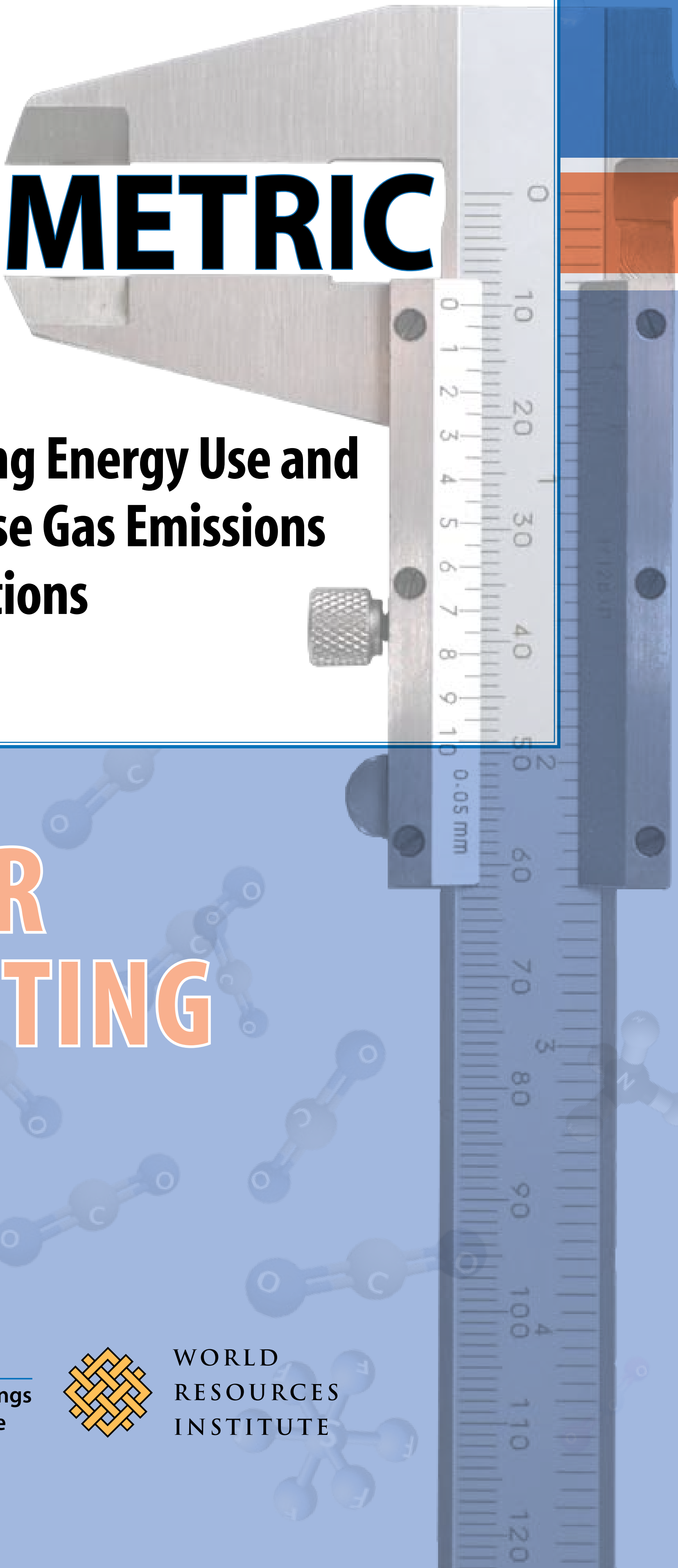
COMMON CARBON METRIC

Protocol for Measuring Energy Use and Reporting Greenhouse Gas Emissions from Building Operations



DRAFT FOR PILOT TESTING

UNEP

UNEP SBCI
Sustainable Buildings & Climate Initiative

WORLD RESOURCES INSTITUTE

Executive Summary

Leading experts from around the world have, through extensive international cooperation, developed a universal method of measuring a building's carbon footprint.

Supported by the United Nations Environment Program, this new 'Common Carbon Metric & Protocol' will allow emissions from buildings around the world to be consistently assessed and compared, and improvements measured.

Why buildings?

The purpose of a Common Carbon Metric & Protocol for buildings is to give the **sector that represents 40% of the world's energy consumption and related 1/3rd of global greenhouse gas (GHG) emissions** a tool that doesn't exist today – a way to measure, report, and verify reductions in a consistent and comparable way. With its high share of emissions the building sector has the responsibility and opportunity to take the global lead in reduction strategies. Awareness of these facts and widespread use of this tool for measuring and reporting **is the key**.

The building sector has more potential to deliver quick, deep and cost effective GHG mitigation than any other. Significantly increasing building energy efficiency can be achieved in the short-term. **Energy consumption in both new and existing buildings could be cut by an estimated 30-50% by 2020** through readily available technologies, design, equipment, management systems, and alternative generation solutions. This can be funded through investments that quickly payback and result in significant environmental, social, and economic benefits. A universal measuring stick for building emissions – a Common Carbon Metric & Protocol – provides the foundation for accurate performance baselines to be drawn, national targets set, and carbon traded on a level playing field.

Success of national carbon reduction targets relies on the low-hanging fruit offered by the mitigation potential of the building sector to avoid further global warming and severe climate impacts.

What is measured?

While all stages of a building's life-cycle (including construction and demolition) produce carbon emissions, **the building's operational phase accounts for 80-90% of emissions** resulting from energy use mainly for heating, cooling, ventilation, lighting and appliances. Therefore, this is the stage of the building's life-cycle that is the focus of the Common Carbon Metric & Protocol.

Working in close cooperation, environmental building ratings organisations, local, regional, and national governments, research institutions, industry experts, and private sector stakeholders *(See Acknowledgements)* have developed a common measurement for GHG emissions from building operations that takes two complementary approaches; one assesses performance at the building level (bottom-up), and the other at the regional or national level (top-down).

The actual reporting is done in weight of carbon dioxide equivalent ($kgCO_2e$) emitted per square meter per year = **$kgCO_2e/m^2/year$** (by building type and by climate region).

Table of Contents

Foreword

The Building Sector is:

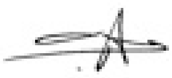
- Collectively responsible for about 30% of total global energy-related greenhouse gas (GHG) emissions;
- Collectively has the greatest potential for delivering major reductions in GHG emissions at zero cost or net savings using currently available technology & knowledge; and
- Collectively the largest single industrial employer, with the potential for creating demand for 'green jobs'.

What has been missing is a collective voice from the sector on these issues. Fundamentally we lack a common language for describing the kind of innovation necessary for the building industry to tackle climate change. More specifically we lack a common approach to measuring GHG emissions and a common approach for reporting on the sector's progress or contribution to achieving emissions reduction targets. Without a common voice, a common language, and a common approach to accounting for emissions, the sector is unable to participate cost effectively in the global carbon market.

UNEP-SBCI is providing a neutral forum for the building sector to come together and develop the common metrics including particularly those stakeholders involved in developing tools and methods for assessing and rating the environmental performance of buildings.

This year is a crucial year for the building sector and the success of the next global protocol on climate change. If we fail to act in a collective and coordinated manner this year, we may indeed fail to effectively address climate change.

UNEP-SBCI will continue to crystallize and amplify the collective voice of the building sector on the need to both further empower the sector, and to promote the sector's demonstrated commitment to lead by example in tackling climate change. UNEP-SBCI will also continue to develop the common ground for measuring emission reductions from buildings. Together we will be more effective in raising awareness and instilling confidence in our national delegations in Copenhagen, that the best chance they have of achieving an effective and profitable global emissions protocol is to seize the opportunity that the building sector can collectively provide.



Arab Hoballah

Chief Sustainable Consumption & Production
UNEP DTIE

Introduction

This paper is offered by the United Nations Environment Program's Sustainable Buildings & Climate Initiative (UNEP-SBCI), a partnership between the UN and public and private stakeholders in the building sector, promoting sustainable building practices globally. The purpose of this proposal for a Common Carbon Metric & Protocol is to support greenhouse gas (GHG) emissions reductions through accurate measurement of energy efficiency improvements in building operations.

Goal: To provide globally applicable common metrics for measuring and reporting the energy use in and GHG emissions from existing building operations to support international, regional, national, and local policy development and industry initiatives.

Objectives: Develop common metrics for use in gathering consistent data and reporting the climate performance of existing buildings in order to:

- Support policy-making to reduce GHG emissions from buildings, especially in developing countries;
- Provide a framework for how to measure emission reduction in buildings so as to support formulation of Nationally Approved Mitigation Action (NAMA) plans, flexible mechanisms, carbon crediting; and other emission reduction mechanisms and plans; and
- Establish a system of measurable, reportable, and verifiable (MRV) indicators for the follow-up of policy implementation, resulting emission reduction and reporting on building-related GHG emissions.

Users: National, regional, and local governments in developed and developing countries, owners of large building portfolios, and national building rating schemes.

Background

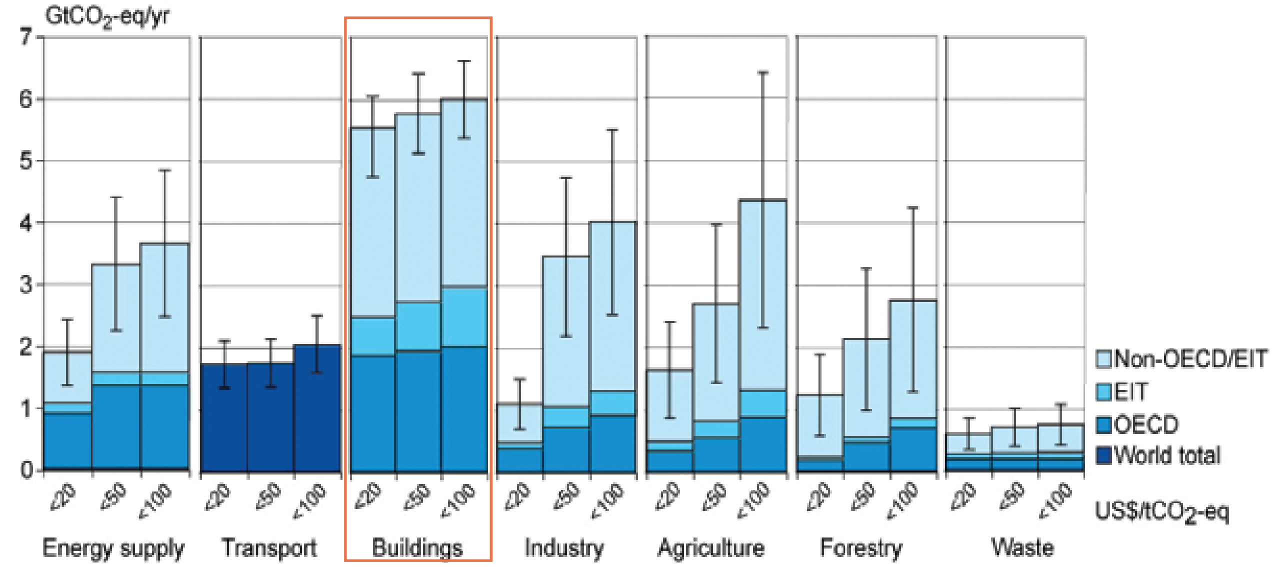
The environmental footprint of the building sector includes; 40% of energy use, 30% raw materials use, 25% of solid waste, 25% water use, and 12% of land use. While this paper focuses on the scope of emissions related to energy use of building operations (See Appendix 1), future metrics are required to address these other impacts in addition to social and financial impacts. **At this time the UN's top priority is climate change and the building sector is responsible for more than one third of global energy-related GHG emissions and, in most countries, is the largest emissions source.** While 80-90% of the energy used by the building is consumed during the use (or operational) stage of a building's life-cycle (for heating, cooling, ventilation, lighting, appliances, etc.), the other 10-20% (figure varies according to the life of the building), is consumed during extraction and processing of raw materials, manufacturing of products, construction and demolition. Furthermore, significant energy is used in transporting occupants, goods and services to and from the building.

The Intergovernmental Panel on Climate Change's 4th Assessment Report (IPCC AR-4) estimated that building-related GHG emissions reached 8.6 billion metric tons (t) CO_2equivalent (e) in 2004, and could nearly double by 2030, reaching 15.6 billion tCO_2e under their high-growth scenario. The report further concluded that **the building sector has the largest potential for reducing GHG emissions and is relatively independent of the price of carbon reduction (cost per tCO_2e) applied. With proven and commercially available technologies, the energy consumption in both new and existing buildings can be cut by an estimated 30-50% without significantly increasing investment costs.** Energy savings can be achieved through a range of measures including smart design, improved insulation, low-energy appliances, high efficiency ventilation and heating/cooling systems, and conservation behavior by building occupants.

The diagram from IPCC AR-4 below indicates that the significant potential for energy efficiency improvements and GHG emissions reductions from buildings is common among developed and developing countries, as well as in economies in transition. Regardless of the price placed on carbon, be it US$20, 50, or 100, buildings offer the greatest potential for emissions reductions over all other sectors.

Construction, renovation, and maintenance of buildings are significant economic activities **contributing 10 - 40% of countries' Gross Domestic Product (GDP) and representing on a global average 10% of country-level employment**, 74% of which are in developing countries and 90% of which are with firms of fewer than ten people. The UNEP-International Labor Organization (ILO) report Green Jobs: Towards decent work in a sustainable low-carbon world (2008), reports that measures improving energy efficiency in buildings lead to direct, indirect, and induced jobs created directly in the real-estate and construction sectors.

IPCC AR-4 {WGIII Figure SPM.6}: Estimated economic mitigation potential by sector and region using technologies and practices expected to be available in 2030. The potentials do not include non-technical options such as lifestyle changes. Note: Organization for Economic Cooperation and Development (OECD) and Economies in Transition (EIT).



Purpose

The Bali Action Plan, paragraph 1, calls for measurable, reportable and verifiable NAMAs. All emissions scenarios used by IPCC AR-4 in modeling how to stabilize the concentration of GHG in the atmosphere below 450ppm CO_2e, assumed high levels of energy efficiency across the sectors. Energy efficiency in buildings offers an obvious opportunity for developed and developing countries to cooperate in achieving common but differentiated action to realize significant GHG emissions reductions. **The enabling conditions already exist:**

> A registry of NAMA by all developing countries should be established, supported and enabled by developed countries through the provision of the means of implementation (technology, financing and capacity-building) to developing countries in a MRV manner in order to develop policy packages that promote emissions reductions in buildings under NAMA. ***These policy packages require the development of common indicators and metrics to report on emissions from buildings and to establish national baselines to enable reporting of achieved emission reductions.***
>
> **UNFCCC Bali Action Plan**

- **POTENTIAL for large GHG emissions reductions in buildings *exists* in all countries.**

- **OPPORTUNITY for country-to-country technology sharing agreements and international capacity building support *exists* and is wide spread** because the level of implementation of energy efficiency measures of the building industry is at different stages in different countries.

- **COMMON METRICS now *exist* to facilitate the technology sharing across different building cultures, climate zones and building types. These are needed for consistent, measurable, reportable and verifiable GHG emissions reductions from buildings. These metrics can be applied** to measure energy use in individual buildings or groups of buildings and converted to CO_2e through emission factors. They are also the basis for monitoring emissions mitigation on regional and global scales.

- **TECHNOLOGIES *exist*, are proven and commercially available.** Transfer of technologies is facilitated through greater understanding, accuracy, and consistency of building performance measurements.

- **FINANCING for energy efficiency improvements in buildings *exists* and can, to a large part, be offset by reduced energy costs of building operations.** Additionally, a concerted approach to investments in energy efficient buildings would support a broader shift towards a low carbon society.

- **BENEFITS of energy efficient buildings *exist* and not only reduce GHG emissions but also support other national sustainable development priorities.** Benefits include: employment generation and upgrading of skills in the existing workforce; provision of more sustainable, affordable and healthy buildings; and improved energy security through reduced overall energy demand. **International technology transfer agreements and support to national capacity building would provide additional incentives for developing countries to undertake energy efficiency in the building sector.**

The challenge is therefore to design mechanisms that will redirect the economic savings associated with emissions reductions in buildings to offset the increased investment costs for energy emissions reductions measures. *This may take the form of three basic models:*

1. **Establish an investment fund for energy efficiency in buildings**. This fund would be used to support additional initial investment costs for energy efficiency in buildings and could be financed through levies of energy use above the ***national average or baseline*** for that particular building type in the country. In this way, the fund would provide additional incentive for reductions among high energy users. This fund could also be financed by redirecting investments in increased energy production avoided by reduced energy demand in buildings. Such a fund could also be supported with seed financing provided under NAMA.

2. **Establish national regulation** that makes energy efficiency investments mandatory in new buildings and renovations of existing buildings. Additional investment costs would no longer be optional and would be carried forward from the investment phase to the use phase in the form of increased building costs. These initial costs would be offset by reduced operational costs.

3. **Allow Cap-and-Trade** of emission reductions from buildings. The funds generated by selling Certified Emission Reductions (CER) could be used to finance investments in emission reduction measures. CER are generated from building projects under the Clean Development Mechanism (CDM) but, due to the fragmentation of the sector and the technology specific focus of CDM, only a handful of building projects have generated CER. With common metrics for assessing GHG emissions from buildings, cap and trade schemes, based on the performance of buildings, could be established.

The above actions require active intervention of policy- and decision-makers, as well as defined standards and definitions for energy efficiency in buildings to underpin these actions. Policy instruments/mechanisms and political understanding and will are needed to harness this opportunity, which must rely on measureable, reportable, and verifiable GHG emissions inventories. Therefore nations must include specific accounting of the building sector's energy and carbon intensities.

The Metric

The Metric

The UNEP-SBCI-WRI Metric & Protocol for measuring and reporting GHG emissions from the building sector is designed to explain the approaches and procedures present in the accompanying Calculation Tool & Reporting Template. All of these resources have been designed through a modular approach, with the intention to add further calculation functionalities relating to additional emission sources, different phases of a building's existence, upstream/downstream emissions, etc. This Metric & Protocol does not include value-based interpretation of the measurements such as weightings or benchmarking. While it is not a building rating tool, it is consistent with the framework and recommended methods for measuring GHG emissions used globally such as the World Business Council for Sustainable Development (WBCSD), World Resources Institute (WRI) GHG Protocol, and International Standards Organization (ISO) 15392:2008 Sustainability in Building Construction and general principles of ISO 14040/44:2006 on Life Cycle Assessment.

This Metric section specifically defines the two major approaches to collecting data on buildings: the bottom-up approach and the top-down approach. Monitoring carbon mitigation measures on a regional or national scale would require a top-down approach while assessing individual building projects would require a bottom-up approach. It also articulates the most relevant metrics that facilitate the comparison of building performance overtime and against benchmarks, including an energy intensity metric and carbon intensity metric. For greater context on these performance metrics, a building(s)' GHG inventory can be correlated with a climate region by the number of heating and cooling degree days of its location. (*See Appendix 8*).

Bottom-up approach

This approach is designed to accept information and data on individual buildings or groups of buildings, which can then be compared to (or benchmarked) to the performance of a defined group, here termed the "Whole." Each country shall obtain MRV data on GHG emissions for statistically representative samples of building types. These data may be readily accessible through utility and/or fuel providers. A building inventory requires that buildings be cataloged by location (country, region, municipality) and identified by street address. Building stock is to be quantified by type: 1) residential (a) single-family and (b) multi-family dwellings, and 2) non-residential (including mixed use and excluding industrial buildings). The stock shall additionally be characterized by age (year built), gross floor area, and occupancy (if available).

Top-down approach

Where GHG emissions reports are required the level of the Whole--i.e., a regional, city or national level--then data on gross energy use and information about the building stock profile are necessary. This information includes age, building type, gross floor area, and occupancy (if available). Where relevant, such aggregated performance data can be compared with a statistically representative sample set of building performance data (bottom-up) from the same area to compare the performance of individual buildings to the estimates made about the sector as a Whole (top-down). It is also critical that other established or newly forming national and international data collections efforts adopt the metrics so that data can be compared easily across the world.

From the above building performance data, the following METRICs should be used to compile consistent and comparable data:

Energy Intensity = kWh/m²/year (*kilo Watt hours per square meter per year*)

Energy Intensity
= kWh/m²/year
= kWh/o/year
Carbon Intensity
= kgCO_2e/m²/year
= kgCO_2e/o/year

Scope: Emissions associated with building energy end-use defined in Appendix 1 are included; purchased electricity, purchased coolth/steam/heat, and/or on-site generated power used to support the building operations. **If available**, emissions associated with fugitives and refrigerants used in building operations should be reported **separately**.

If available, occupancy data should be correlated with the building area to allow Energy Intensity per occupant (o) to be calculated = **kWh/o/year.**

GHG emissions are calculated by multiplying the above Energy Intensity times the official GHG emission coefficients, for the year of reporting, for each fuel source used (*See Appendix 5 & 6*).

Carbon Intensity = kgCO_2e/m²/year or **kgCO_2e/o/year** (*kilograms of carbon dioxide equivalent per square meter or per occupant per year*)

Note: GHG conversion factors for each fuel type shall be the same as those used under national reporting for flexible mechanisms for the Kyoto Protocol for the six GHG (*See Appendix 5 & 6*).

The Protocol

The Protocol

For consistency in global reporting, a common protocol, calculation tool and reporting template is necessary to ensure that data is collected through the same method and parameters. This section provides a step-by-step guide on how to measure and report the energy consumption data and related GHG emissions from buildings. For detailed information on selected emission units of measurement and default emission factors see Appendix 5 & 6.

Building Information

The Calculation Tool & Reporting Template has an introduction, where reporters are asked to identify themselves, the reporting boundary and the reporting period. This is done by filling in information on the building including:

- reporting period,
- type,
- owner (optional),
- address,
- age,
- area and
- occupancy.

The building name shall be the street address. See the following example:

Property Record for Inventory	
Reporter Identification	
Reporting Period	Drop-down Menu ↓
Building Type	Drop-down Menu ↓
Building Owner (optional)	
Street Address	
City	
Zip Code	
Country	Drop-down Menu ↓
Year Constructed	Drop-down Menu ↓
Building Area	
Total # of Full-Time Occupants	

The reporter listed is responsible for the data quality and must be able to answer questions on the data collection process, the data quality and other assumptions. It is important that the information be as correct as possible and that the reporter makes sure that nothing is omitted or redundant.

The building data can also be used to calculate an organization's or property owner's energy consumption in multiple or shared buildings. The reporter must enter the total area of the building(s) in addition to partial areas occupied by the same owner.

Building Energy Consumption Data

Data about energy consumed in owned or leased buildings is normally available from the following sources:

- Utility provider reports and contracts
- Electricity bills
- Invoices for fuel deliveries
- Meter readings (estimated from invoices if meter readings are not available)
- Gas bills
- Pipeline measurements
- Energy management software

The data source should always be stated in the tool for future performance assessments.

The GHG emissions included in the inventory are aggregated automatically by using an estimate of their GWP. The total GHG are thus expressed in CO_2e.

Note: Biogenic CO_2 is typically reported separately.

Calculating Emissions

The following is a description of the methods used by the calculator tool to quantify the emissions from four common sources: purchased electricity, fuel combustion in stationary equipment such as boilers and furnaces (that is power generation), purchased steam, and refrigeration and air-conditioning equipment.

Scope		*Source*	*GHG*
Direct Emissions	1	Power generation	CO2, CH_4 & N_2O
		Refrigeration and air-conditioning equipment	HFCs & PFCs
Indirect Emissions	2	Consmption of purchased electricity	CO_2, CH_4 & N_2O
		Purchased steam/heat	CO_2
	3	Not included at this time	CO_2, CH_4 & N_2O

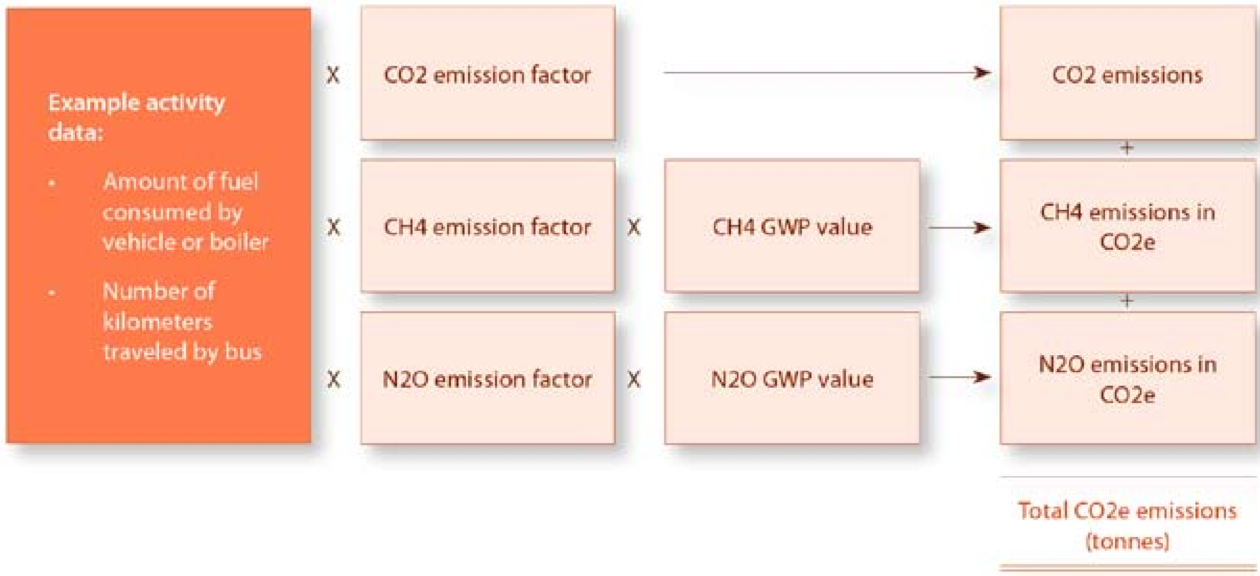
In general, the emissions from energy consumption are quantified by using methods that are based on emission factors. Emission factors are coefficients that describe the amount of a specific GHG that is released from doing a certain activity, such as burning one tonne of fuel in a furnace. The tool uses default emission factors, each of which is based on a sample of representative data (see Appendix 5 and 6). As a result, the tool allows you to calculate emissions without the need to gather site-specific data on the quantity of emissions released. However, because these are default emissions, they may not necessarily reflect the specific types of fuel combustion and emissions control technologies at each building. Additional geographically- or technologically-specific emissions factors may result in more accurate calculations, and shall be used by the reporter as long as they are credible and as long as the user can document their source.

Note: For certain sources, GHG emissions may be calculated in different ways to accommodate differences in the type of activity data available to individual reporting offices or to help ensure that the calculations are as accurate as possible. This section explains when one alternative method is to be used over another.

Because different GHGs differ in the strength of their impact on the climate, the tool also adjusts the emissions of a specific GHG to reflect the actual impact of these emissions. This adjustment is done by using GWP values, which convert emissions of each GHG into a comparable unit (tonnes CO_2 -equivalent; CO_2e).

The total climate impact from an individual reporting office or facility is thus measured as the CO_2e emissions from across all of the sources associated with that office. The default GWP values used in the tool are listed in Appendix 7.

In summary, the emission-factor calculation approach involves the following:



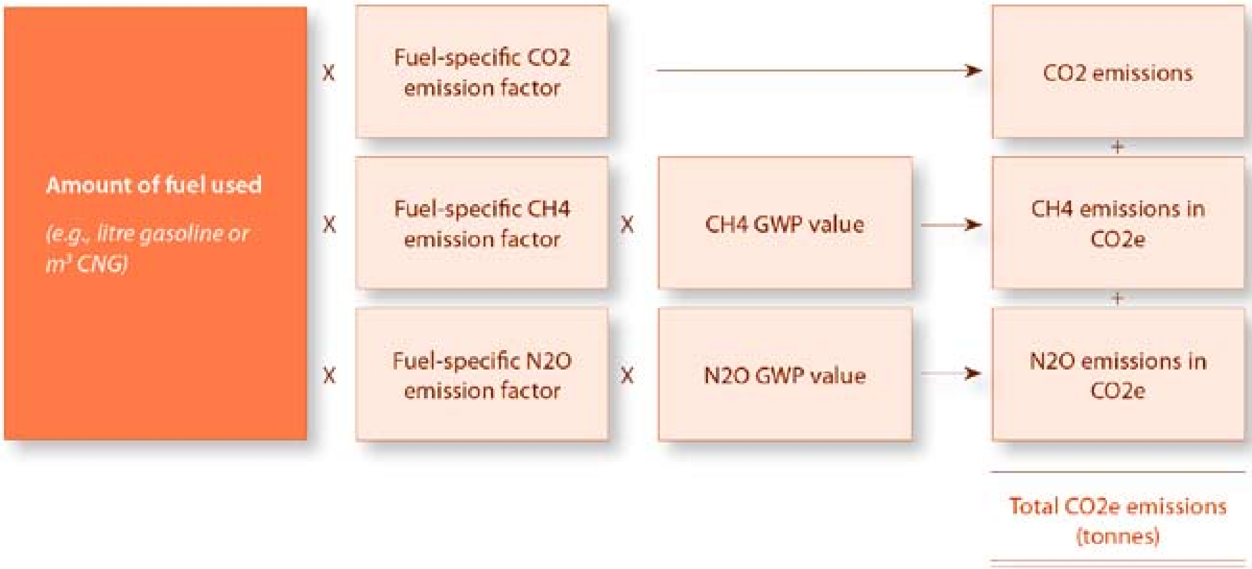
Finally, all methodologies are based on guidance from the GHG Protocol and the IPCC, while emission factors are drawn from a range of sources, including the IPCC, US EPA and the International Energy Agency (see Appendix 1).

Power Generation

Scope 1 emissions also result from the on-site generation of power from the combustion of fuels in stationary equipment, such as boilers and furnaces and other types of stationary fuel technologies owned or controlled by the organization. To complete this section, information on fuel type and fuel consumption is required. The reporter is asked to select the closest available fuel type from a drop-down list. Power generation mainly results in the release of CO_2. CH_4 and N_2O are emitted in smaller amounts. The CO_2 emissions are mainly determined by fuel carbon content, whereas the N_2O and CH_4 emissions depend not only upon fuel characteristics, but also upon the technology type, the combustion characteristics, the maintenance and operational practices, as well as other factors. The default emission factors for CO_2, N_2O and CH_4 are listed in Appendix 6, Tables 6.1-6.3.

The tool allows the reporter to input fuel use data in units of energy (such as GJ and kWh), mass (such as tonnes), and volume (such as m3 and litres). However, the reporter should be aware that fuel density information is not available for some fuels. In these cases, input data may only be available in units of energy or mass.

The GHG emissions are calculated as:



Purchased Electricity

Purchased electricity is an indirect emissions source because the emissions from the generation of electricity occur at the energy plant, rather than at the building. Nonetheless, these emissions shall be included in the report because they result from the building's activities. The Calculation Tool estimates indirect emissions from the electricity supplier only if the user provides activity data on the amount of electricity consumed in the building.

The GHG emissions from electricity purchased from a grid reflect the energy mix used to generate the electricity. The Calculation Tool & Reporting Template provides as many country-specific emission factors as possible. If the reporting country is not shown, then the default value for the geographical region should be used.

The Calculation Tool & Reporting Template does not currently allow for the use of more geographically-specific emission factors. Future versions of the tool may include these options. For example:

- Brazil: http://www.mct.gov.br/index.php/content/view/index.php
- USA: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

The tool implements country-specific default emission factors for CO_2. But CH_4 and N_2O emissions are not quantified for several reasons:

1. CH_4 and N_2O emissions vary with the size, efficiency and vintage of the combustion technology, as well as with the maintenance and operational practices. Because these variables vary significantly amongst electricity plants, they are not easily represented in simple, country-specific emission factors.

2. No current emission factors are available for CH_4 and N_2O. While CO_2 emission factors are updated on an annual basis by the International Energy Agency (EIA), CH_4 and N_2O emission factors are not updated as regularly and are currently out of date.

The CO_2 emissions from purchased electricity can be calculated via the following method:

Method 1: *Based on metered electricity use*

Use this method for buildings with available electricity bills or other data records that directly show how much electricity was consumed.

The CO_2 emissions are calculated as:

Amount of electricity purchased (e.g., kWh) x Country-specific CO2 emission factor = CO2e emissions

Default emission factors are listed in Appendix 5.

Emission sources not included in the current Calculation Tool & Reporting Template

Refrigeration and Air-conditioning Equipment

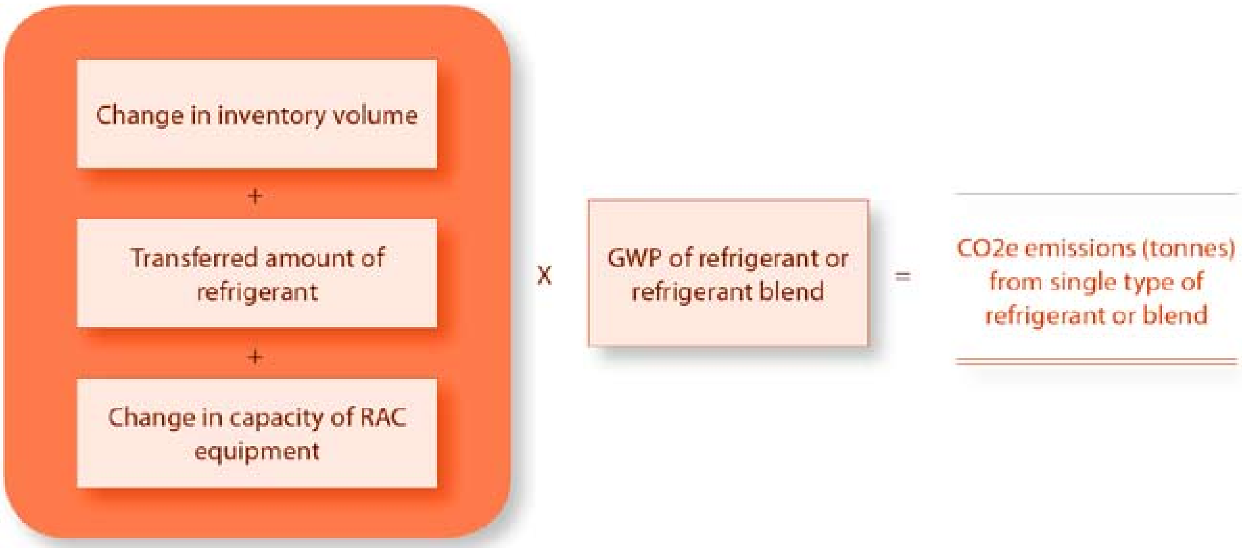
Refrigeration and air-conditioning (RAC) equipment leaks refrigerants during installation, maintenance, operation and disposal. Because many refrigerants are GHGs with high GWP values, RAC equipment may be a significant emissions source for some reporting offices.
To calculate the emissions from RAC equipment, the tool implements three alternative methods to calculate or estimate the refrigerant losses associated with installation, maintenance, operation and disposal. You should choose amongst these methods based on the available data. You should be aware that individual refrigerants may be GHGs themselves, that is, the refrigerant may be an HFC or a PFC. Alternatively, the refrigerants may be blends of different chemicals, only a portion of which are PFCs or HFCs. The reporter shall take care to calculate the emissions separately for each GHG or refrigerant blend.

In calculating emissions, the tool allows you to select from a list of the most commonly used refrigerants or refrigerant blends. The GWPs of these refrigerants or blends are then automatically used to calculate the CO_2e emissions.

Method 1: *Detailed mass balance method*

Use this method for buildings that maintain their own equipment. The method estimates HFC and PFC emissions based on the amount of refrigerant purchased and used by the equipment user, and it requires data that should be available from entity purchase and service records. The reporter shall input this data in kilogrammes (kg).

The GHG emissions from a single refrigerant or refrigerant blend are calculated as follows:



Where:

- "Change in inventory volume" includes only gas stored on-site such as cylinders and not within equipment. Change in inventory volume is calculated as:
  Inventory at beginning of year –
  Inventory at end of year

- "Transferred amount" =
  Refrigerant purchased from producers/distributors in bulk +
  Refrigerant provided by manufacturers with or inside equipment +
  Refrigerant added to equipment by contractors +
  Refrigerant returned after offsite recycling or reclamation -
  Sales of refrigerant (in bulk, not equipment) to other entities -
  Refrigerant left in equipment that is sold to other entities -
  Refrigerant returned to suppliers -
  Refrigerant sent off-site for recycling or reclamation -
  Refrigerant sent off-site for destruction

- "Change in capacity of RAC equipment" =
  Total new charge of new equipment +
  Total full charge of equipment retrofitted to use this refrigerant –
  Original total full charge of equipment that is retired or sold to other entities –
  Total full charge of equipment retrofitted away from this refrigerant to a different refrigerant

This calculation process is repeated for each refrigerant or blend of refrigerants.

Method 2: *Simplified mass balance method*

This method is a simplified version of Method 1 and is used for buildings that hire contractors to maintain their RAC equipment. The activity data that are supplied by the user must be obtained from the contractor. If notified in advance of the need for this information, the contractor should be able to provide it.

Method 2 tracks emissions from the installation, servicing and disposal of RAC equipment as follows:

Emissions of individual GHG or loss of refrigerant blend =
(PN - CN + PS + CD - RD) x GWP

Where:

- PN = Purchases of refrigerant used to charge new equipment (omitted if the equipment has been pre-charged by the manufacturer)
- CN = Total full capacity of the new equipment (omitted if the equipment has been pre-charged by the manufacturer)
- PS = Quantity of refrigerant used to recharge existing equipment
- CD = Total full capacity of retiring equipment
- RD = Refrigerant recovered from retiring equipment

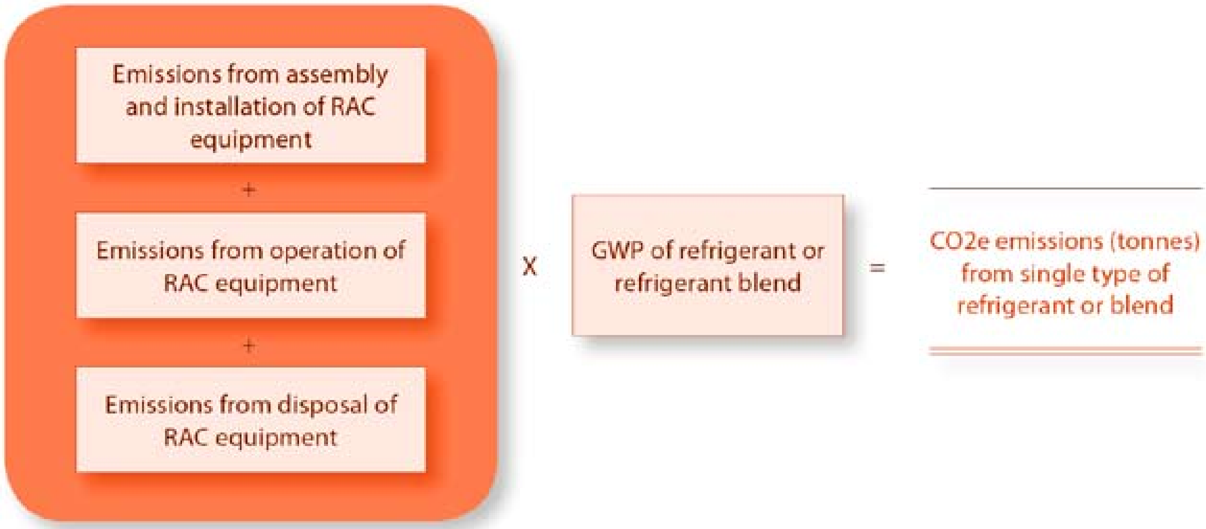
The reporter shall input data in kilogrammes (kg), and this calculation process should be repeated for each refrigerant or blend of refrigerants.

Method 3: *Emission-factor based approach*

Method 3 uses default emission factors to separately calculate the emissions of individual GHGs or refrigerant blends, associated with the assembly, installation, operation and disposal of RAC equipment. The default emission factors implemented in the tool are specific to broad categories of RAC equipment, such as domestic and commercial refrigerators.

Method 3 is likely to be less accurate than either Method 1 or Method 2. As a result, Method 3 is recommended as a screening method to determine the significance of the emissions from RAC equipment. If RAC equipment is deemed to be a significant component of the building emissions, then the reporter shall strive to collect the activity data necessary by either Method 1 or Method 2. Otherwise, the GHG emissions estimated with Method 3 can be reported.

For each type of RAC equipment, the emissions of an individual GHG, or refrigerant blend, are calculated as:



Where:

- "Emissions from the assembly or installation of RAC equipment" (kg) =
  Number of new RAC units of type x •
  Original refrigerant charge in each unit (kg) •
  Emission factor for the assembly and installation of RAC equipment of type x (% of original charge / year).

- "Emissions from the operation of RAC equipment" (kg) =
  Number of RAC units of type x •
  Original refrigerant charge in each unit (kg) •
  Annual leakage rate for RAC equipment of type x (% of original charge / year).

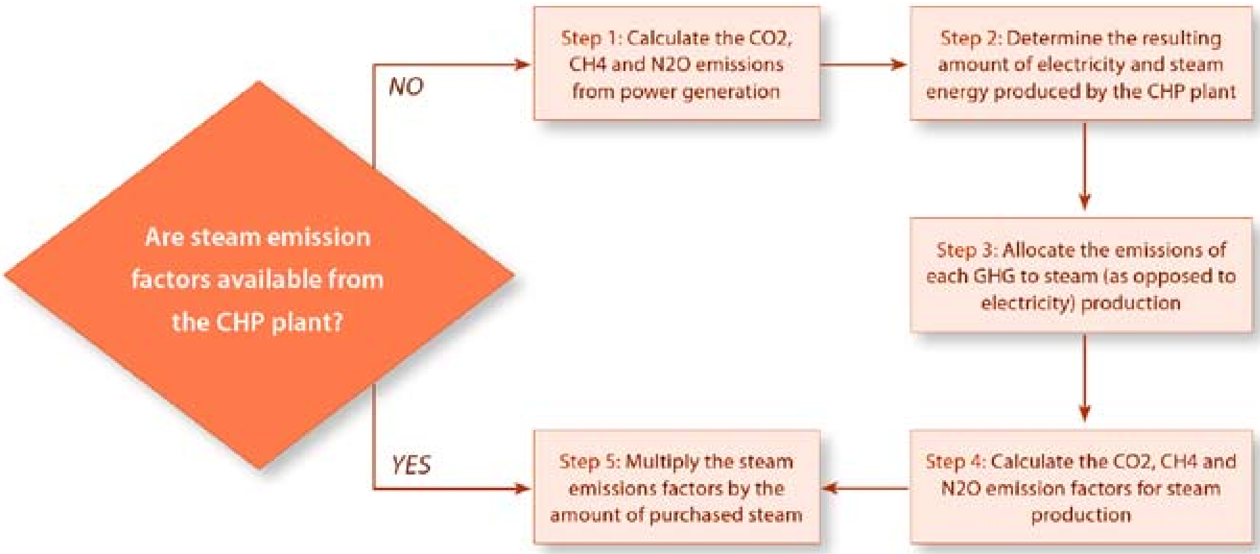
- "Emissions from the disposal of RAC equipment" (kg) =
  Number of RAC units of type x disposed of during the reporting period •
  Original refrigerant charge in each unit (kg) •
  [1 – (Annual leakage rate for RAC equipment of type x • Time since last recharge (years)] •
  [1 – (Recycling efficiency for RAC equipment of type x) – Amount of refrigerant i destroyed].

Appendix 6 (Table 6.4) lists the default emission factors implemented in Method 3. The reporter must supply the time period since the last discharge and the amount of refrigerant that has been sent for destruction.

Purchased Steam/Heat

Combined Heat and Power (CHP) plants generate both electricity and heat/steam. The emissions associated with the electricity should be calculated assuming that the plant is grid-connected. The purchased steam spreadsheet should be used whenever reporting offices purchase a portion of the heat or steam outputs from an individual CHP plant.

The calculation of the indirect (Scope 2) emissions from steam purchases requires information on the GHG emissions that stem from power generation at the CHP plant. This GHG information is used to calculate an emission factor for steam production, which is then multiplied by the amount of steam or heat purchased by the reporting office to quantify the Scope 2 emissions from purchased steam. CHP plants may be able to supply emission factors for steam production. Otherwise, these factors have to be developed by the reporting office by using information on fuel consumption and energy production by the plant. The general process for developing steam emission factors and calculating the Scope 2 emissions is summarized on the following page as:



If the energy provider is able to supply emission factors for steam production, the reporting office should proceed to step 5. Otherwise, you can calculate the emission factors following steps one through four below. Each step should be repeated for each GHG: CO_2, CH_4 and N_2O.

Step 1: Calculate the emissions of a GHG from stationary combustion in the CHP system. The fuel consumption data will have to be supplied by the energy provider.

Step 2: Determine the energy in the steam and electricity output streams generated by the CHP system. These values should be inthe same units, for example, GJ or a similar SI unit. Again, the data will have to be supplied by the energy provider.

Step 3: Determine the fraction of the total emissions of each GHG (CO_2, CH_4 and N_2O) to allocate to steam production (as opposed to electricity production) using the following formula:

$$E_H = \frac{H/e_H}{H/e_H + P/e_P} \cdot E_T$$

Where:

E_H = emissions allocated to steam production
H = steam output (energy)
e_H = assumed efficiency of steam production
P = delivered electricity generation (energy)
e_P = assumed efficiency of electricity generation
E_T = total direct emissions of the CHP system

Default efficiency factors are provided in Appendix 6 (Table 6.5).

Step 4: Calculate the emission factor for steam production as follows:

$$Emission\ factor\ for\ steam\ production = \frac{E_H}{H}$$

Step 5: Estimate emissions from steam purchases as:

$$GHG\ emissions =$$

$$Amount\ of\ steam\ purchased \cdot Emission\ factor\ for\ steam\ production$$

Other Optional Emissions

Reporters may find that some buildings have significant GHG emissions from sources outside the established boundary that are not covered by the calculation methodologies in this Protocol and Calculation Tool & Reporting Template. Although calculating and reporting these emissions are optional, the reporter is encouraged to begin collecting this data so that a more complete understanding of the building's climate impact can be obtained.

Examples of optional emission sources could include, but are not limited to:

- Personnel commuting to and from the work place;
- GHG emissions embodied in materials;
- GHG Emissions associated with building maintenance;
- Construction; and
- Provision for water and sewage treatment.

The reporter is responsible for identifying the best available methodology for their optional emission sources.

Note: Emissions from biomass fuels are to be reported separately from fossil fuel emissions. The reporter must therefore distinguish between biomass CO_2 and fossil CO_2. See the following example below:

Biomass CO_2 emissions are from the combustion of biofuels such as wood and ethanol, whereas fossil CO_2 emissions are from the combustion of oil and coal products. A list of biomass fuels can be consulted in Appendix 6. Calculation methods and other important references for the optional activities entered must be explained.

Appendices

Appendix 1: Scope of Emissions

The building sector is nested within a larger context of global GHG emissions. (*See Figure 1*)

Total emissions from a building's life-cycle begins with the Before-Use Phase including extraction of raw materials, agriculture or forestry, then continues with manufacturing of building products and equipment and construction ***(See Figure 2)***. Building emissions extend for long periods of time during the Use-Phase of the building including operations, maintenance, and retrofits of the building ***(See Figure 2)***. Finally, emissions conclude with the After-Use phase including demolition, re-use and recycling of material components or energy content, and waste processing ***(See Figure 2)***. All Stages involve transportation of goods, services, and people.

On a global scale, data for Stage I and III are lacking for many regions, generally difficult to quantify, and can lead to double counting of emissions in other sectors such as industry, forestry, agriculture, and transport. **Because over 80% of GHG emissions are emitted during Stage II** and these emissions are measurable, reportable, and verifiable, only this Stage is included in the Common Carbon Metric & Protocol represented in this paper. The impacts due to maintenance, repair and/or refurbishment and transport, shown in Figure 2, are not included in the Common Carbon Metric & Protocol.

Furthermore, the Common Carbon Metric & Protocol and Calculation Tool & Reporting Template is based on a modular approach allowing future expansion to capture a greater scope of emissions from this sector. The modular approach recognizes that responsibility of decision-makers changes over different Stages and time, and that measurement and emissions boundaries will become further defined.

Scope 1: Direct, on-building-site or on-building-stocks, GHG Emissions

Direct on-site emissions result from sources within the boundaries of the building or building stocks under study that can be quantified by the reporting entity, including stationary combustion emissions, process

Figure 2: Description of the three Life Cycle Stages of a building and the different processes allocated to these stages, (Source: SB Alliance)

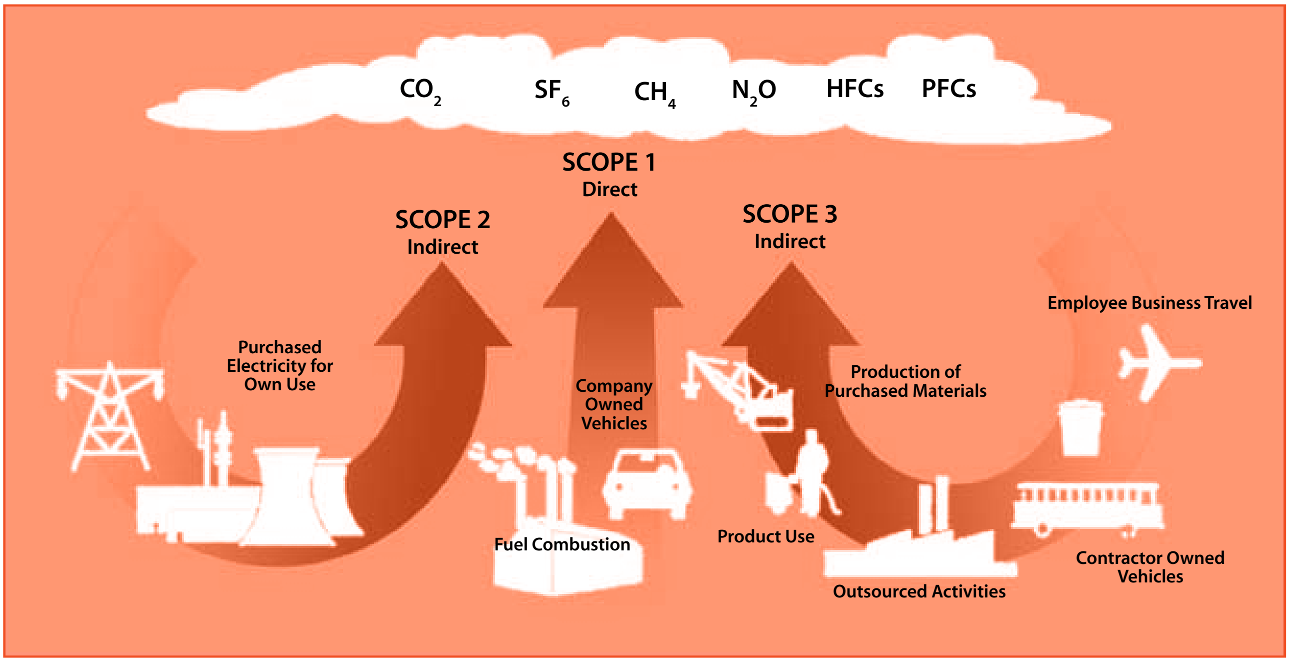
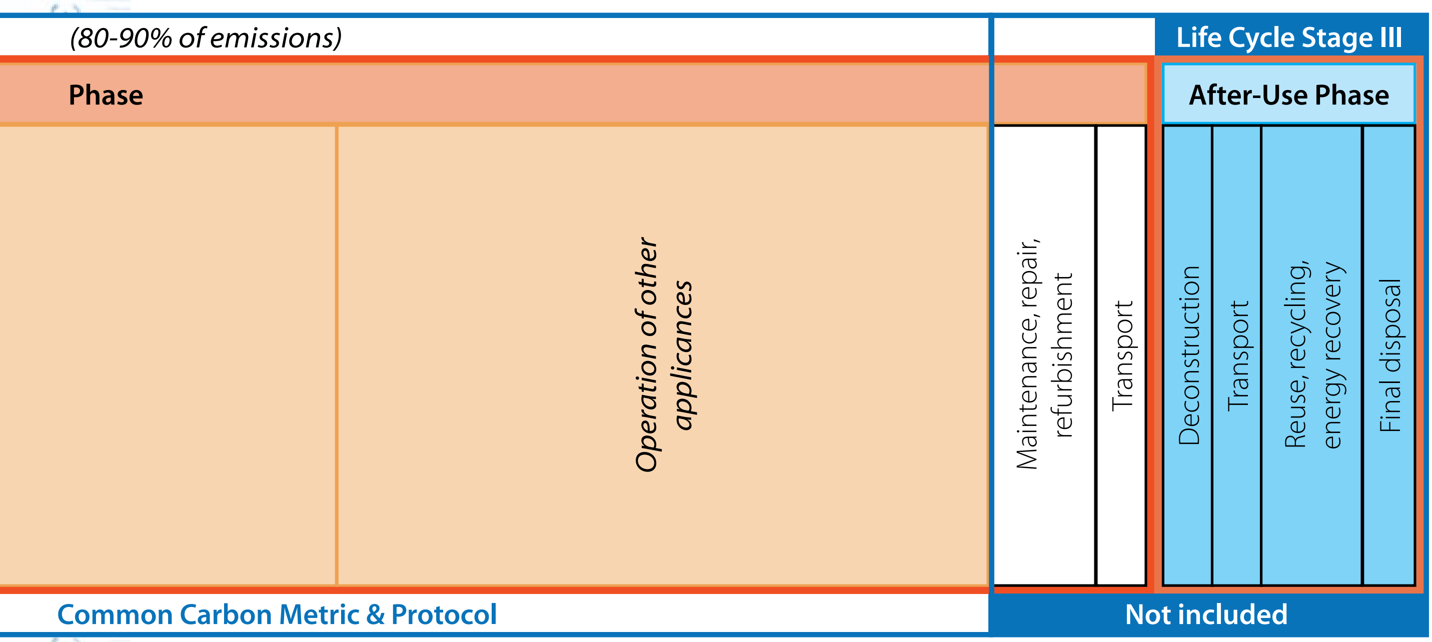


Figure 1: Scope of Emissions (Source: WRI-WBCSD Corporate Standard)

emissions (e.g. of typical "small" building operation like refrigeration or use of computers, but not industrial processes like manufacture or assembly of products) and fugitive emissions. Scope 1 emissions included in the Common Carbon Metric & Protocol are all direct GHG emissions, with the exception of fugitive emissions and direct GHG emissions from biogenic or industrial sources controlled by the reporting entity. Direct emissions are typically produced from the following types of activities:

- Stationary combustion emission from generation of on-site electricity, cooling, heat or steam
- Fugitive emissions from intentional or unintentional releases



Stationary combustion emissions result from the burning of fuels to produce electricity, steam, heat, or power using equipment, such as boilers, furnaces, etc., on the building site.

Fugitive emissions result from the intentional or unintentional releases of GHGs. They commonly arise from the production, processing, transmission, storage and use of fuels and other chemicals, often through joints, seals, packing, gaskets and so on. Calculating fugitive emissions from the use of refrigerants in heating/cooling systems is not part of the current draft of the Calculation Tool & Reporting Template, but are described in the Common Carbon Metric & Protocol.

Scope 2: Indirect on-building-site GHG Emissions

Indirect emissions are a consequence of the activities that occur outside the building site, for example activities at a community power plant for providing the energy consumed on-building-site. Scope 2 emissions here include all GHG emissions associated with the overall generation of purchased energy such as electricity. (Note: the current draft of this Calculation Tool & Reporting Template does not include emissions from purchased heat/steam/cooling at this time. However, this calculation is described in the Common Carbon Metric & Protocol.). Reporting of Scope 2 emissions is a useful tool to help gauge energy usage and identify areas to reduce costs and emissions. By utilizing energy efficient technologies and implementing energy conservation practices, energy use is reduced, which in turn reduces costs and produces less GHG emissions.

Scope 3: Other Indirect GHG Emissions

Scope 3 addresses indirect emissions not covered in Scope 2 activities that are relevant to building performance. The Calculation Tool & Reporting Template does not currently provide a means of identifying or calculating scope 3 sources, nor are these described in detail in the Metric & Protocol.

Examples of these emissions include:

- Upstream and downstream emissions related to the before-use phase of the buildings, e.g. raw material extraction for metals.
- Transport related activities in vehicles related to all stages of the building life cycle
- After-Use phase activities such as:
    - Re-use, Recycling
    - Thermal recycling
    - Waste disposal processes, such as GHG emissions from final deposits

When accounting Scope 3 emissions, take care to choose activities that have not already been included in Scopes 1 or 2 and be transparent regarding included or omitted processes.

Appendix 2: Calculation Tool and Reporting Template - Sample

UNEP

UNEP SBCI Sustainable Buildings & Climate Initiative

WORLD RESOURCES INSTITUTE

Introduction

This "Building Sector Greenhouse Gas (GHG) Calculator" is a series of spreadsheets designed to help organizations estimate their annual GHG emissions from the energy used in the operational phase of individual buildings, or groups of buildings. To use this tool users must supply information on the profile of the building(s), including characteristics such as building area (in m^2), building type (excluding industrial use buildings), occupancy, energy use and, if available, building age. Based on these data the tool calculates performance metrics on energy consumption and GHG emissions that allow for consistent comparisons within relevant categories.

The tool is framed around two different scenarios:
Top-Down: Producing a GHG inventory for a defined group of buildings, termed here as the "Whole". The Whole may represent a city, in which case the boundary of the Whole is the physical boundary at the city's limits, or it may be a portfolio of buildings, in which case the Whole is the total area of that portfolio's stock. The top-down approach requires information on the Whole that may (or may not) be disaggregated by different categories of buildings.
Bottom-Up: Producing a GHG inventory and performance metrics for individual building(s). This information may then be compared (benchmarked) against the performance of the Whole.

Notes on the calculations:
The calculation methodology in this tool is consistent the Greenhouse Gas Protocol in the World Resources Institute, as well as with the UNEP-SBCI Common Carbon Metric. To aid transparency, the emission factors used in specific calculations are displayed in the relevant spreadsheet, and all emission factors and their reference sources are listed separately in the *Reference* page. Where possible, the tool calculates the emissions of three GHGs (CO_2, CH_4 and N_2O) and combines these amounts into a single measure for representing GHG impact - metric tonnes CO2 equivalent (CO_2e).

Software requirements: This tool requires Excel 2007 and macros must be enabled to ensure full functionality.

1 Provide your contact details:

Name:	Example dataset
Telephone no:	
Email address:	
Postal address:	

2 Describe your building stock

Country (required):	United States
City:	Hypothetical City
Year of data being entered (required):	2005
Quarter:	All quarters (entire year)

3 Select which method you want to use:

Method 1. Top down approach for assessing the performance of the Whole — Go

Method 2. Bottomup approach for assessing the performance of individual building(s) and possibly benchmarking these data against the performance of the Whole — Go

Acknowledgements

This tool has been developed by the GHG Protocol and UNEP-SBCI. It should be cited in the following format:
"GHG Protocol Building Sector Greenhouse Gas Calculator. Version 1.0, March 2010. Developed by WRI and UNEP-SBCI."

References

Method 1. Top down approach. Data input.

This approach calculates the performance of the Whole based on high-level data on patterns of energy consumption, area and occupancy. Note there may be several sources of energy serving the Whole, and relevant energy information may be obtained directly from local power providers, electrical or gas utilities, or, where such information is not available, from permit records or energy reporting programs. These providers may also be able to identify how much energy has been consumed by different categories of building types (residential, non-residential, etc.).

You must first complete this method before benchmarking the performance of individual building(s) against the Whole using Method 2.

1 Characterise the Whole

What is the total area of the Whole, in m²?	15000000
What tier of accuracy best describes your data on area?	Estimated
What is the total occupancy of the whole, in number of occupants?	60000
What tier of accuracy best describes your data on occupancy?	Measured
Can these data be broken down by specific types of building categories?	Yes
Can the data on area be broken down by age of the building stock?	No

Percentage of area / occupancy attributable to:		Area (%)	Percentage of area of Whole (%) in different age classes				Occupancy (%)	Notes / Sources of data
			< 1900	1900-1950	1951 - 2000	>2000		
Residential sector	Single-family	40					50	
	Multi-family	10					13	
	Other known category	0						
Non-residential sector	Office	30					16	
	Retail	10					9	
	Hotel	2.5					2	
	Other known category	7.5					10	
		100	0				100	

2 Enter data on electricity used by the Whole

How much electricity was used by the Whole?	300000	Megawatt hour (MWh)
What tier of accuracy best describes your data these data?	Estimated	
Can these data be broken down by specific types of building categories?	Yes	

Percentage of electricity use attributable to:		Percentage use (%)	Allocated energy consumption (TJ)	Allocated emissions (tonnes CO_2e.)	Notes / Sources of data
Residential sector	Single-family	30	324.00	51276.33	
	Multi-family	5	54.00	8546.06	
	Other known category	0	0.00	0.00	
Non-residential sector	Office	45	486.00	76914.50	
	Retail	15	162.00	25638.17	
	Hotel	5	54.00	8546.06	
	Other known category	0	0.00	0.00	
		100			

Assumption: *Emissions calculations are based on the following emission factor (kg CO2 per kWh):* *0.569737*

Total emissions across sectors should be (metric tonnes): *170921.1*

3 Enter data on fuel consumed by the Whole

Can fuel consumption data be broken down by specific types of building categories? Yes

	Fuel	Used?	Amount	Units	Notes / Sources of data	Conversion factor to TJ fuel	Emission factor (tonnes / unit)	Calculated emissions (tonnes CO_2e.)	Calculated energy use (TJ)
			User information			Assumptions			
Fossil fuels	Residual fuel oil		Yes 0	US gallon		0.000	0.011	13353.774	172.506
	Natural gas		Yes 0	Therm (thm)		0.000	0.006	5919.402	105.506
	Diesel oil		No						
	Liquified Petroleum Gases		No						
	Kerosene		No						
	Gasoline		No						
	Anthracite coal		No						
	Brown coal briquettes		No						
	Coke oven coke		No						
	Lignite		No						
	Lignite coke		No						
	Other bituminous coal		No						
	Patent fuel		No						
	Petroleum coke		No						
	Sub bituminous coal		No						
	Municipal waste (Non biomass fraction)		No						
Biomass fuels	Wood or Wood waste		Yes 0	Metric tonne		0.016	1.752	2627.914	23.400
	Other primary solid biomass fuels		No						
	Charcoal		No						
	Biogasoline		No						
	Biodiesels		No						
	Other liquid biofuels		No						
	Landfill gas		No						
	Sludge gas		No						
	Other biogas		No						
	Municipal wastes (Biomass fraction)		No						
	Peat		No						
								21901.089	301.411

What percentage of these fuels was used in the different building categories?

Fuel	Residential				Non-residential					Total percentage allocated (%)
	Overall	Single-family	Multi-family	Other	Overall	Office	Retail	Hotel	Other	
Residual fuel oil		20	5	0		60	10	5		100
Natural gas		25	5	0		65	5	0		100
Wood or Wood waste		95	5	0						100
Allocated GHG emissions (tonnes CO_2e.)	0.000	6647.123	1095.054	0.000	0.000	11859.876	1631.348	667.689	0.000	
Allocated energy consumption (TJ)	0.000	83.108	15.071	0.000	0.000	172.082	22.526	8.625	0.000	

Introduction

View summary

View sampling requirements

Method 1. Performance of the Whole. Results summary.

Combined emissions and energy consumption data:

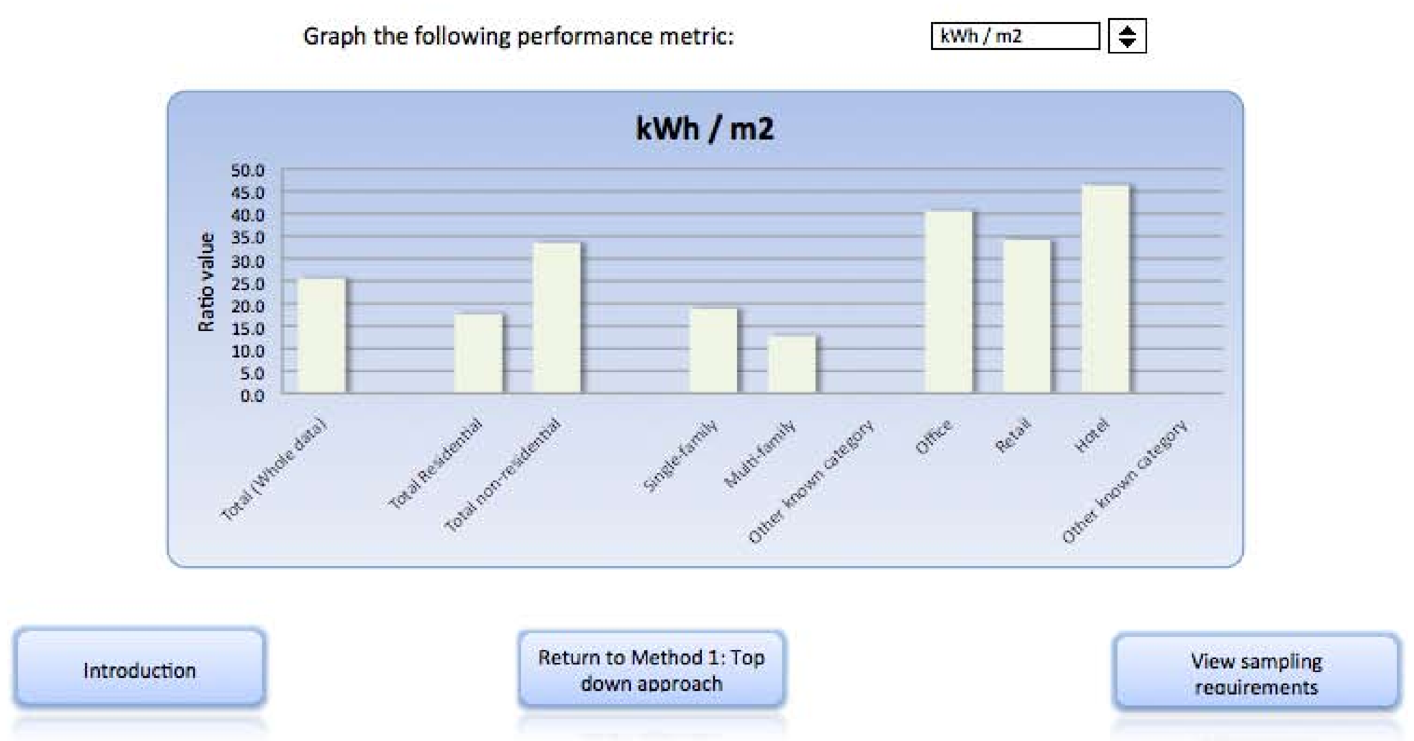
	Energy use (TJ)			GHG emissions (metric tonnes CO_2e.)			Area (m^2)	Occupants
	Electricity	Fuel use	Total	Electricity	Fuel use	Total		
Total Residential	**378.00**	**98.18**	**476.18**	**59,822.39**	**7,742.18**	**67,564.56**	**7,500,000.0**	**37,800**
Single-family	324.00	83.11	407.11	51,276.33	6,647.12	57,923.45	6,000,000.0	30,000
Multi-family	54.00	15.07	69.07	8,546.06	1,095.05	9,641.11	1,500,000.0	7,800
Other known category	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0
Total non-residential	**702.00**	**203.23**	**905.23**	**111,098.72**	**14,158.91**	**125,257.63**	**7,500,000.0**	**22,200**
Office	486.00	172.08	658.08	76,914.50	11,859.88	88,774.37	4,500,000.0	9,600
Retail	162.00	22.53	184.53	25,638.17	1,631.35	27,269.51	1,500,000.0	5,400
Hotel	54.00	8.63	62.63	8,546.06	667.69	9,213.74	375,000.0	1,200
Other known category	0.00	0.00	0.00	0.00	0.00	0.00	1,125,000.0	6,000
Total (Based on data on the Whole)[1]	**1,080.00**	**301.41**	**1,381.41**	**170,921.10**	**21,901.09**	**192,822.19**	**15,000,000.0**	**60,000**

[1] *Values for building categories are based on the percentage allocations of high-level data to these categories. Depending on whether 100% of data have been allocated, the sum of these values may not match the total for the Whole.*

Performance metrics:

	By area				By occupant			
	kWh / m^2		kg CO_2e./ m^2		kWh / occupant		kg CO_2e. / occupant	
Total Residential	3.0	**17.6**	**3.0**	**9.0**	**3.0**	**3499.3**	**3.0**	**1787.4**
Single-family	3.0	18.8	3.0	9.7	3.0	3769.5	3.0	1930.8
Multi-family	3.0	12.8	3.0	6.4	3.0	2459.8	3.0	1236.0
Other known category	1.0		-1.0		-1.0		-1.0	
Total non-residential	3.0	**33.5**	**3.0**	**16.7**	**3.0**	**11326.7**	**3.0**	**5642.2**
Office	3.0	40.6	3.0	19.7	3.0	19041.7	3.0	9247.3
Retail	3.0	34.2	3.0	18.2	3.0	9492.1	3.0	5049.9
Hotel	3.0	46.4	3.0	24.6	3.0	14496.6	3.0	7678.1
Other known category	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
Total (Based on data on the Whole)	3.0	**25.6**	**3.0**	**12.9**	**3.0**	**6395.4**	**3.0**	**3213.7**

3	Data have been provided for electricity and fuel consumption, as well as area / occupancy
2	Data on fuel or electricity consumption have not been provided
1	Data are missing and performance metrics cannot be determined


Graph the following performance metric:
kWh / m2
kWh / m2
Ratio value
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Total (Whole data)
Total Residential
Total non-residential
Single-family
Multi-family
Other known category
Office
Retail
Hotel
Other known category
Introduction
Return to Method 1: Top down approach
View sampling requirements

Sampling requirements and tracking

This worksheet shows the area (in m^2) that needs to be sampled of different building categories to ensure that the sampled data are statistically representative of the composition of the Whole. These sampling requirements can be used to more accurately calculate the performance of the Whole or individual building categories and they are based on the high-level information provided in the Top down approach (Method 1). Sample data can be entered into the tool on a different worksheet ('Buildings' - Method 2) and the current worksheet will track users' progress towards attaining the required sample sizes.

The sampling requirements are based on the following assumptions: a 95% confidence interval, 5% precision and p=0.5 (maximum variability amongst the Whole).

Building category	Required sample size (m^2)	Area sampled so far (m^2)	
Total Residential		**5850**	
Single-family	399.9733351	1050	262.5175
Multi-family	399.8933618	4800	1200.32
Other known category	0	0	
Total non-residential		**255909.5**	
Office	399.9644476	114687	28674.299
Retail	399.8933618	4500	1125.3
Hotel	399.573788	136722.5	34217.084
Other known category	399.8578283	0	0
Total	**N/A**	**261759.5**	

Note: These sampling requirements are not broken down by age of the building stock. Because building performance likely varies with time, sampled data may not truly be representative of the Whole. Users are encouraged to enter data on the age distribution of their building stock (see the Top-down approach - Method 1).

Introduction

Calculate performance of individual buildings

Method 2. Bottom up approach. Data input.

Use this worksheet to calculate the performance of individual building(s), including that of samples designed to be statistically representative of the Whole. This worksheet will then compare the performance of individual buildings against both: (a) the mean performance of buildings sampled from the same category so far; (b) the performance of the Whole (based on the high-level data entered in the Top-down approach, Method 1).

1 Characterise the individual building(s)

Are these buildings distributed across more than one region (e.g., city or country)? No

			Address				
Building name	Building category	Year of construction (YYYY)	Street	Street number	Number of occupants	Area (m_2)	Notes / Source of data
Hotel A	Non-residential: Hotel	1980	Fictional St.	10	200	16722.5	
Office A	Non-residential: Office	1987	Street X	15	150	4217	
Office B	Non-residential: Office	1968	Street Y	20	200	6000	
Office C	Non-residential: Office	2004	No Name St	25	50	1250	
Hotel B	Non-residential: Hotel	1888	ST Q	30	300	20000	
Office D	Non-residential: Office	1951	Lane R	35	200	23220	
Office E	Non-residential: Office	1929	Road X	40	1000	80000	
Hotel C	Non-residential: Hotel	1999	Broad Ave	45	1000	100000	
Retail A	Non-residential: Retail	1985	Main St	50	20	2000	
Retial B	Non-residential: Retail	1957	High St	55	10	1000	
Retail C	Non-residential: Retail	1922	High St	60	17	1500	
Family 1	Residential: Single-family	1988	Residential St	65	5	500	
Family 2	Residential: Single-family	1998	Residential Ln	70	3	200	
Family 3	Residential: Single-family	2002	Home Circuit	75	4	350	
Family 4	Residential: Multi-family	1967	Home Avenue	80	60	4800	

Add

Track sampling progress

0 inch 1 2 3 4 5 6 7 8

❷ Enter data on energy use by these buildings

Building name	Purchased electricity		Burnt fuel						Performance		
	Amount	Units	Biomass or fossil?	Specific fuel	Amount	Units	Conversion factor to convert to TJ fuel used	Emission factor (tonnes CO_2e. / unit)	Total GHG emissions (tonnes CO_2e)*	Total energy consumption (kWh)	Notes / Sources of data
Hotel A	4208701	Kilowatt hour (kWh)	Fossil	Natural gas	56850.65	Therm (thm)	0.000105506	0.005919402	2,734.4	5,874,829.2	
Office A	989358	Kilowatt hour (kWh)							563.7	989,358.0	
Office B	1500000	Kilowatt hour (kWh)							854.6	1,500,000.0	
Office C	280	Megawatt hour (MWh)							159.5	280,000.0	
Hotel B	6000000	Kilowatt hour (kWh)	Fossil	Residual fuel oil	500	Metric tonne	0.0404	3.12738824	4,982.1	11,611,111.1	
Office D	1058500	Kilowatt hour (kWh)	Fossil	Residual fuel oil	200	US gallon	0.000143755	0.011128145	605.3	1,066,486.4	
Office E	6852369	Kilowatt hour (kWh)	Fossil	Natural gas	10000	One million BTUs (mm	0.001055056	0.059194017	4,496.0	9,783,079.8	
Hotel C	20000	Megawatt hour (MWh)	Biomass	Biogasoline	1000	Metric tonne	0.027	1.9118862	13,306.6	27,500,000.0	
Retail A	370000	Kilowatt hour (kWh)							210.8	370,000.0	
Retail B	70000	Kilowatt hour (kWh)							39.9	70,000.0	
Retail C	70000	Kilowatt hour (kWh)							39.9	70,000.0	
Family 1	15000	Kilowatt hour (kWh)							8.5	15,000.0	
Family 2	12000	Kilowatt hour (kWh)							6.8	12,000.0	
Family 3	9000	Kilowatt hour (kWh)							5.1	9,000.0	
Family 4	20	Megawatt hour (MWh)	Fossil	Residual fuel oil	2000	US gallon	0.000143755	0.011128145	33.7	99,863.8	
									28,046.9	59,250,728.3	

*, *Emissions calculations are based on the following emission factor for electricity use (kg CO_2e. / kWh):* *0.569737*

Introduction

View results

Method 2. Bottom up approach. Summary

Individual performance metrics

This table compares the performance of individual buildings with that of all buildings sampled from the same building category (e.g., a hotel would be compared with all hotels within the sample).

	kWh / m²		kg CO_2e. / m²		kWh / occupant		kg CO_2e. / occupant	
Building name	This building	All	This building	All	This building	All	This building	All
Hotel A	351.3	329.0	163.5	153.8	29374.1	29990.6	13671.9	14015.4
Office A	234.6	118.7	133.7	58.2	6595.7	8511.8	3757.8	4174.4
Office B	250.0	118.7	142.4	58.2	7500.0	8511.8	4273.0	4174.4
Office C	224.0	118.7	127.6	58.2	5600.0	8511.8	3190.5	4174.4
Hotel B	580.6	329.0	249.1	153.8	38703.7	29990.6	16607.1	14015.4
Office D	45.9	118.7	26.1	58.2	5332.4	8511.8	3026.5	4174.4
Office E	122.3	118.7	56.2	58.2	9783.1	8511.8	4496.0	4174.4
Hotel C	275.0	329.0	133.1	153.8	27500.0	29990.6	13306.6	14015.4
Retail A	185.0	113.3	105.4	64.6	18500.0	10851.1	10540.1	6182.3
Retial B	70.0	113.3	39.9	64.6	7000.0	10851.1	3988.2	6182.3
Retail C	46.7	113.3	26.6	64.6	4117.6	10851.1	2346.0	6182.3
Family 1	30.0	34.3	17.1	19.5	3000.0	3000.0	1709.2	1709.2
Family 2	60.0	34.3	34.2	19.5	4000.0	3000.0	2278.9	1709.2
Family 3	25.7	34.3	14.7	19.5	2250.0	3000.0	1281.9	1709.2
Family 4	20.8	20.8	7.0	7.0	1664.4	1664.4	560.9	560.9
Average	168.1	-	85.1	-	11394.7	-	5669.0	-

Performance benchmarked against the Whole

This table compares the performance of the entire sample with that of the Whole.

	kWh / m²		kg CO_2e. / m²		kWh / occupant		kg CO_2e. / occupant	
	Sample	Whole	Sample	Whole	Sample	Whole	Sample	Whole
Total Residential	**23.2**	**17.6**	**9.3**	**9.0**	**1887.0**	**3499.3**	**752.2**	**1787.4**
Single-family	34.3	18.8	19.5	9.7	3000.0	3769.5	1709.2	1930.8
Multi-family	20.8	12.8	7.0	6.4	1664.4	2459.8	560.9	1236.0
Other known category								
Total non-residential	**231.0**	**33.5**	**109.4**	**16.7**	**18784.5**	**11326.7**	**8895.1**	**5642.2**
Office	118.7	40.6	58.2	19.7	8511.8	19041.7	4174.4	9247.3
Retail	113.3	34.2	64.6	18.2	10851.1	9492.1	6182.3	5049.9
Hotel	329.0	46.4	153.8	24.6	29990.6	14496.6	14015.4	7678.1
Other known category		0.0		0.0		0.0		0.0
Total	**226.4**	**25.6**	**109.4**	**12.9**	**18406.6**	**6395.4**	**8712.9**	**3213.7**

Sample performs better than the Whole

Sample performs worse than the Whole

Introduction

Return to Method 2: Bottom up approach

Appendix 3: Glossary of Terms

Activity Data	Data on the magnitude of a human activity resulting in GHG emissions. Data on energy use, miles travelled, input material flow and product output are all examples of activity data that might be used to compute GHG emissions.
Average Weather	Average weather may include average temperature, precipitation and wind patterns.
Biomass	Non-fossilized and biodegradable organic material originating from:
	· Plants, animals, and micro-organisms, including products, byproducts, residues and waste from agriculture, forestry and related industries
	· Non-fossilized and biodegradable organic fractions of industrial and municipal wastes, including gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material.
Biomass CO2	Emissions from the combustion of biofuels such as wood and ethanol. Emissions from biomass fuels are to be reported separately from fossil fuel emissions.
Building	Construction works that has the provision of shelter for its occupants or contents as one of its main purposes; usually partially or totally enclosed and designed to stand permanently in one place.
Building Floor Area (GFA)	Building area is measured in meters squared (m2) of Gross Floor Area (GFA) of a building. GFA is measured from the exterior perimeter of the building envelope. Areas of internal walls & structure, shafts, elevators, and stairways are to be included in the GFA.
Building Operations	The Metric & Protocol are designed to measure and report on building operation related greenhouse gas emissions, and to enable stock aggregation to generate baseline performance data. Therefore they only include emissions related to the in-use or 'operational' phase of the building life-cycle. This phase is the service-life of a building and can be measured two years from occupancy to significant change in use or demolition.
CH_4	Methane. A Kyoto Protocol greenhouse gas.
Climate Change	Climate change is any long-term significant change in the average weather of a region or the earth as a whole. For more information, see average weather.
Climate Neutrality	Climate neutrality is a term that refers to an entity with no net GHG emissions. Achieved by reducing greenhouse gas emissions as much as possible and by using carbon offsets to cover the remaining emissions.
CO_2	Carbon dioxide. A Kyoto Protocol GHG.
Combined Heat and Power (CHP)	An energy conversion process in which more than one useful product, such as electricity and heat or steam, is generated from the same energy input stream (cogeneration).

CO_2 Equivalent (CO_2e)	The universal unit for comparing emissions of different GHGs, expressed in terms of the global warming potential (GWP) of one unit of carbon dioxide. For more information, see GWP.
Common Approach	The Metric & Protocol have been developed through consensus building and collaboration facilitated by UNEP-SBCI. It is closely linked with approaches to measuring and reporting on building related greenhouse gas emissions used by several current building performance assessment tools and methods. As such, it is intended to be used with or augment existing approaches to measuring building related greenhouse gas emissions in countries where these schemes exist. Where no existing schemes exist, this effort can be used independantly or as a basis for the development of such tools, and for generating performance baselines that can inform policy making.
Direct Emissions	Emissions from sources within the reporting entity's organizational boundaries that are owned or controlled by the reporting entity, including stationary combustion emissions, mobile combustion emissions, process emissions and fugitive emissions.
Emissions	See Appendix 1.
Emission Factor	GHG emissions expressed on a per unit activity basis. For example, metric tons of CO_2 emitted per million Btus of coal combusted or metric tons of CO_2 emitted per kWh of electricity consumed.
Fugitive Emissions	Emissions that are not physically controlled, but result from the intentional or unintentional releases of GHGs. They commonly arise from the production, processing transmission storage and use of fuels and other chemicals, often through joints, seals, packing, gaskets, and so on.
Greenhouse Gas (GHG)	The earth receives energy from the sun and returns the energy by reflecting light and emitting heat. Part of the outgoing heat flow is absorbed by greenhouse gases and re-irradiated back to the earth. While carbon dioxide is the greatest contributor to global warming, there are several reasons for opting to include the six gases covered by the Kyoto Protocol (Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydro-fluorocarbons (HFC's), Per-fluorocarbons (PFC's), and Sulfur Hexafluoride (SF_6)).
Gross Floor Area (GFA)	Total floor area contained within a building, including the horizontal area of external walls.
GHG Inventory	A quantified list of an organization's GHG emissions sources.
Global Warming Potential (GWP)	The ratio of radiative forcing that would result from the emission of one unit of a given GHG compared to one unit of carbon dioxide (CO_2).
HFCs	Hydrofluorocarbons. HFCs are Kyoto Protocol greenhouse gases.
Indirect GHG Emissions	Emissions that are a consequence of the activities of a company but that occur at sources owned or controlled by another company. Indirect emissions include Scope 2 and Scope 3 emissions. For more information see the related definitions.

Intergovernmental Panel on Climate Change (IPCC)	International body of climate change scientists. The role of the IPCC is to assess the scientific, technical and socio-economic factors relevant to understanding the risk of human-induced climate change (www.ipcc.ch).
Metric	A method of measuring building performance indicators
Mobile Combustion Emissions	Emissions from the combustion of fuels in:
	· Transportation sources, such as cars, trucks, buses, trains, airplanes, and marine vessels
	· Emissions from non-road equipment, such as equipment used in construction, agriculture, and forestry.
	Note: A piece of equipment that cannot move under its own power but that is transported from site to site, an emergency generator for example, is a stationary, not mobile, combustion source.
Modular Approach:	UNEP-SBCI recognises the importance of considering the whole building life-cycle when considering its environmental, social and economic impacts. Also recognised is the need for measurable, verifiable and reportable indicators building performance. UNEP-SBCI therefore shall work toward a holistic framework for assessing the climate impact over the building life-cycle, where reporting GWP from building operations is a mandatory first step. Emissions arising from other phases of the building life-cycle are considered optional for reporting and may be reported separately. At this stage emissions related to initial and recurring embodied energy shall also be reported separately.
NAMA (Nationally Approved Mitigation Action)	Unlike the commitments made by developed countries, which are specific, mandated, measurable commitment, NAMAs are voluntary actions supported by technological and capacity assistance from the developed world.
N_2O	Nitrous oxide. A Kyoto Protocol greenhouse gas.
Performance Based Approach	The performance based approach is primarily concerned with the description of what a construction process and/or building product and/or service is/are required to achieve (the 'end'), not about how they should be achieved (the 'means'). The Metric & Protocol adopt the performance based approach to provide a common methodology to describe the energy performance and related greenhouse gas emissions of a building through a framework for monitoring and reporting. It therefore does not provide or advise on specific strategies for improving energy performance and reducing greenhouse gas emissions.
Performance Baselines	The actual measured performance of a building or aggregation of buildings of the same type, minimally normalised, in a region/location/climate zone. The Metric & Protocol can be used to collect data to establish a baseline for building energy performance reported in kWh/yr and greenhouse gas emissions reported in tCO2-e/yr.
Performance Targets	A desired level of building performance relative to which actual building performance can be compared. For example, baseline energy performance of office buildings can be compared relative to minimum performance target established by building regulations, or best-practice performance targets set by industry leaders.

Performance Benchmarking	The process of comparing actual performance relative to desired performance is known as benchmarking. The Metric & Protocol support benchmarking by providing a consistent framework for collecting and reporting baseline building energy and GHG emissions performance.
PFCs	Perfluorocarbons. PFCs are Kyoto Protocol GHGs.
RAC	Refrigeration and Air-Conditioning.
Radiative Forcing	The degree of warming of the atmosphere. A positive forcing (more incoming energy) tends to warm the system, while a negative forcing (more outgoing energy) tends to cool it.
Scope 1 Emissions	All direct GHG emissions, with the exception of direct CO2 emissions from biogenic sources.
Scope 2 Emissions	Indirect GHG emissions associated with the consumption of purchased electricity, heating, cooling, or steam.
Scope 3 Emissions	All indirect emissions not covered in Scope 2. Examples include:
	· Upstream and downstream emissions
	· Emissions resulting from the extraction and production of purchased materials and fuels
	· Transport related activities in vehicles not owned or controlled by the reporting Entity
	· Use of sold products and services
	· Outsourced activities
	· Recycling of used products
	· Waste disposal
Stationary Combustion Emissions	Emissions from the combustion of fuels to produce electricity, steam, heat, or power using equipment, such as boilers, furnaces, etc., in a fixed location.

Appendix 4: Data Sources

Emission sources included in the Calculation Tool & Reporting Template

Stationary Combustion / Power generation

- Source of method and fuel density data: GHG Protocol Calculation Tool for Direct Emissions from Stationary Combustion, Version 3.1.
- Emission factors: 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapters 1 and 2.

Purchased electricity

- Source of method: GHG Protocol tool 'Indirect CO_2 emissions from Purchased Electricity, Heat, or Steam'
- Emission factors: International Energy Agency Data Services. 2006. "CO_2 Emissions from Fuel Combustion (2006 Edition)."

Emission sources not included in the current version of the Calculation Tool & Reporting Template

Purchased cooling/steam/heat

- Source of method: GHG Protocol tool 'Allocation of GHG emissions from a combined heat and power (CHP) plant'; Version 1.
- Factors: The default factors for the assumed efficiency of electricity and steam production are sourced from the US EPA Climate Leaders program.

Refrigeration and air-conditioning equipment

- Source of method: GHG Protocol tool 'Calculating HFC and PFC Emissions from the Manufacturing, Servicing, and/or Disposal of Refrigeration and Air-Conditioning Equipment'; Version 1.0.
- Emission factors: 2006 IPCC Guidelines for National GHG Inventories; Volume 3, Chapter 3.

Other Optional emissions

- Source of CFC and HCFC emission Factors: IPCC Special Report on Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons, Special Report of the IPCC, Cambridge, England, 2005.

References

- EMG: A Strategy for a Climate Neutral UN. www.unemg.org/climateneturalun.
- UNEP/GRID- Arendal: Kick the Habit – a UN guide to climate neutrality. A UNEP Publication 2008.
- WRI/WBCSD: The Greenhouse Gas Protocol – A corporate accounting and reporting standard.
- Carbon Disclosure Tool – Appendix A for Climatic Zones and Annual Adjustments
- UNEP (United Nations Environment Programme), 2007. Buildings and Climate Change: Status, Challenges and Opportunities, lead authors P. Huovila, M. Ala-Juusela, L. Melchert, and S. Pouffary, 2007, UNEP Sustainable Buildings and Climate Initiative, Paris.
- UNEP, 2007a. Assessment of Policy Instruments for Reducing Greenhouse Gas Emissions from Buildings, lead authors D. Urge-Vorsatz, and S. Koeppel. UNEP, Paris, France.
- UNEP, 2008. The Kyoto Protocol, The Clean Development Mechanism and the Building and Construction Sector – A Report for the UNEP Sustainable Buildings and Construction Initiative, lead authors C. Cheng, Pouffary, S., Svenningsen, N., Callaway, M. UNEP, Paris, France.
- UNEP (in-press 2009) Sustainable Buildings – Case-studies to establish benchmarks of high-performance, lead Authors Hartkopf, V., Yang, X., Azizan, A. Carnegie Mellon University – Centre for Building Performance.
- UNEP (in-press, 2009) SUSTAINABILITY METRICS REPORT An international review of sustainable building performance indicators & benchmarks, lead Authors LOWE, C. Building Research Establishment, UK & PONCE, A. CSTB France; Contributing Authors: Nils Larsson, FRAIC, executive director iiSBE; Dr. David Lorenz, Lorenz property advisors, chartered surveyors, Prof. Dr. Ing. Habil Thomas Lützkendorf, Karlsrühe University, Andrea Moro, iiSBE Italia & Dr. Josephine Prior, BRE.
- UNEP (in-press, 2009) Developing a consensus on a global framework and indicators for performance reporting of sustainable building, lead Authors: SEO, S., Foliente, G.C., Tucker, S.N., CSIRO Australia
- BROAD Air, 2009 Building Energy Conservation Guidelines, Lead Author Zhang Yue, Changsha China.
- International Standards Organisation (ISO), 2006 Sustainability in building construction – Sustainability indicators – Part 1: Framework for the development of indicators for buildings, ISO/TS 21929-1, 12p.
- ISO 15392:2008, Sustainability in building construction -- General principles
- ISO/TS 21931-1:2006, Sustainability in building construction -- Framework for methods of assessment for environmental performance of construction works -- Part 1: Buildings
- ISO 14040:2006, Environmental management -- Life cycle assessment -- Principles and framework

Appendix 5: Electricity emission factors

(Source: International Energy Agency, CO2 Emissions from Fuel Combustion, 2008)

Country	Year-specific emission factor (kg CO2 / kWh)						
	2000	2001	2002	2003	2004	2005	2006 onwards
Albania	0.048642	0.0603048	0.0580777	0.0304432	0.0320289	0.0344451	0.0324402
Algeria	0.6858415	0.6872739	0.6993607	0.6998468	0.6996617	0.6709294	0.6881182
Angola	0.3824699	0.3813999	0.3539564	0.372808	0.216229	0.1543404	0.0982004
Argentina	0.3384653	0.2671451	0.2581042	0.2746517	0.3168683	0.307203	0.3033696
Armenia	0.2358542	0.2430216	0.1533606	0.1480246	0.1197077	0.138329	0.1382909
Australia	0.86268	0.890203	0.938218	0.918712	0.914206	0.921851	0.920527
Austria	0.179847	0.202697	0.195777	0.23436	0.228254	0.222809	0.214471
Azerbaijan	0.6483436	0.5611304	0.4895583	0.5231113	0.5113228	0.5038991	0.4734752
Bahrain	0.8678482	0.8399183	0.8350802	0.8830508	0.8813498	0.8901022	0.8248637
Bangladesh	0.5558199	0.6022123	0.6035002	0.5743256	0.6276187	0.5571221	0.5843308
Belarus	0.3062537	0.2969185	0.2974544	0.2921579	0.3006714	0.2959063	0.2963771
Belgium	0.284388	0.271556	0.2663	0.274227	0.280563	0.270999	0.260036
Benin	0.6013333	0.9548182	0.9498413	0.751675	0.740037	0.7094393	0.6962126
Bolivia	0.3036634	0.5071933	0.4692486	0.448168	0.5249735	0.5126527	0.5049688
Bosnia & Herze-govina	0.7971711	0.7667476	0.825342	0.8487069	0.7406088	0.7521496	0.801958
Botswana	1.8762798	1.3179881	1.3226425	1.319832	1.7389546	1.8513522	1.8514539
Brazil	0.0879491	0.1038713	0.0856142	0.0791719	0.0852495	0.0842382	0.0814376
Brunei Darussalam	0.7949823	0.7989236	0.8181174	0.8008533	0.8015021	0.7817601	0.8210049
Bulgaria	0.4306759	0.4633784	0.4328453	0.4702482	0.4706009	0.4499187	0.4479618
Cambodia	1.7980067	1.9395504	1.9698481	1.8801984	1.3008549	1.205425	1.0049344
Cameroon	0.0100356	0.0161398	0.0269397	0.0310261	0.0277168	0.0390902	0.0425357
Canada	0.221934	0.231245	0.217379	0.225667	0.208695	0.195691	0.184179
Chile	0.3314262	0.2605082	0.2622276	0.2794296	0.34117	0.3276607	0.2942425
China (including Hong Kong)	0.7637152	0.7392958	0.7478536	0.7760018	0.805541	0.7875759	0.7883087
Colombia	0.2006519	0.1911704	0.1871719	0.1763352	0.1631386	0.1630354	0.1496172
Congo	0	0	0	0.0955711	0.0830581	0.1029908	0.1023289
Costa Rica	0.0036451	0.0037192	0.0035937	0.003403	0.0032014	0.0029567	0.0027816
Côte d'Ivoire	0.0082427	0.0141249	0.0152577	0.0196727	0.0173793	0.0268748	0.0473985
Croatia	0.3794569	0.3939408	0.4092423	0.3841679	0.4038817	0.4449239	0.4362172
Cuba	0.303265	0.3128552	0.3566689	0.3796708	0.3000055	0.3108118	0.318398
Cyprus	1.0240706	0.9914933	1.0903425	1.1377718	1.0746459	1.0117289	1.0194389
Czech Republic	0.8376335	0.7774295	0.7560465	0.8332966	0.7726093	0.7885526	0.7582802
Democratic Republic of Congo	0.59637	0.583616	0.560964	0.524299	0.525235	0.525407	0.526629
Denmark	0.339329	0.33591	0.332003	0.357022	0.308095	0.281566	0.341339
Dominican Republic	0.7594265	0.6580476	0.7338179	0.6608694	0.6046025	0.5901474	0.6238551

Country	Year-specific emission factor (kg CO2 / kWh)						
	2000	2001	2002	2003	2004	2005	2006 onwards
Ecuador	0.2152637	0.2721655	0.2809849	0.2985651	0.3022298	0.3690357	0.3957349
Egypt	0.4118251	0.3810078	0.4366883	0.4324818	0.4731555	0.4714592	0.4698084
El Salvador	0.2876796	0.3024137	0.3098698	0.2964936	0.274723	0.2633951	0.2167277
Eritrea	0.713381	0.7490901	0.6586757	0.6936823	0.722159	0.6772083	0.690342
Estonia	0.6913669	0.678414	0.6627483	0.7173835	0.7008656	0.6648508	0.6401581
Ethiopia	0.0113793	0.0094677	0.0077666	0.0055318	0.0062525	0.0033483	0.002914
Finland	0.211425	0.241947	0.25273	0.292742	0.253686	0.192889	0.241592
France	0.08283	0.070748	0.076348	0.08047	0.078102	0.091648	0.084953
Gabon	0.3255255	0.272225	0.2817934	0.3059481	0.3216103	0.3763892	0.3466605
Georgia	0.1929331	0.1327927	0.0716422	0.0760192	0.09958	0.1028153	0.1449678
Germany	0.493814	0.505503	0.507675	0.434394	0.436128	0.405421	0.403629
Ghana	0.0681033	0.114547	0.2553183	0.2769188	0.0835203	0.1467859	0.2756985
Gibraltar	0.759808	0.7537778	0.7599845	0.7545075	0.7659265	0.7395103	0.7304305
Greece	0.817326	0.831209	0.814165	0.777519	0.776432	0.775676	0.724964
Guatemala	0.3920903	0.420902	0.484156	0.4040128	0.4341858	0.3840404	0.3344147
Haiti	0.3456307	0.3396633	0.3994534	0.3195738	0.3005996	0.3071583	0.3051825
Honduras	0.2802692	0.329411	0.2817498	0.3521216	0.4506195	0.4107094	0.4132526
Hong Kong, China	0.7118212	0.7199642	0.7251555	0.7950479	0.8307945	0.8094353	0.8546126
Hungary	0.409762	0.39368	0.391365	0.424645	0.392429	0.340648	0.343927
Iceland	0.000622	0.000603	0.00061	0.000618	0.000608	0.000614	0.000542
India	0.9392939	0.9348198	0.9198197	0.904032	0.9432511	0.9364167	0.9440385
Indonesia	0.5959232	0.6785769	0.6549039	0.7108372	0.6901426	0.6936732	0.6767253
Iran	0.568412	0.5776161	0.559711	0.5336079	0.5324447	0.5281749	0.5143547
Iraq	0.7311342	0.8129179	0.7512158	0.7870133	0.7024988	0.7004078	0.7009096
Ireland	0.642102	0.668213	0.634876	0.599776	0.574207	0.58177	0.535333
Israel	0.7608988	0.7728351	0.8227822	0.8177361	0.8094542	0.7977321	0.773651
Italy	0.49855	0.482551	0.506214	0.516454	0.416336	0.412539	0.403512
Jamaica	0.8209787	0.8235476	0.8029198	0.7945297	0.785098	0.7341132	0.8297551
Japan	0.400724	0.401668	0.422356	0.444808	0.427633	0.426643	0.418346
Jordan	0.7084217	0.7023017	0.7406763	0.6801646	0.6825746	0.6309245	0.6018739
Kazakhstan	0.4797295	0.4216501	0.4648772	0.4654289	0.4568649	0.4492335	0.5200265
Kenya	0.5620558	0.3918549	0.2708664	0.1998878	0.280026	0.3068003	0.3174905
Kuwait	0.5835887	0.5825964	0.5680109	0.5417746	0.528461	0.521796	0.5331955
Kyrgyzstan	0.447498	0.476933	0.454174	0.449327	0.474576	0.460307	0.464337
Latvia	0.6890093	0.6702995	0.6242148	0.6632918	0.7535054	0.8075562	0.6429168
Lebanon	0.1059152	0.1014482	0.1055218	0.0940333	0.0895848	0.0816262	0.079161
Libya	0.199933	0.1894489	0.1879367	0.1826753	0.166361	0.1619035	0.1673881
Lithuania	0.7332778	0.7511499	0.7215798	0.7085811	0.5645362	0.6674061	0.6946497
Luxembourg	1.0223558	0.9964422	0.9705141	0.9782802	0.8884029	0.9065093	0.8788286
Macedonia	0.1605423	0.148648	0.1250207	0.1142706	0.1155096	0.139143	0.139482

Country	Year-specific emission factor (kg CO2 / kWh)						
	2000	2001	2002	2003	2004	2005	2006 onwards
Malaysia	0.255069	0.239947	0.328771	0.33019	0.333814	0.327756	0.326047
Malta	0.6802566	0.7777156	0.7223198	0.6646698	0.6786687	0.6439682	0.6189059
Mexico	0.5166751	0.5406954	0.5911045	0.5254512	0.5376214	0.6411917	0.6553582
Moldova	0.8621695	1.022071	0.814847	0.8087513	0.896157	0.8550973	0.8340854
Mongolia	0.566131	0.568478	0.570326	0.576498	0.52779	0.555201	0.541285
Morocco	0.7387891	0.7671716	0.737925	0.7554372	0.5149158	0.5187097	0.475568
Mozambique	0.586715	0.5853653	0.61327	0.5535913	0.5261558	0.5332243	0.52331
Myanmar	0.7698989	0.763902	0.7655835	0.736906	0.7495018	0.7237765	0.7079012
Namibia	0.0047449	0.0039261	0.0031108	0.0030804	0.0031735	0.0013377	0.0010178
Nepal	0.4570031	0.4053165	0.3761292	0.4255319	0.4144975	0.3647604	0.3382211
Netherlands	0.0209533	0.029446	0.0753247	0.0742681	0.0750051	0.0757205	0.0756469
Netherlands Antilles	0.0122936	0.0072828	0.001601	0.0014993	0.0056279	0.0038894	0.0037996
New Zealand	0.446998	0.460074	0.458011	0.462952	0.440095	0.387062	0.394315
Nicaragua	0.7168858	0.7170365	0.7175009	0.7169644	0.7175934	0.7179503	0.7170685
Nigeria	0.229921	0.277961	0.250401	0.294528	0.275098	0.312418	0.3091
North Korea	0.6097142	0.6127748	0.562551	0.5575682	0.5572785	0.5387725	0.5497637
Norway	0.4065908	0.340192	0.3541939	0.3403783	0.3995282	0.383394	0.3861378
Oman	0.004063	0.005831	0.005296	0.008329	0.007014	0.00555	0.006867
Pakistan	0.7956358	0.8167283	0.8293552	0.8533625	0.885115	0.8543975	0.8561127
Panama	0.4794254	0.4629172	0.4427578	0.370599	0.3971433	0.3798984	0.4128082
Paraguay	0.2310653	0.3994819	0.2703469	0.3559679	0.2656568	0.2746714	0.2288439
Peru	0	0	0	0	0	0	0
Philippines	0.1517011	0.1201491	0.1430884	0.1477967	0.2060132	0.1976988	0.1723235
Poland	0.4981119	0.5299027	0.4821932	0.4601703	0.4569744	0.4951414	0.4350061
Portugal	0.67074	0.659545	0.661868	0.66226	0.664077	0.656655	0.65865
Qatar	0.479403	0.441836	0.511857	0.413436	0.451914	0.500925	0.416424
Romania	0.7709436	0.7812838	0.7817194	0.7792543	0.6488941	0.6179696	0.6257141
Russia	0.395507	0.4120619	0.4121279	0.4509292	0.4181164	0.4002267	0.428605
Saudi Arabia	0.320761	0.3214793	0.3266583	0.3293001	0.3248552	0.3249678	0.3285654
Senegal	0.809691	0.7781007	0.7511593	0.7393915	0.7616009	0.7524292	0.7553734
Serbia	0.7818546	0.7991528	0.6452999	0.5203122	0.5551314	0.634202	0.7258949
Singapore	0.8066566	0.7640638	0.7949393	0.8251128	0.7805569	0.6638241	0.7155911
Slovak Republic	0.6637622	0.6346518	0.5950352	0.5737891	0.5562526	0.5439599	0.5360586
Slovenia	0.266686	0.241163	0.214865	0.254784	0.24002	0.229003	0.223412
South Africa	0.3302966	0.339892	0.3719069	0.3673126	0.3365373	0.3282646	0.3317589

Country	Year-specific emission factor (kg CO2 / kWh)						
	2000	2001	2002	2003	2004	2005	2006 onwards
South Korea	0.8930285	0.8289466	0.8194428	0.8452379	0.8655495	0.8483711	0.8689996
Spain	0.429943	0.381724	0.434018	0.378378	0.381758	0.396067	0.349794
Sri Lanka	0.4273044	0.4062693	0.434705	0.3778602	0.4286689	0.3976336	0.3137244
Sudan	0.5328853	0.5334371	0.6319006	0.7432537	0.8278385	0.637187	0.6139183
Sweden	0.041517	0.042048	0.051701	0.05939	0.050981	0.044041	0.047966
Switzerland	0.022032	0.021361	0.021766	0.022569	0.023663	0.02621	0.025723
Syria	0.5665752	0.5585878	0.5536515	0.5625102	0.5564203	0.5897168	0.6043992
Tajikistan	0.0414305	0.0414266	0.0270805	0.0270206	0.0279479	0.027412	0.0280183
Tanzania	0.1924903	0.0699357	0.0566409	0.0509026	0.1380954	0.268369	0.3155122
Thailand	0.5640424	0.562348	0.5476618	0.5278635	0.5386878	0.5354128	0.5109283
Togo	0.5611943	1.4932033	0.3333882	0.2161761	0.4423656	0.3520053	0.4586697
Trinidad and Tobago	0.6910934	0.6935966	0.7722236	0.7311852	0.759428	0.7090288	0.7243096
Tunisia	0.574219	0.5844183	0.563942	0.5542789	0.5319145	0.4763189	0.5458586
Turkey	0.518856	0.543888	0.471981	0.444078	0.419388	0.426378	0.438222
Turkmeni-stan	0.7949213	0.7950884	0.7950971	0.7951045	0.7951183	0.7951234	0.7951304
Ukraine	0.3468043	0.3295225	0.3247336	0.3805892	0.3162784	0.3308819	0.3443288
United Arab Emirates	0.7284334	0.7463885	0.7642596	0.8049414	0.9132203	0.8435464	0.8199856
United Kingdom	0.461064	0.473981	0.459842	0.477943	0.485317	0.483897	0.504733
United States	0.586096	0.602272	0.575982	0.57486	0.572479	0.569737	0.55866
Uruguay	0.0568805	0.0026782	0.0039063	0.0018918	0.1504441	0.1027509	0.2963499
Uzbekistan	0.4582118	0.4666505	0.4746977	0.4538724	0.4480578	0.4422013	0.44636
Venezuela	0.2099621	0.2819794	0.2775316	0.2450399	0.2454326	0.1892012	0.2084422
Vietnam	0.4204958	0.3923147	0.4235188	0.3747151	0.4073047	0.4055956	0.3963138
Yemen	0.9296299	0.9300977	0.9189146	0.8841907	0.874403	0.8405719	0.8230311
Zambia	0.0069578	0.0068308	0.0066557	0.0068063	0.0069122	0.0068391	0.0067574
Zimbabwe	0.739766	0.8482746	0.7169936	0.5153283	0.5718589	0.5723237	0.5727689
Other Africa	0.469464	0.4778739	0.4809761	0.4855521	0.4799626	0.4885073	0.4886113
Other Asia	0.2425699	0.222594	0.2537792	0.2871644	0.3095522	0.3078937	0.3078166
Other Latin America	0.496456	0.4856387	0.5005977	0.5141675	0.5074758	0.5089302	0.5089928

Appendix 6: Additional Emission Factors

Table 6.1 Fuel-specific CO_2 emission factors

Fuel		*Energy basis* *kg/GJ*	*Mass basis* *kg/tonne*	*Liquid basis* *kg/ litre*	*Gas basis* *kg/m³*
Oil products	Kerosene	71.9	3149.22	2.52	
	Gas/Diesel oil	74.1	3186.3	2.68	
	Residual fuel oil	77.4	3126.96	2.94	
	Liquified Petroleum Gases	63.1	2984.63	1.61	
	Petroleum coke	97.5	3168.75		
Coal products	Anthracite	98.3	2624.61		
	Other bituminous coal	94.6	2440.68		
	Sub bituminous coal	96.1	1816.29		
	Lignite	101	1201.9		
	Brown coal briquettes	97.5	2018.25		
	Patent fuel	97.5	2018.25		
	Coke oven coke	107	3017.4		
	Lignite coke	107	3017.4		
Natural gas	Natural gas	56.1	2692.8		1.88
Other wastes	Municipal waste (Non biomass fraction)	91.7	917		
Biomass	Wood or Wood waste	112	1747.2		
	Other primary solid biomass fuels	100	1160		
	Charcoal	112	3304		
	Biogasoline	70.8	1911.6		
	Biodiesels	70.8	1911.6		
	Other liquid biofuels	79.6	2181.04		
	Landfill gas	54.6	2751.84		2.48
	Sludge gas	54.6	2751.84		
	Other biogas	54.6	2751.84		
	Municipal wastes (Biomass fraction)	100	1160		
	Peat	106	1034.56		

Table 6.2 Fuel-specific CH4 emission factors

Fuel		Energy basis kg/GJ	Mass basis kg/tonne	Liquid basis kg/ litre	Gas basis kg/m³
Oil products	Kerosene	0.01	0.438	0.0004	
	Gas/Diesel oil	0.01	0.43	0.0004	
	Residual fuel oil	0.01	0.404	0.0004	
	Ethane	0.005	0.232		0.0003
	Petroleum coke	0.01	0.325		
Coal products	Anthracite	0.01	0.267		
	Other bituminous coal	0.01	0.258		
	Sub bituminous coal	0.01	0.189		
	Lignite	0.01	0.119		
	Brown coal briquettes	0.01	0.207		
	Patent fuel	0.01	0.207		
	Coke oven coke	0.01	0.282		
	Lignite coke	0.01	0.282		
Natural gas	Natural gas	0.005	0.24		0.0002
Other wastes	Municipal waste (Non biomass fraction)	0.3	3		
Biomass	Wood or Wood waste	0.3	4.68		
	Other primary solid biomass fuels	0.3	3.48		
	Charcoal	0.2	5.9		
	Biogasoline	0.01	0.27		
	Biodiesels	0.01	0.27		
	Other liquid biofuels	0.01	0.274		
	Landfill gas	0.005	0.252		0.0002
	Sludge gas	0.005	0.252		
	Other biogas	0.005	0.252		
	Municipal wastes (Biomass fraction)	0.3	3.48		
	Peat	0.01	0.0976		

Table 6.3 Fuel-specific N_2O emission factors

Fuel		*Energy basis* *kg/GJ*	*Mass basis* *kg/tonne*	*Liquid basis* *kg/ litre*	*Gas basis* *kg/m³*
Oil products	Kerosene	0.0006	0.0263	0.00002	
	Gas/Diesel oil	0.0006	0.0258	0.00002	
	Residual fuel oil	0.0006	0.0242	0.00002	
	Liquified Petroleum Gases	0.0001	0.0047	2.5542E-06	
	Petroleum coke	0.0006	0.0200		
Coal products	Anthracite	0.0015	0.0401		
	Other bituminous coal	0.0015	0.0387		
	Sub bituminous coal	0.0015	0.0284		
	Lignite	0.0015	0.0179		
	Brown coal briquettes	0.0015	0.0311		
	Patent fuel	0.0015	0.0311		
	Coke oven coke	0.0015	0.0423		
	Lignite coke	0.0015	0.0423		
Natural gas	Natural gas	0.0001	0.0048		0.000003
Other wastes	Municipal waste (Non biomass fraction)	0.004	0.04		
Biomass	Wood or Wood waste	0.004	0.0624		
	Other primary solid biomass fuels	0.004	0.0464		
	Charcoal	0.001	0.0295		
	Biogasoline	0.0006	0.0162		
	Biodiesels	0.0006	0.0162		
	Other liquid biofuels	0.0006	0.0164		
	Landfill gas	0.0001	0.0050		0.000005
	Sludge gas	0.0001	0.0050		
	Other biogas	0.0001	0.0050		
	Municipal wastes (Biomass fraction)	0.004	0.0464		
	Peat	1.4	0.0137		

Refrigeration and air-conditioning equipment

Table 6.4 Emission factors implemented in Method 3. The tool assumes the mid point of the ranges in parentheses.

Application	*Average Charge (kg)*	*Average Lifetime (years)*	*Average Assembly*	*Average Annual Leakage Rate*	*Average Recycling Efficiency*
Domestic refrigeration	0.28 (0.05 - 0.5)	16.00 (12 - 20)	0.60% (0.2 -1%)	0.30% (0.1 - 0.5%)	70%
Stand-alone commercial applications	2.90 (0.2 - 6)	12.50 (10 - 15)	1.75% (0.5 - 3%)	7.50% (1 - 15%)	75% (10 - 80%)
Medium and large commercial refrigeration	1025.00 (50 - 2,000)	8.50 (7 - 10)	1.75% (0.5 -3%)	22.50% (10 - 35%)	85% (80 - 90%)
Transport refrigeration	5.50 (3.0 - 8.0)	7.50 (6 - 9)	0.6 (0.2 - 1%)	32.50% (15 - 50%)	75% (70 - 80%)
Industrial refrigeration including food processing and cold storage	4995.00 (10 - 10,000)	22.50 (15 - 30)	1.75 (0.5 - 3%)	16% (7 - 25%)	85% (80 - 90%)
Chillers	995.00 (10 - 2,000)	22.50 (15 - 30)	0.6 (0.2 - 1%)	8.50% (2 - 15%)	87.50% (80 - 95%)
Residential and commercial A/C, including heat pumps	49.75 (0.5 - 100)	15.00 (10 - 20)	0.6 (0.2 - 1)	3% (1 - 5%)	75% (70 - 80%)
Mobile air conditioners	1.00 (0.5 - 1.5)	12.50 (9 - 16)	0.35% (0.2 - 0.5)	15% (10 - 20%)	0%

Purchased Steam/Heat

Table 6.5 Efficiency factors for steam/heat and power production.

eH Assumed efficiency of typical power production	*eP Assumed efficiency of typical steam production*
0.8	0.35

Appendix 7: GWP values

Table 7.1 GWP values for individual greenhouse gases.

Gas			
Formula	**Common Name**	**Chemical Name**	**GWP**
CO_2	Carbon dioxide		1
CH_4	Methane		21
N_2O	Nitrous oxide		310
SF_6	Sulfur hexafluoride		23,900
Hydrofluorocarbons (HFCs)			
CHF_3	HFC-23	trifluoromethane	11,700
CH_2F_2	HFC-32	difluoromethane	650
CH_3F	HFC-41	fluoromethane	150*
$C_5H_2F_{10}$	HFC-43-10mee	1,1,1,2,3,4,4,5,5,5-decafluoropentane	1300*
C_2HF_5	HFC-125	pentafluoroethane	2,800
$C_2H_2F_4$	HFC-134	1,1,2,2-tetrafluoroethane	1,000
$C_2H_2F_4$	HFC-134a	1,1,1,2-tetrafluoroethane	1,300
$C_2H_3F_3$	HFC-143	1,1,2-trifluoroethane	300
$C_2H_3F_3$	HFC-143a	1,1,1-trifluoroethane	3,800
$C_2H_4F_2$	HFC-152	1,2-difluoroethane	43*
$C_2H_4F_2$	HFC-152a	1,1-difluoroethane	140
C_2H_5F	HFC-161	fluoroethane	12*
C_3HF_7	HFC-227ea	1,1,1,2,3,3,3-heptafluoropropane	2,900
$C_3H_2F_6$	HFC-236cb	1,1,1,2,2,3-hexafluoropropane	1,300*
$C_3H_2F_6$	HFC-236ea	1,1,1,2,3,3-hexafluoropropane	1,200*
$C_3H_2F_6$	HFC-236fa	1,1,1,3,3,3-hexafluoropropane	6,300
$C_3H_3F_5$	HFC-245ca	1,1,2,2,3-pentafluoropropane	560
$C_3H_3F_5$	HFC-245fa	1,1,1,3,3-pentafluoropropane	950*
$C_4H_5F_5$	HFC-365mfc	1,1,1,3,3-pentafluorobutane	890*
Perfluorocarbons (PFCs)			
CF_4	PFC-14 (Perfluoromethane)	tetrafluoromethane	6,500
C_2F_6	PFC-116 (Perfluoroethane)	hexafluoroethane	9,200
(C_3F_8)	PFC-218 Perfluoropropane	octafluoropropane	7,000
C_4F_{10}	Perfluorobutane	decafluorobutane	7,000
$c\text{-}C_4F_8$	Perfluorocyclobutane	octafluorocyclobutane	8,700
C_5F_{12}	Perfluoropentane	dodecafluoropentane	7,500
C_6F_{14}	Perfluorohexane	tetradecafluorohexane	7,400

Source: The GWP values are from the IPCC Second Assessment Report (1995), unless indicated otherwise (*), in which case they are from the IPCC Third Assessment Report (2001). Third Assessment Report values have only been included for greenhouse gases that were not originally covered by the Second Assessment Report.
Note: All GWP values were calculated assuming a 100 year time horizon.

Table 7.2 GWP values for refrigerant blends.

Chemical blend	*GWP*
R-401A	18
R-401B	15
R-401C	21
R-402A	1,680
R-402B	1,064
R-403A	1,400
R-403B	2,730
R-404A	3,260
R-406A	0
R-407A	1,770
R-407B	2,285
R-407C	1,526
R-407D	1,428
R-407E	1,363
R-408A	1,944
R-409A	0
R-409B	0
R-410A	1,725
R-410B	1,833
R-411A	15
R-411B	4
R-412A	350
R-413A	1,774
R-414A	0
R-414B	0
R-415A	25
R-415B	105
R-416A	767
R-417A	1,955
R-418A	4
R-419A	2,403
R-420A	1,144
R-500	37
R-501	0
R-502	0
R-503	4,692
R-504	313
R-505	0
R-506	0
R-507 or R-507A	3,300
R-508A	10,175
R-508B	10,350
R-509 or R-509A	3,920

Note: The GWPs of blends are based only on the GWPs of their HFC and PFC constituents. Other constituents are considered to have a GWP of zero, even though they may have significant climate impacts, because these gases are not recognized under the Kyoto Protocol. The HFC and PFC contents of these blends have been obtained from ASHRAE Standard 34.

Table 7.3 GWPs of ozone depleting substances

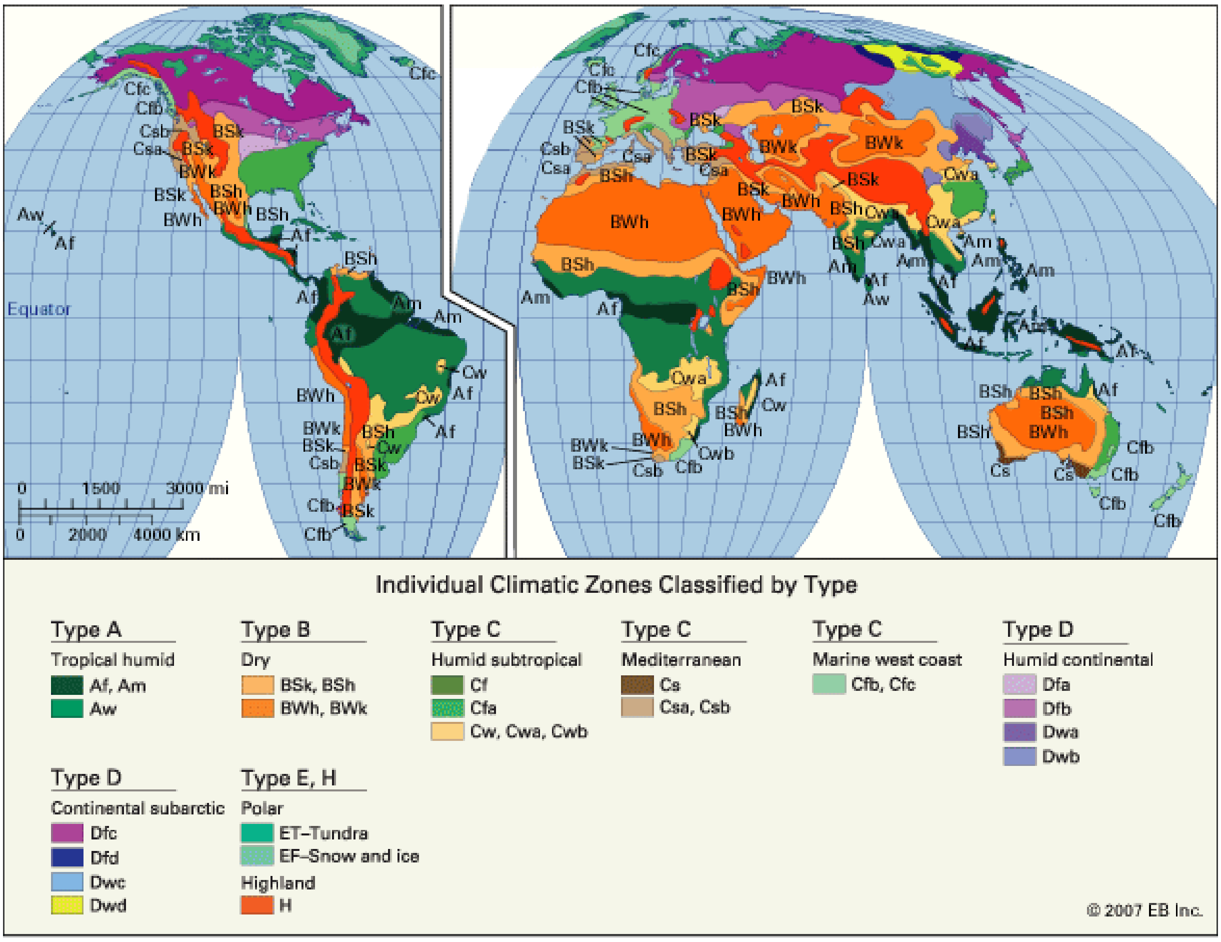
Ozone Depleting Substance	*GWP**
CFC-11 (CCl3F) Trichlorofluoromethane	4680
CFC-12 (CCl2F2) Dichlorodifluoromethane	10720
CFC-113 (C2F3Cl3) 1,1,2-Trichlorotrifluoroethane	6030
CFC-114 (C2F4Cl2) Dichlorotetrafluoroethane	9880
CFC-115 (C2F5Cl) Monochloropentafluoroethane	7250
Halon 1211 (CF2ClBr) Bromochlorodifluoromethane	1860
Halon 1301 (CF3Br) Bromotrifluoromethane	7030
Halon 2402 (C2F4Br2) Dibromotetrafluoroethane	1620
CFC-13 (CF3Cl) Chlorotrifluoromethane	14190
CCl4 Carbon tetrachloride	1380
Methyl Chloroform (C2H3Cl3) 1,1,1-trichloroethane	144
Methyl Bromide (CH3Br)	5
HCFC-22 (CHF2Cl) Monochlorodifluoromethane	1780
HCFC-123 (C2HF3Cl2) Dichlorotrifluoroethane	76
HCFC-124 (C2HF4Cl) Monochlorotetrafluoroethane	599
HCFC-141b (C2H3FCl2) Dichlorofluoroethane	713
HCFC-142b (C2H3F2Cl) Monochlorodifluoroethane	2270
HCFC-225ca (C3HF5Cl2) Dichloropentafluoropropane	120
HCFC-225cb (C3HF5Cl2) Dichloropentafluoropropane	586

*All GWPs are based on a 100 year time horizon.

Appendix 8: Köppen Climate Classification

Many users wish to contextualize their building performance data by linking energy use and related emissions to degree days, which are largely a function of climate region. One such climate classification scheme, called Köppen's classification, is based on a subdivision of terrestrial climates into five major types, which are represented by the capital letters A, B, C, D, and E. Each of these climate types except for B is defined by temperature criteria. Type B designates climates in which the controlling factor on vegetation is dryness (rather than coldness). Aridity is not a matter of precipitation alone but is defined by the relationship between the precipitation input to the soil in which the plants grow and the evaporative losses. Since evaporation is difficult to evaluate and is not a conventional measurement at meteorological stations, Köppen was forced to substitute a formula that identifies aridity in terms of a temperature-precipitation index (that is, evaporation is assumed to be controlled by temperature). Dry climates are divided into arid (BW) and semiarid (BS) subtypes, and each may be differentiated further by adding a third code, h for warm and k for cold.

Köppen Climate Classification



As noted above, temperature defines the other four major climate types. These are subdivided, with additional letters again used to designate the various subtypes. Type A climates (the warmest) are differentiated on the basis of the seasonality of precipitation: Af (no dry season), Am (short dry season), or Aw (winter dry season). Type E climates (the coldest) are conventionally separated into tundra (ET) and snow/ice climates (EF). The mid-latitude C and D climates are given a second letter, f (no dry season), w (winter dry), or s (summer dry), and a third symbol (a, b, c, or d [the last subclass exists only for D climates]), indicating the warmth of the summer or the coldness of the winter. Although Köppen's classification did not consider the uniqueness of highland climate regions, the highland climate category, or H climate, is sometimes added to climate classification systems to account for elevations above 1,500 metres (about 4,900 feet). The table, which includes the highland climate category, gives the specific criteria for the Köppen-Geiger-Pohl system of 1953.

Acknowledgements

Special thanks to UNEP-SBCI's Benchmarking & Climate Change Think Tank members (including ADEME, BRE, BROAD AIR, Blue Holdings, Centre for Building Performance and Diagnostics, Carnegie Mellon University, CIB, CIDB, CSIRO, CSTB, FIDIC, IEA, iiSBE, Lend Lease Corporation, the Marrakech Task Force on Sustainable Buildings & Construction, TERI, the UNEP Finance Initiative Responsible Property Working Group, UNEP Risoe Centre, UNESCO Chair for Sustainable Construction the US GBC and the WGBC) **and SB Alliance and members of the core group** (BRE, CSTB, DGNB, FCAV, ITC-CNR, NIST, VTT) **for their technical contributions and to the coalition of leading green building councils** (USGBC, UKGBC, GBCA) **for their leadership**.

Special thanks to hosts of SBCI Think Tank Round Tables:

- Institute Sultan Iskandar, Universiti Teknologi Malaysia (Kuala Lumpur, November 2007)
- Groupe Monplaisir (Martinique, May 2008)
- City of Madrid (Madrid, December 2008)
- U.S. Green Building Council (Washington D.C., April 2009)
- Broad Air-conditioning (Paris, September 2009)
- The Building & Construction Authority of Singapore (Singapore, October 2009)

Contributors that participated in meetings and in reviewing documents that formed the basis of this paper include the following people. Blue-shaded rows indicate people who have had a direct input in shaping and drafting the metric document.

UNEP-SBCI Members

Agence de l'environnement et de la maîtrise de l'énergie (ADEME)	Stephane	Pouffary
Arcelor-Mittal Company	Pierre	Bourrier
Arcelor-Mittal Company	Thierry	Braine-Bonnaire
Bayer MaterialScience AG	Manfred	Rink
Blue Holdings	Jean-Robert	Mazaud
Broad Air Conditioning	Bruce	L.Peng
Broad Air Conditioning	Ling	Xie
Broad Air Conditioning	Michael	Collins
Broad Air Conditioning	Jerry	Nie
Broad Air Conditioning	Xian	Ming Zhang
Broad Air Conditioning	Yue	Zhang
Building & Construction Authority (BCA), Singapore	Whatt Bin	Choo
Building & Construction Authority (BCA), Singapore	Jocelyn	Chua
Building & Construction Authority (BCA), Singapore	Yvonne	Soh
Building Research Establishment (BRE)	Claire	Lowe
Building Research Establishment (BRE)	David	Crowhurst
Building Research Establishment (BRE)	Carol	Atkinson
Building Research Establishment (BRE)	Martin	Townsend
Building Research Establishment (BRE)	Richard	Hardy
CEMEX Central S.A. de C.V.	Maria Claudia	Ramírez
CEMEX Central S.A. de C.V.	Roy	Schorsch

Centre Scientifique et Technique du Bâtiment (CSTB)	Serge	Salat
Centre Scientifique et Technique du Bâtiment (CSTB)	Bruno	Mesureur
Centre Scientifique et Technique du Bâtiment (CSTB)	Jean-Christophe	Visier
Centre Scientifique et Technique du Bâtiment (CSTB)	Jean	Carassus
Centre Scientifique et Technique du Bâtiment (CSTB)	Patrick	Nossent
International Council for Building Research and Innovation (CIB) W108 & CSTB	Jean-Luc	Salagnac
City of Madrid	Catalina	De Miguel
City of Madrid	Ana	Iglesias
City of Sao Paulo	Volf	Steinbaum
Conselho Brasileiro de Construção Sustentavel (CBCS)	Marcelo	Vespoli Takaoka
Construction Industry and Development Board (CIDB)	Rodney	Milford
Environment, Health and Safety (EHS) Dubai	Jagannathan	Paravasthu
Gravel, Leclerc & Associates	Jean-Charles	Bancal
HINES China	Shu Yu	HUANG
Hydro Aluminum	Birgitte	Holter
International Federation of Consulting Engineers (FIDIC)	Ike	van der Putte
Istituto per l'innovazione e Trasparenza degli Appalti e la Compatibilita Ambientale (ITACA)	Adriano	Bellone
Istituto per l'innovazione e Trasparenza degli Appalti e la Compatibilita Ambientale (ITACA)	Andrea	Moro
Jordan Green Building Council	Mohammad	Asfour
Lafarge	Constant	von Aerschot
Lend Lease Corporation	Maria	Atkinson
Monplaisir Group	Ralph	Monplaisir
Natural Resources Defense Council (NRDC)	Zhengchun (Kevin)	Mo
Plastedil, SA	Jean-Louis	Chardenet
Property Council of Australia	Peter	Verwer
Real Property Association of Canada (REALpac)	Michael	Brooks
Residential Energy Services Network (RESNET)	Philip	Fairey
Residential Energy Services Network (RESNET)	Steve	Baden
Résilience	Asma	Benslimane
SIKA Technology AG	Urs	Mäder
Sinotech Engineering Consultants, LTD.	Nelson	N.S Chou
SKANSKA	Noel	Morrin
Sustainable Building Research Center (SUSB)	Sungwoo	SHIN
Sustainable Buildings Alliance (SBAlliance)	Alfonso	Ponce
US Green Building Council (USGBC)	Joel Ann	Todd
US Green Building Council (USGBC)	Rick	Fedrizzi
US Green Building Council (USGBC)	Scot	Horst
US Green Building Council (USGBC)	Tom	Hicks
World Green Building Council (WGBC)	Andrew	Bowerbank
World Steel Association	Ian	Christmas

Contributors and Reviewers

2B Architects, Green Practice Committee, Singapore Institute of Architects	Yew Kee	Cheong
Agence Française de Normalisation -AFNOR (CEN TC 350)	Bernard	Leservoisier
Agence Française de Normalisation -AFNOR (CEN TC 350)	Rodolphe	Civet
ALECTIA	Lone	Loklindt
ALECTIA	Steffen	Wissing
American Forest & Paper Association	Robert	Glowinski
Arup Singapore Pte Ltd	Russell	Cole
Austin Energy Green Building	Richard	Morgan
Autodesk Asia Pte Ltd	Sunil	Moongadi Kunjayyappan
AXA REAL ESTATE INVESTMENT MANAGERS	Gilles	Bouteloup
Bayer MaterialScience AG	Andrew	Tong
Bayer MaterialScience AG	Bagavathi	Veeralakshmanan
Bayer MaterialScience AG	Jan-Peter	Schmelz
Belgian Building Research Institute (BBRI)	Johan	van Dessel
Blue Holdings	Robert	Mazaud
British Property Federation (BPF)	Liz	Peace
Building System & Diagnostics Pte Ltd (BSD)	Nicolas	M.Moossa
Building System & Diagnostics Pte Ltd (BSD)	Ping Quen	Yong
Caisse des Depots/UNEP FI Property Working Group	Blaise	DesBordes
Carbon Disclosure Project (CDP)	Paul	Dickinson
Carbon Disclosure Project (CDP)	Sylvie	Giscaro
Carbon Trust	Tom	Delay
Carnegie Mellon University	Vivian	Loftness
Central European University (CEU)	Diana	Urge-Vorsatz
Centre for Building Performance and Diagnostics, School of Architecture, Carnegie Mellon University	Azizan	Aziz
Centre for Building Performance and Diagnostics, School of Architecture, Carnegie Mellon University	Volker	Hartkopf
Centre for Sustainable Construction & Tall Buildings, Institute Sultan Iskandar, Universiti Teknologi Malaysia;	Faridah	Shafii
China Green Building Committee	Xun	Li
China Green Building Committee	Yanqing	Zou
China Green Building Committee	Youwei	Wang
City Developments Ltd (CDL)	Allen	Ang
City Developments Ltd (CDL)	Boon Bee	Chua
City Developments Ltd (CDL)	Esther	An
City of Malmo	Roland	Zinkernagel

Clinton Climate Initiative (CCI)	Nathaniel	Manning
Commonwealth Scientific and Industrial Research Organization (CSIRO)	Greg	Foliente
Commonwealth Scientific and Industrial Research Organization (CSIRO)	Selwyn	Tucker
Commonwealth Scientific and Industrial Research Organization (CSIRO)	Seongwon	Seo
Cornell University, USA	Ying	Hua
Council for Built Environment	Nana	Mhlongo
CPG Consultants Pte Ltd	Shao Yen	Tan
Deutsche Gesellschaft für Nachhaltiges Bauen e.V (DGNB) German Sustainable Building Council	Christian	Donath
Deutsche Gesellschaft für Nachhaltiges Bauen e.V (DGNB) German Sustainable Building Council	Eva	Schmincke
Diamond and Schmitt Architects Inc.	Shenshu	Zhang
DP Architects Pte Ltd	Lee Siang	Tai
Environmental Resources Management Limited	Peter	Rawlings
EURAC Research - UNESCO Chair Project	Silke	A. Krawietz
FCAV	José Joaquim	do Amaral Ferreira
GDF Suez	Alexandre	Jeandel
Global Reporting Initiative (GRI)	Katherine	Miles
Green Building Council of Australia (GBCA)	Andrew	Aitken
Green Building Council of Australia (GBCA)	Romilly	Madew
Green Dot Consulting Pte Ltd	Eng Hock	Guah
Haute Qualité Environnementale (HQE)	Anne-Sophie	Perrissin-Fabert
ICLEI Local Governments for Sustainability	Andrea	Nuesse
ICLEI Local Governments for Sustainability	Yunus	Arikan
Institute Stuttgart	Hans	Erhorn
Integral Group (The)	Kevin	R. Hydes
International Code Council (ICC) Inc., USA	Darren	B. Meyers
International Code Council (ICC) Inc., USA	Drew	Azzara
International Council for Research and Innovation in Building & Construction (CIB)	Bill	Porteous
International Council for Research and Innovation in Building & Construction (CIB)	Faridah	Shafii
International Energy Agency (IEA)	Jens	Laustsen
International Institute for a Sustainable Built Environ-ment (iiSBE)	Nils	Larsson
ITC-CNR	Italo	Meroni
Jones Lang LaSalle	Chris	Wallbank
Jones Lang LaSalle	Jonny	McCaig
Jones Lang LaSalle	Franz	Jenowein

Jones Lang LaSalle	Rob	Greenoak
Karan Grover & Associates, architects, planners & interior designers	Karan	Grover
Marrakech Task Force on Sustainable Buildings and Construction (SBC)	Kaarin	Taipale
Organization for Economic Cooperation and Development (OECD)	Michael	Donovan
Organization for Economic Cooperation and Development (OECD)	Tadashi	Matsumoto
Pan-United Concrete Ptd Ltd	Alvin	Chan
Pan-United Concrete Ptd Ltd	Wai Mun	Chan
Perkins + Will	Russell	Drinker
Plastedil, SA	Jean-Louis	Chardenet
Queensland University of Technology	Jay	Yang
RSP Architects Planners & Engineers (PTE) Ltd.	Wynn Chi-Nguyen	Cam
Saint-Gobain	Fredrik	Jensen
Saint-Gobain	Pierre	Delayen
Singapore Economic Development Board (EDB)	Teck Yong	Lim
SOMFY	Serge	Neuman
SQUIRE MECH PTELTD	Eng Kiong	Ng
SRG Bangladesh Limited (SRGB)	Saidul	Haq
Sustainable Energy Partnerships	Adam	Hinge
TERAO Sarl	Michel	Raoust
Terra Virdis Partnership Limited	Swati	Puchalapalli
The Energy Resources Institute (TERI)	Priyanka	Kochhar
UK Green Building Council & World Green Building Council	Joanne	Wheeler
UNEP DTIE	Donna	McIntire
UNEP DTIE	Tatiana	de Feraudy
UNEP DTIE SBCI	Inhee	Chung
UNEP DTIE- Sustainable Consumption and Production Branch	Arab	Hoballah
UNEP DTIE- Sustainable United Nations Unit	Niclas	Svenningsen
UNEP FI (Finance Initiative) Property Investment Working Group	Paul	McNamara
UNEP- Ozonaction	Thanavat	Junchaya
UNEP Risoe Centre on Energy, Climate and Sustainable Development (URC)	Chia Chin	Cheng
UNEP/SETAC Life Cycle Initiative	Sonia	Valdivia
UNEP-Sustainable Buildings and Climate Initiative	Peter	Graham
UNFCCC	Grant	Kirkman
United Kingdom - Green Building Council (UK-GBC)	Joanne	Wheeler

United Kingdom - Green Building Council (UK-GBC)	Paul	King
United Kingdom - Green Building Council (UK-GBC)	Sarah	Jeffcote
University of Catania,Italy	Silke	Krawietz
Utsunomiya University	Nori	Yoko
VTT	Pekka	Huovila
VTT Materials and Construction	Tarja	Häkkinen
WBCSD- Energy Efficiency in Buildings (EEB)	Christian	Kornevall
World Bank	Daniel	Hoornweg
World Business Council for Sustainable Development (WBCSD)	Bjorn	Stigson
World Business Council for Sustainable Development (WBCSD)	Christian	Kornevall
World Economic Forum	Carlos	Schnapp
World Economic Forum	Darren	Wachtler
Zerofootprint Inc.	Robert	Ouellette

About the World Resources Institute (WRI)

WRI is an independent environmental think tank that goes beyond research to find practical ways to protect the earth and improve people's lives. Our mission is to move human society to live in ways that protect Earth's environment and its capacity to provide for the needs and aspirations of current and future generations. We organize our work around four key programmatic goals: Climate Protection, Governance, Markets & Enterprise, and People & Ecosystems. A fifth goal—institutional excellence—supports and enhances WRI's ability to achieve results.

WORLD RESOURCES INSTITUTE

The GHG Protocol Initiative is a joint partnership between WRI and the World Business Council on Sustainable Development that provides publications and tools to understand, quantify and manage greenhouse gas emissions. These standards serve as the foundation for nearly every GHG accounting and reporting program in the world—from the International Standards Organization to The Climate Registry—as well as hundreds of GHG inventories prepared by individual companies. The GHG Protocol is working with businesses, governments and environmental groups around the world to build a new generation of credible and effective programs for tackling climate change.

For more information, see www.wri.org

About the Sustainable Buildings and Climate Initiative

Launched in 2006 by the United Nations Environment Program (UNEP), the Sustainable Buildings and Climate Initiative (SBCI), formerly the Sustainable Buildings and Construction Initiative, is a partnership between the private sector, government, non-government and research organizations formed to promote sustainable building and construction globally.

UNEP SBCI
Sustainable Buildings & Climate Initiative

SBCI harnesses UNEP's unique capacity to provide a convening and 'harmonizing' role to present a common voice from the building sector on climate change issues. More specifically UNEP-SBCI aims to:

1. Provide a common platform for and with all building and construction stakeholders to collectively address sustainability issues such as climate change;
2. Establish globally consistent climate-related building performance baselines and metrics for monitoring and reporting practices based on a life cycle approach;
3. Develop tools and strategies for achieving a wide acceptance and adoption of sustainable building practices throughout the world;
4. Implementation - Promote adoption of the above tools & strategies by key stakeholders.

For more information,
see **www.unepsbci.org**

UNEP

SBCI Members

EXPO 2010 SHANGHAI CHINA
BROAD 远大
Global Partner of Expo 2010 Shanghai China
中国2010年上海世博会全球合作伙伴

CONSELHO BRASILEIRO DE CONSTRUÇÃO SUSTENTÁVEL

FIDIC

HYDRO

LAFARGE

Lend Lease

U.S. GREEN BUILDING COUNCIL USGBC

ADEME
French Environment & Energy Management Agency

ArcelorMittal

Bayer MaterialScience

BLUE

BQDRI
BARWA & QATARI DIAR RESEARCH INSTITUTE

Building and Construction Authority

Canada Wood
Produits de bois canadien

CBE

CEMEX

cidb
development through partnership

EHS

madrid
Área de Gobierno de Urbanismo y Vivienda
emvs

ITC Limited

MONPLAISIR GROUPE

NRDC
The Earth's Best Defense

PLASTBAU

PREFEITURA DE SÃO PAULO
SECRETARIA DO VERDE E DO MEIO AMBIENTE

PROPERTY COUNCIL of Australia

REALpac
Real Property Association of Canada
Association des biens immobiliers du Canada

Resilience

RESNET
Setting the Standards for Quality

SAINT-GOBAIN

Sika

中興工程顧問股份有限公司
SINOTECH ENGINEERING CONSULTANTS, LTD.

SKANSKA

Sustainable Building Alliance

worldsteel ASSOCIATION

WORLD GREEN BUILDING COUNCIL