator, this one is simpler to use, however it is not as detailed, does not produce charts and has no temporal component.

The emission factors are updated in line with the AGO publication "Factors and Methods Workbook: for use in Australian greenhouse emissions reporting", with the latest edition published in 2005. The emission factors can be adjusted for each state in the country.

There are also many other technical tools available from the AGO for members which may be useful in terms of evaluating campus sustainability, however this is not available world wide.

## UK: Carbon Calculator

There do not seem to be many online GHG emissions calculators for the UK, and none were designed specifically for university campuses. A personal emissions calculator was found at Warwick University's Carbon Footprint Group website.

The four main categories of input information were travel, heating, electricity and shopping, which is perhaps not an ideal spread of variables for a university campus. The site explains in detail how the emissions are calculated, but does not specify where the conversion factors are obtained from or the date of publication for those factors.

## On-Campus Electricity Generation: Yale University

Yale collects yearly metrics regarding campus energy usage, and calculates the GHG emissions in metric tons carbon equivalent (MTCE). This includes emissions from the two Yale cogeneration powerplants and purchased electricity, which make up the majority of the emissions, and does not include transportation, carbon sinks and other emissions.

The coefficients used in the calculation of emissions from the powerplants are values calibrated with the boilers by the facilities systems engineers at Yale. The coefficient for calculating the emissions from the purchased electricity is the accepted value for the Yale local region.

The powerplant emissions coefficients are particular for Yale, and provide an example of factors calculated specifically for the relevant university. Other universities with generators on campus should be following a similar methodology for their inventories, ideally also including the coefficients associated with transportation, carbon sinks and other emissions.

## Other Countries: World Resources Institute SafeClimate Carbon Footprint Calculator

An effort was made to find GHG emissions calculators for other countries, however this proved to be a difficult task. Online calculators were few and far between, and language was sometimes a problem.

One calculator that was applicable to emissions from various countries was from the World Resources Institute, which determines eCO2 emissions from energy consumption and transport by car and plane. Because the focus is on household emissions, the scope is not one that encompasses all aspects of a university campus's emissions, but does cover the two major GHG sources. The data input is straightforward and easy to enter online, though not always applicable.

The coefficients used in the computation were from the World Business Council for Sustainable Development GHG protocol initiative calculation tools. For the US and Canada regions, the province or state could be chosen, while the factors for other countries worldwide are from the International Energy Agency, the latest figures from 2004.

The advantages for this calculator are its simplicity and global application, but there are issues with the relevance and accuracy of international coefficient data. The value in this particular calculator would be to gain an overall estimate in GHG emissions for energy and transport for each campus, however the details of each university's inventory cannot be taken into account.

Unfamiliarity with the governmental or other organisations meant emissions factors for each of the countries was hard to find. It is recommended that each of the universities in the IARU supply their respective GHG emissions calculators and/or emissions coefficients. In particular, campuses with onsite power generators will need to specify the calibrated coefficients for those energy sources.

For complete international consistency, it may be possible to modify an existing calculator for calculations of different countries. Clean Air – Cool Planet appears to be the most effective calculator that strikes a balance between data scope, user-friendliness and computation complexity. It will also allow an experienced and proficient user to change certain aspects of the spreadsheet, and with coefficients for the countries supplied by each university, a global calculator that encompasses all the relevant countries could be constructed.

## *Implications for the IARU*

The establishment of a global standard to compare GHG emissions will enable the universities in the IARU to meaningfully compare their individual impacts on the environment. While data collection and calculation can be time consuming, the results of an absolute as well as comparative analysis can be very interesting. With the inventory metrics, each institution can evaluate the effectiveness of current practices and facilitate the management and implementation of policies to improve campus sustainability.

In order for comparison across universities in the IARU that differ in size, population and other factors, the resulting metric for kg of eCO2 emitted per annum for each campus needs to be normalized to eliminate certain unavoidable trends. This can be achieved by identification of an appropriate relative ratio (%) or denominator (per square m, per capita). It may also be the case that universities are missing data, and this will need to be specified clearly and efforts made to gather the relevant data for future inventories.

The analysis between universities with emissions inventory metrics is not necessarily just a summed figure for kg of eCO2 per annum. Breaking down the eCO2 emissions for different sections mentioned above and comparing campuses within those categories is also important in identifying where the most and least emissions are coming from and factoring the relative amounts into campus planning and development.

The GHG inventory is also a key indicator of an institution's environmental/sustainability performance. The raw numerical values as well as the scaled figures obtained from the inventory can be used for the calculation of a Global Campus Sustainability Standard (GCSS) index, which aims to assess the institution's capacity and potential for improvement.

Furthermore, the information gathered from the GHG inventory is not just solely confined to the universities themselves. Relative assessments for GHG emissions can also be made for the particular institution with other infrastructure within its region. Emissions coefficients vary across the globe, and examination of this conversion factor data can lead to conclusions being made about the nature of the country's electricity industry, environmental consequences of citizen habits and the cultural attitude towards sustainable behaviour. A multitude of information from global inventory analyses is the result.

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Yale Facilities Systems Engineering Group and various emails between staff from the universities in the IARU