GN3 Study of Environmental Impact Inventory of Greenhouse Gas Emissions and Removals – HEAnet

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1 Introduction

1.1 Background

IN 2009, HEAnet adopted an environmental policy, as part of its strategy for the period to 2013. In this, the company committed to best environmental practice and to promote appropriate networking technology as an alternative to practices which act as large GHG sources, and to observe prudence in our use of resources, reduce wastage as far as economically possible, and monitor and review progress periodically. This involved taking stock of our current impact on the environment.

In addition, HEAnet is taking part in the GN3 pan-European network project. One of the tasks it has committed resources to is GN3-NA3-Task 5, the main objective of which is to conduct a green audit of the GÉANT network. HEAnet will also audit its own network as part of this exercise; this coincides with the company objective to measure its current carbon footprint. This document is the output of that audit.

There are many measures used in calculating and reporting on green audits. In order to establish metrics which can be validated, and which can be replicated at different times and in different organisations, it is important to adhere to recognised standards. In this instance, the ISO standard is the set of documents under ISO 14064 [ISO14064-1, ISO14064-2, ISO14064-3]. These documents are used to guide the form and content of the inventory process.

1.2 HEAnet: Purpose and Profile

HEAnet Limited is a not-for-profit company, incorporated in Ireland in 1997. It was founded to provide network and ancillary services to the Irish education and research communities. Its clientele is restricted to publicly-funded education and research institutes, and some closely associated bodies, such as the Higher Education Authority and the Central Applications Office, both statutory bodies. In total, there are 55 client institutions. HEAnet also provides backbone connections and Internet transit for the schools network, which comprises almost 4,000 primary and post-primary schools throughout Ireland.

The company provides national, regional and local networking services by means of an infrastructure which spans the country. This comprises over 2000 km of fibre optic transmission medium, together with optical, switching and routing equipment.

2 Inventory Design and Development

2.1 Organisational Boundaries

HEAnet and its network services comprise several separate facilities, some owned and controlled by the organisation, others shared with separate organisations. The GHG emissions of HEAnet are consolidated into four categories, and each is measured in a controlled and documented manner. In this way, HEAnet will account for all GHG emissions and removals from facilities over which it has financial and operational control.

2.2 Responsible Party

The inventory is carried out by HEAnet's Environmental working group, made up of the following personnel:

- Katie Harris.
- Daniel Lete.
- Andrew Mackarel.
- Will McDermott.
- Mike Norris.
- Louis Twomey.

All are HEAnet staff. The group leader is Mike Norris mike.norris@heanet.ie, tel +353.1.6609040.

2.3 Reporting Period Covered

The period covered by this inventory is the year from July 2008 to June 2009, both inclusive.

2.4 Base Years

This is the first GHG inventory for HEAnet, covering the year July 2008 to June 2009. This period will serve as historical base year as well as base year for this inventory.

2.5 Base Year Changes and Recalculations

This section explains any change to the base year or other historical GHG data, and any recalculation of the base year or other historical GHG inventory.

All facilities and equipment in use by HEAnet and responsible for indirect GHG emissions is detailed in the company's asset database and internal documentation. Documentation describing the asset database and how it is administered is maintained on the company's wiki, and the first page is shown in the attached file "ResourceDatabase–HEAnetWiki.html" The asset database gives details of each item of equipment, including its type, its manufacturer, model number, physical location, service status etc. The purpose of the asset database, besides serving as authoritative source of information for the GHG emissions report, is to be the central repository to record company assets. It is company policy to keep the database updated with new acquisitions, disposals and movement of equipment. By having this company policy in relation to the asset database, the accuracy of the information used for the purpose of the GHG emission report is ensured.

ResourceDatabase-HEAnetWiki.html (ResourceDatabase-HEAnetWiki.html.HTM)

2.6 GHG Emissions and Removals

2.6.1 Direct GHG Emissions for Each GHG

The GHGs are:

- Carbon dioxide (CO_2).
- Methane (CH_4).
- Nitrous Oxide (N_2O).
- Hydrofluorocarbons (HFCs).
- Perfluorocarbons (PFCs).
- Sulphur Hexafluoride (SF_6).

HEAnet does not own any car or other form of motorised transport or any source of direct emission of the GHGs listed.

HEAnet uses commercial facilities at Blanchardstown, City West, Kilcarbery and Park West. Network and ancillary equipment at these locations is powered by electricity provided by the ESB (Electricity Supply Board) to the companies which run the facilities. These companies operate diesel generators as a backup to the mains electricity, and their operation is tested on a regular basis, usually once a month.

During the period of the inventory, there was no reported recourse to the generators for emergency cover. They were used, instead of the mains electricity, only for brief scheduled test periods.

We have not accounted for this mimimal usage and emission. Any such direct emission by the diesel generators would in any event replace a corresponding amount of indirect emission due to the mains electricity.

So the value for direct CO_2 emission is 0 tons.

2.6.2 GHG Removals

HEAnet is not responsible for any GHG removals.

2.6.3 Energy-Indirect GHG Emissions

HEAnet quantifies all indirect GHG emissions from the generation of imported electricity, heat or steam consumed by the organisation in Section below.

2.6.4 Other Indirect GHG Emissions

Transport is a necessary feature of the activities of HEAnet staff. In commuting and for “on mission” duties, staff must travel. HEAnet does not own any of the transportation vehicles in such transport, so GHG emissions arising from transport are listed as other indirect emissions.Direct CO2 Emissions from the Combustion of Biomass

HEAnet is not responsible for any combustion of biomass, hence its emissions from this quarter are 0 tons of CO_2.

3 Energy-Indirect GHG Emissions – Methodology

This section covers the methodology use to quantify energy-indirect GHG emissions, by sector, within HEAnet boundaries.

3.1 Quantification Methodologies

In this inventory, only recurrent emissions are considered. The embedded energy and consequent GHG emissions from building and production of facilities and equipment are not included. HEAnet does not produce any GHGs by direct emission. Indirect emissions are calculated from activities in four main areas:

The office: the leased premises at 5 George's Dock, Dublin 1, which serves as the company's sole premises and where all staff are employed.

Data centres: space is rented by HEAnet at two commercial facilities for the location and interconnection of data services on behalf of our clients.

Transport: this comprises transport undertaken by HEAnet staff in commuting to and from work ("commuting"), and travel necessarily incurred as part of their work ("on mission").

Backbone: the backbone network comprising its two main facilities, or PoPs (points of presence), and CPE (customer premises equipment) managed by HEAnet. HEAnet also operates a network for schools, which shares the same facilities. This will be accounted for separately under the backbone category.

In the case of facilities rented from other parties, HEAnet accounts for its share of GHG emissions. In each case, HEAnet has referred to the owner of the facility to determine the method of consolidation of GHG emissions to be used by all organisations that use that facility.

3.2 Reasons for Selection of Inventory Sectors

The four sectors were selected so as to facilitate the allocation of the inventory task to all members of the Environment Working Group, in a fair and sensible manner. The sectors chosen are distinct (with no overlap between them) and comprehensive (no omissions from the GHG profile of the organisation). Within each sector, consistent and reproducible methods of quantifying GHG emissions are described below.

3.3 Methodology Changes

This section explains any change to quantification methodologies previously used.

Not applicable.

3.4 GHG Emission or Removal Factors Used

This section provides reference to, or documentation of, GHG emission or removal factors used.

Indirect GHG emissions need to be calculated from the amount of energy used (measured in kilowatt-hour, kWh) and a conversion factor. Such factors depend on the method of generation of the power used. In this inventory, a conversion factor is used that is derived from a weighted average of the modes of electricity generation; these include fossil fuel combustion (oil, coal, peat and gas), hydroelectric, wind power, and pumped storage. The source for the values is the "Change CMT Calculator: Emission Factor Sources" [ChangeCMTCalc], published by the Environmental Protection Agency (EPA).

This document also provides conversion factors for various forms of transport, in the form of the mass of CO_2 emitted per kilometre travelled or, in the case of airplane flights, emissions for domestic, short haul and long flights.

The sources from which these factors were derived, and the dates, are given in the "Change CMT Calculator" document. Inevitably, some uncertainty attaches to these values, as they can change over time, and vary within categories e.g. GHG emissions from motor vehicles. The conversion factor for electricity, for instance, is based on a mix of generation technologies and a range of transmission losses; the value used in this audit is based on a report of the Commission on Energy Regulation published in 2007. By using the most recent official summary of the various conversion factors, it is felt that such uncertainties are minimised, within the resources and the time available to carry out the audit.

Since the audit was completed, the Commission on Energy Regulation has published (February 2010) a report with the latest value for the electricity emission factor. The value given is 533 g/kWh. This compares with the previous value of 538g/kWh, as used in this report, and shows that such emission factors can vary, though not substantially, over a period of a few years.

3.5 Impact of Uncertainties on the Accuracy of the Data

This section describes the impact of uncertainties on the accuracy of the GHG emissions and removals data.

HEAnet has just started, in 2009, to measure and report on GHG emissions. The approach is to begin with the simplest methods available, which include invoiced amounts of power consumed, systematic sampling and projection, and reference to equipment specifications. Having reported through this baseline inventory and having engaged senior management in the process of implementing the environmental policy of the organisation, more accurate procedures and systems to measure energy consumed will be used.

Nonetheless, the methodologies used in conducting this inventory have been discussed and agreed by the team responsible. We believe that they give a reasonably accurate indication of the level of GHG emissions by the organisation in the reporting period.

3.6 Compliance Statement

This section confirms that the GHG report has been prepared in accordance with the appropriate part of ISO 14064.

This GHG inventory has been prepared in accordance with ISO 14064-1.

3.7 Verification Statement

This section describes whether the GHG inventory, report or assertion has been verified, including the type.

This report will be submitted for independent validation. As this is the first such exercise carried out by HEAnet, we will seek limited assurance that the report is in accordance with ISO 14064.

4 Energy-Indirect GHG Emissions – Data

4.1 The Office

4.1.1 Facilities

The HEAnet office comprises the 1st Floor at 5 George's Dock, IFSC, Dublin 1. All HEAnet staff work in this office. There are 45 employees, 44 full time equivalents.

4.1.2 Exclusions

Four members of senior management sometimes work from home, using broadband data and voice connections to simulate the office environment. Indirect emissions so incurred are not taken into account, nor is the reduction in emissions due to mechanised transport.

4.1.3 Sample

A sample bill [SampleElecBill] and a summary of the calculations [SampleElecBillCalcs]are shown here.


ESB Bill.pdf


ESB Bill Calculations.pdf

4.1.4 Measurement Method

All GHG emissions are indirect, resulting from the consumption of electricity for power, lighting, heating and cooling. Electricity is supplied by the Electricity Supply Board (ESB). The ESB billing periods do not correspond to yearly quarters or monthly periods. We calculate the average number of units used per day of billing period and multiply by number of days that fall into the quarter being assessed. We add all relevant portions of ESB bills together to arrive at the quarterly amount. The unit used by the ESB is the kilowatt hour: 1 unit = 1 kWh.

4.2 Data Centres

4.2.1 Facilities

The two facilities used as data centres by HEAnet are all located in the greater Dublin area and are:

- Blanchardstown: Waspar facility at Blanchardstown, Co. Dublin.
- Park West: Interxion facility at Park West, Dublin 12.

4.2.2 Exclusions

The figure for the Blanchardstown data centre excludes the substantial usage of super-computing equipment, which is hosted by HEAnet on behalf of a client institution. The equipment in question is owned and operated by the client, and its GHG emissions are attributable to the client rather than to HEAnet. There are no other exclusions either of facilities or of relevant contributors to indirect GHG emissions in the listed facilities.

The two facilities of section 4.2.1 also host equipment classified under section 4.4, the figures provided in this section 4.2 do not include consumption for those devices. The approach taken has been to calculate the overall consumption of the facilities and extract from them the consumption of the Schools Network.

4.2.3 Sample

Sample invoices with metered power consumption for each of the data centres are attached.


blanch-pop-invoice.pdf


parkwest-pop-invoice-feb09-may09.pdf

4.2.4 Measurement Method

The following measurement methods were used in each facility:

- Blanchardstown: measurement based on actual meter readings
- Park West: measurement based on meter readings for some months, and estimates for un-metered months

Summaries of the measurements and details of the calculations are given in the attached spreadsheet, data-centres-usage.xlsx


data-centres-usage.xlsx

Each of the facilities has an associated PUE, which value has been provided by the management company in charge of the facilities themselves.

4.3 Backbone Network, Third Level

4.3.1 Facilities

The “backbone” has two facilities, Citywest (operated by Esat-X/BT) and Kilcarbery Park (operated by Data Electronics Group). These are generically known as PoPs (for points of presence). There are several other PoPs, located at client premises in locations around the country. These are used to house network equipment (switches and routers) to facilitate connections to local clients. Finally, there are trunk circuits or links interconnecting the PoPs in a resilient mesh. Equipment is needed on these links to generate and sustain the optical signals which transmit data over the network.

4.3.2 Exclusions

The backbone facilities also record consumption for HEAnet partners JANET and DANTE equipment hosted in them. The measurement in the facilities is comprehensive; any device located in there is being measured under this section and will have been removed from any other section.

4.3.3 Sample

Included are a historical record of measurements in the facility Citywest [SampleBBNConsumption] and mapping of equipment models to power consumption [SampleElecConsumption].


BBN_equipment_consumption.xls


CWT_consumption.doc

4.3.4 Measurement Method

PoP routers or facilities: For these two physical locations the provider of the facilities gives either monthly invoices (that is the case of Kilcarbery Park) or reports (that is the case of Citywest) detailing the amount of electricity consumed by the devices that HEAnet hosts in them. The values of the report under the PoP section of the backbone represent then the total amount of electricity consumed by any device hosted in those facilities.

In each of the two facilities the provider companies have provided the PUE of the site (1.7 in the case of Citywest and 2.2 in the case of Kilcarbery Park) but only one of them has been used, to simplify the calculation. The method hence has been to gather the total electricity consumption for each of the two locations based on the consumption reported by the facilities provider in the form of a report (CWT) or invoices and add them; the resulting figure has then been multiplied by the PUE of one of the sites. Note that the location "Citywest" contains equipment from the section "schools". The figure used in this section of the report for the location Citywest is the result of subtracting the calculated value of Schools in this location from that of the reports provided by the provider of the facility.

Other routers & switches: These devices are distributed in numerous physical locations (different from the ones listed in the PoP section) across the country and HEAnet does not control the facilities nor has equipment to take direct measurements of power consumption. On the other hand, HEAnet does have an accurate inventory of what equipment in this category is being used in any of the locations; see section 2.5 above. The approach taken in this section has been to:

- Take direct measurements of one sample device of each type. These measurements have recorded the Amperes used by a device during 2 one minute periods using an Ampmeter with a 6% margin of error (600 A AC/DC True-rms Clamp Meter from the manufacturer Fluke). Each of the Amperes values is converted to Kw using a constant voltage of 220 Volts.
- Create a table containing the reference routers and switches models used in the network recording the part number of the manufacturer and the electricity consumed (value in previous point).
- Query HEAnet database containing detailed information about location of devices and their part numbers.
- For each of the reference models, add the reference consumption measurement as many times as devices of that type are recorded in the database. Exclude from this formula devices located in the locations described in the POP section and those not in production (for example spares).
- Add the subtotal for each model, obtaining a total Kw for all the devices of all the models
- Multiply the total by a PUE of 2. The value of PUE has been determined to be 2 as a result of querying all the facilities where HEAnet host devices and are able to provide that value. From that collection of values, the number 2 is the average.
- Obtain the Kwh by multiplying the previous value by 24 (hours in one day) and then 365 (days in one year).

Links: Follow the same method as in "Other routers and switches" except that when querying the database we do so only regarding part numbers of devices under this category.

4.4 Backbone Network, Schools Network

4.4.1 Facilities

All elements of the schools network were included in the audit of GHG emissions. The schools network is a geographically diverse network topology with footprints in two data centres and 2 PoPs (points of presence) and approximately 3370 CPE (Client Premises Equipment), located in primary and post primary schools throughout the country.

The four facilities or PoPs used by the schools network are all located in the greater Dubin area and are:

- ServeCentric: Blanchardstown, Co. Dublin
- Interxion: Park West, Dublin 12
- DEG: Kilcarbery Park, Co. Dublin
- Citywest: City West, Co. Dublin

4.4.2 Exclusions

This was a comprehensive audit and no elements of the schools network were excluded from the audit.

4.4.3 Sample

The schools network equipment in each of the facilities is listed in the attached document [SampleSchools]. The CPE devices at each school are also listed. Samples of different measurement techniques of power consumption are given at the end of the document.


SchoolsEquipment

4.4.4 Measurement Method

Measurement of the distributed elements of the schools network was a combination of actual measurement from the device, assumed measurement factoring in the load of the device taken from our network accessible PDUs (power distribution units) and prescribed power usage figures provided by the manufacturer.

Where possible, actual power measurement of the devices was used; however, in certain circumstances, where actual power usage values were unavailable, due to MIB unavailability on the device for example, the manufacturer-provided power usage value was used to calculate the overall figure. This was kept to a minimum, as the aim was to arrive at a realistic figure for the Schools Network.

One limitation of our PDUs is that we are unable to measure on a per-socket basis. Instead we can only get the total power usage for the whole PDU bank, and from that we must extrapolate the power values for devices. Although a limitation, it also gives us the ability to sanity check the power values presented by manufacturers for their devices, against the actual power usage that we observe.

The attached spreadsheet [Infrastructure-Calculations.xlsx] lists all schools equipment per facility, as in the SchoolsEquipment list, and shows how the power and the energy used is calculated in each case.


Infrastructure-Calculations.xlsx

5 Other Indirect GHG Emissions – Data

5.1 Other indirect emissions

Transport is necessitated for HEAnet staff in commuting to and from work, and in the normal course of work. Transport "on mission", for instance, is involved in attending meetings with clients, or in carrying out on-site maintenance at a network PoP. Such travel involves the use of transport which consumes fuel and so, either directly or indirectly, is responsible for GHG emissions. None of the vehicles involved belongs to the company, so these emissions are categorised as "other indirect".

The sources of these emissions arise from the following sources:

Gasoline and diesel fuel: used by private cars, motorbikes, taxis, buses, and trains

Aviation fuel: used by aircraft for air travel

Electricity: used by trains and trams (and generated by a mix of technologies represented in the relevant conversion factor – see Section 3.4)

5.2 Transport

5.2.1 Scope of Transport

In this section, GHG emissions due to forms of transport are considered in two categories, concerning all employees of HEAnet: commuting to and from work, and travel "on mission" as part of one's duties to HEAnet.

5.2.2 Exclusions

There are no exclusions from either category of transport.

5.2.3 Sample

The attached file [SampleTravel] contains samples of summaries of travel by employees in connection with their work – "on mission" travel.


SampleTravel

5.2.4 Measurement Method

For transport associated with commuting to and from work, a log is kept of the area where each employee lives. The approximate distance for each staff member's daily journey is taken from http://www.aarouteplanner.ie and categorised by walk/cycle, train, Luas (Dublin's light rail tram system), bus, motorbike, taxi, car. We assume that each employee completes a round-trip on the days they commute to the office. We assume 60 working days per quarter. (5 working days per week x 52 weeks – 20 days annual leave = 240 working days per year. 240 days / 4 = 60 days per quarter). Daily kilometres per category are calculated and are multiplied by 60 days to get the quarterly figure. These are multiplied by four to give the total for each category in the measurement year.

In the case of transport used while on mission:

Flights: a log is kept of all flights taken by staff for travel to and from meetings, conferences etc. The approximate distance of each flight is calculated from http://www.webflyer.com. The distances of all flights per quarter added to arrive at quarterly figure. This is repeated for each of the four quarters in the measurement period of one year.

Trains: a log is kept of all trains taken by staff for travel to and from meetings, conferences etc. The approximate distance of trains is calculated from http://www.aarouteplanner.ie. The distances of all train journeys per quarter are added to arrive at the quarterly figure. This is repeated for each of the four quarters in the measurement period of one year.

Taxis: a sample of 3 journeys per month is taken at random from our monthly invoice from National Radio Cabs. (All taxi journeys take place within the city centre so journeys would occur over similar distances). The approximate distance of journeys is taken from http://www.aarouteplanner.ie. The average distance for the 3 sample journeys is calculated. This average journey distance is multiplied by number of journeys in month. This is repeated for three months to get the quarterly figure. The figures for each of the four quarters are added to give the total for the measurement period of one year.

6 Summary of GHG Emissions within HEAnet Boundaries

The results from all sectors are shown in Table 6.1. All conversion factors are taken from "Change CMT Calculator Emission Factor Sources" [ChangeCMTCalc]. The live spreadsheet, showing the calculations, is attached as [GHG-Audit-HEAnet-Full]

The final figure for GHG emissions by HEAnet Ltd in the year July 2008 to June 2009, both inclusive, is **1765 tons of CO_2 equivalent**.

GHGH-Audit-HEAnet-Full

HEAnet: GHG Audit

July 2008 - June 2009

							CO2 factor (g/kWh)	Total (tons CO2)
Office								
	Office space (m2)	Total employees	Full time equivalent					
	948	45	44					
Electricity (kWh)	228902						538	123
Data centres								
	Blanchardstown	Park West						
Equipment (kWh)	496015	20958					538	540
PUE factor	1.94	2						
Transportation at work								
Commuting	Walk/cycle	Train/tram	Bus	Motorbike	Taxi	Car		
Number of Staff	14	19	5	2	0	4		
(km)	41112	192432	35721	4560	0	71520		
CO2 factor (g CO2/km)	0	44.3	77	93.9	161.3	155		
CO2/year (kg)	0	8525	2751	428	0	11086		23
On mission	Flight	Train/tram	Bus	Motorbike	Taxi	Car		
(km)	176092	2386	0	0	2635	0		
CO2 factor (g CO2/km)	110	44.3	77	93.9	161.3	155		
CO2/year (kg)	19370	106	0	0	425	0		20
Backbone								
	PoP routers	Other routers & switches	Links					
kWh	233178	440404	106960				538	697
	1.7	1.7	1.4					
Schools Network								
	Blanchardstown	Park West	Kilcarbery	City West	Schools			
kWh	110691	1110	2720	21234	416389		538	363
PUE factor	1.94	2	1.7	1.7	1			
Total CO2								**1765**

Table 6.1: Summary of GHG emissions from all sectors

7 Ancillary Results

In parallel with carrying out the inventory of GHG emissions, the environmental working group developed an environmental policy for HEAnet. This has been discussed within the organisation and approved by senior management.

In the course of the inventory, several uncertainties in quantifying GHG emissions were encountered. In such cases, more accurate means of monitoring and measuring have been identified and will be taken into account in operational and environmental policies.

Several potentials for reducing GHG emissions emerged during the measurement process in the four sectors. These have been documented for further investigation and implementation as appropriate.

HEAnet is also actively investigating the use of renewable energy – specifically, wind power and solar power – as sources of energy for its facilities.

Appendix A GHG Global Warming Potentials

(informative)

Table A.1 below provides various global warming potentials (GWPs) for a 100-year time horizon published by the Intergovernmental Panel on Climate Change (IPCC) in their 1996 reporting guidelines for national GHG gas inventories.

Gas	Chemical Formula	Global Warming Potential
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Hydrofluorocarbons (HFCs)		
HFC-23	CHF_3	11700
HFC-32	CH_2F_3	650
HFC-41	CH_3F	150
HFC-43-10mee	$C_5H_2F_{10}$	1300
HFC-125	C_2HF_5	2800
HFC-134	$C_2H_2F_4$ (CHF_2CHF_2)	1000
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1300
HFC-143	$C_2H_3F_3$ (CHF_2CH_2F)	300
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3800

Gas	Chemical Formula	Global Warming Potential
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
HFC-227ea	C_3HF_7	2900
HFC-236fa	$C_3H_2F_6$	6300
HFC-245ca	$C_3H_3F_5$	560
Hydrofluoroethers (HFEs)		
HFE-7100	C_4F9OCH_3	500
HFE-7200	$C_4F9OC_2H_5$	100
Perfluorocarbons (PFCs)		
Perfluoromethane(tetrafluoromethane)	CF_4	6500
Perfluoroethane(hexafluoroethane)	C_2F_6	9200
Perfluoropropane	C_3F_8	7000
Perfluorobutane	C_4F_{10}	7000
Perfluorocyclobutane	c-C_4F_8	8700
Perfluoropenane	C_5F1_2	7500
Perfluorohexane	C_6F1_4	7400
Sulphur hexafluoride	SF_6	23900

Table A.1: GHG global warming potentials

Adobe Acrobat Document

[ChangeCMTCalc]

References

[ChangeCMTCalc]	"Change CMT Calculator: Emission Factor Sources" http://cmt.epa.ie/Global/CMT/emission_factor_sources.pdf
[GGP]	"Green GÉANT Plan" v0.2 12/03/2009 <insert rest of URL> Green-Geant-Plan.xls
[ISO14064-1]	ISO 14064-1:2006 "Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals" <insert URL>
[ISO14064-2]	ISO 14064-2:2006 "Greenhouse gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements" <insert URL>
[ISO14064-3]	ISO 14064-3:2006 "Greenhouse gases – Part 3: Specification with guidance for the validation and verification of greenhouse gas assertions" <insert URL>
[SampleBBNConsump]	Embedded in this document
[SampleElecConsump]	Embedded in this document
[SampleElecBill]	Embedded in this document
[SampleElecBillCalcs]	Embedded in this document
[SamplePoPInvoice]	Embedded in this document
[SampleSchools]	Embedded in this document
[SampleTravel]	Embedded in this document

Glossary

CH_4	Methane
CO_2	Carbon dioxide
CPE	Customer Premises Equipment
EPA	Environmental Protection Agency
ESB	Electricity Supply Board
GHG	Greenhouse gas
GWP	Global Warming Potentials
HFC	Hydrofluorocarbon
HFE	Hydrofluoroether
IPCC	Intergovernmental Panel on Climate Change
kWh	kilowatt-hour
N_2O	Nitrous Oxide
PDU	Power Distribution Unit
PFC	Perfluorocarbon
PoP	Point of Presence
SF_6	Sulphur hexafluoride