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Deliverable DN3.5.1: Study of Environmental Impact

Energy Audit of the GÉANT Backbone Services

Deliverable DN3.5.1

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Abstract

This document defines the common approach taken by all GN3 partners to conducting environmental (greenhouse gas) audits, in compliance with the ISO 14064 standard, and includes the audit of the GÉANT network.

Table of Contents

Table of Figures

Table of Tables

Executive Summary

GN3 Network Activity 3 (Status and Trends) Task 5 (Study of Environmental Impact) has several objectives. The first of these is to produce an environmental audit for each of the national and regional networks of the partners and of the GÉANT network itself. Each audit is carried out and documented in compliance with the ISO 14064 standard. This document defines the common approach taken by all GN3 partners to the audit process, and includes the audit of GÉANT as a contractual deliverable.

The first section introduces the Task within the context of the overall GN3 project and details the partners and the networks they are auditing. At the outset, the team took three key decisions:

- They themselves would carry out the audits and would produce the corresponding reports.
- They would use the ISO 14064 standard to provide the necessary context and discipline.
- They would seek validation of the audits from a qualified external body.

In the second section, the steps involved in conducting the audits are outlined. These include a study of the ISO 14064 standard, and training in its use to measure greenhouse gas (GHG) emissions. Next, the team agreed on a common categorisation of National Research and Education Network (NREN) and GÉANT components for the purpose of the GHG audits; these components are: office, data centres, backbone network and transport. The team also produced a measurement template as a tool for recording data and calculating results. The team also agreed guidelines on organisational and operational boundaries, and also on exclusions, which would be explicitly reported as such in the audits.

In conclusion, the findings are that the collective approach to the Task added value to the audit exercise. By adhering to an international standard such as ISO 14064, the audit results can be asserted and compared with those of other networks, and with results over time. The model used to categorise the components of an NREN, or of a regional or pan-European network in the case of NORDUnet and GÉANT respectively, proved to be a reasonably good fit across a range of research and education networks – national, regional and continental. The common template used to record and calculate measurements was also universally applicable and saved a lot of time and effort. Finally, the concept of external validation is a very useful one, and can add value to the audits by providing an independent critical review, and a corrective to any errors and omissions.

1 Introduction

As part of the pan-European GN3 network project, Network Activity 3 (Status and Trends) Task 5 (Study of Environmental Impact) (NA3 T5) has been assigned to conduct green audits of the GÉANT network and the National Research and Education Networks (NRENs) of the Task partners. This document describes the standards and methodologies used to carry out the audits, and the benefits derived from working within a common framework, sharing ideas and resources. It also presents the carbon audit of the GÉANT network.

1.1 Scope of the Network Audits

Table 1.1 summarises the networks on which greenhouse gas (GHG) audits were conducted, and the responsible GN3 members. The audits are available on the GN3 Intranet (see [GHGAudits]) and will be published on the GN3 website in due course.

Network	Type of Research and Education Network	Responsible Partner
GÉANT	Pan-European (30+ countries)	DANTE, UNI-C
HEAnet	National	HEAnet
HUNGARnet	National	NIIF
NORDUnet	Regional (5 countries)	UNI-C
PIONIER	National	PSNC

Table 1.1: Networks conducting GHG audits.

1.2 Baseline Audits

Having decided on ISO 14064 as an appropriate, recognised standard by which to conduct the audits (also known as inventories) of greenhouse gas (GHG) emissions and absorptions (GHG audits), the Task team considered how best to carry out the work. One option was to specify the work in some detail and outsource the necessary measurements and research to experts. It was felt, however, that NRENs had a lot to gain from doing as much as possible of the inventory work themselves. That way, they would become familiar with all aspects of their own network from the perspective of GHG sources and sinks. They would have to measure

GHG emissions themselves. In so doing, they would be better placed to devise means of reducing emissions without adverse effect on levels of service.

The team decided to conduct the audits themselves. Within the framework of the standard, they would endeavour to use similar categories for components of their network and its organisation. They would also try to use similar templates for recording measurements, and would share information and experience in creating inventories for their networks. It was agreed, however, that the validation phase (a component of the ISO 14064 standard) would be entrusted to an independent third party. These team decisions established the foundations for the substantive work of conducting GHG audits.

2 Inventory Standards and Design

2.1 Standard Identification

Many measurements are used in calculating and reporting on green audits. To establish metrics that 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.

The ISO standard and associated sources refer collectively to the greenhouse gases. The standard lists 26 such gases, each with its own global-warming potential. The predominant gas is Carbon Dioxide, CO_2, but there are several other reasonably familiar chemicals, such as Methane (CH_4), Nitrous Oxide (N_2O), and the Hydrofluorocarbons (HFCs). As CO_2 is the largest component of GHG emissions, it is often used as the reference for all such gases. The exclusion of other GHGs does not affect the overall results significantly, as CO_2 has by far the largest share in global GHG emissions.

2.2 Training

The Task team organised a two-day training course in ISO 14064. This was presented in Dublin in June 2009 by Dr Ken Beattie, School of Mechanical Engineering, Dublin Institute of Technology. The course was attended by staff from three of the four partners. The course provided the full documentation set of ISO 14064, and was tailored to meet the needs of the partners to carry out the audit on diverse and distributed ICT equipment.

2.3 Organisational Components for the GHG Inventory

For the purposes of the GHG audits, it was agreed that a common high-level organisational model should be used to represent the research and education networks – whether national (the NRENs), regional (such as NORDUnet) or pan-European (GÉANT). A broad categorisation of the NRENs was discussed, and the following components were agreed to define the NREN for the purposes of the GHG audits:

- The office or offices of the NREN organisation.

This comprises the office space, whether owned or leased, used by an NREN to house its staff. All GHG emissions arising from the use of the office space are to be accounted for.

- Data centre power consumption.

  The data centres used by the NREN, whether owned or rented, are facilities that consume significant amounts of electrical power. In this respect, they can often be indirectly responsible for large amounts of GHG emissions arising from the primary generation of electricity, e.g. if generation by the combustion of fossil fuels is used, wholly or in part.

- Network backbone.

  This category covers all equipment managed by the NREN as part of its backbone network. It includes any dark fibre and associated equipment, and access circuits if they are dark fibre. It includes leased wavelength circuits, as for example in the case of the GÉANT network. The networking equipment includes Customer Premises Equipment (CPE) that is managed by the NREN. Whether the NREN pays for the electricity consumed by such equipment is not relevant.

- Transportation.

  This includes all transportation used by staff in carrying out their duties for the NREN. The two main categories are transportation involved in commuting to and from work, and transportation necessitated by travel for the NREN. The latter would include travel to work at off-site facilities, attendance at conferences, meetings with clients at their institutions, etc.

The four components were selected to facilitate the allocation of the inventory tasks among the requisite qualified staff in a fair and sensible manner. The components chosen are distinct (with no overlap between them) and comprehensive (no omissions from the GHG profile of the organisation). Within each component, consistent and reproducible methods of quantifying GHG emissions could be determined by each partner.

2.4 Measurement Template

A common template for recording measured data and for calculating the corresponding amounts of GHG emissions was developed by Jørgen Moth of UNI-C (see Figure 2.1). This template records the relevant data under the four main components of the NREN, and also under sub-categories, where appropriate. Under transport, for instance, there are sub-categories for commuting and for travel on company business. Under each of these, an NREN would record the distance travelled and the number of people involved in each mode of transport, such as train, bus, private car or bicycle. The template, which takes the form of an Excel spreadsheet, includes a conversion factor for that mode of transport, to convert from distance travelled to kg of GHG emitted.

The measurement template has already been shown, and used, in the first workshop organised by the team, at NORDUnet in Copenhagen in February 2010. As part of the overall Task, the team will revise and brand this template, for distribution to and use by the NREN community.

Conversion factors for items like planes, buses, private cars, motorbikes and bicycles are fairly standard and do not vary between countries. Other conversion factors (particularly between kWh of consumed electrical power and the equivalent amount of GHG emitted) can vary considerably between countries, or even within a country.

This factor is determined by the mix of methods used to generate the electricity; the more green and sustainable the technologies used (such as wind and hydroelectric power), the lower the conversion factor. Thus, the common template has to be localised for each NREN. For the regional and pan-European networks involved, NORDUnet and GÉANT,, electrical power consumption has to be measured and converted to kilograms of CO2 for each country in which the network has facilities.

NREN Climate Accounting Template						CO2 factor (g/kWh)	Total (kg CO2)
Office							
	Office space	Number of employees					
	(m2)	(total)	(full time equivalent)				
	300	25	18				
Heating/air condition (kWh/year)						113	0
Electricity (kWh/year)						429	0
Data center servers (NREN services)							
	Eduroam	Video conferencing	FTP				
Equipment (kWh/year)						429	
PUE factor							0
Transportation at work							
	Flight	Taxi	Own car	Train	Bus		
(km/year)							
CO2 factor (g CO2/km)	110	199	175	40	90		
CO2/year (kg)	0	0	0	0	0		0
Backbone							
	PoP routers	Other routers & switches	Links				
kWh/year						429	
PUE factor							0
Total CO2/year							**0**

Figure 2.1: Measurement template.

2.5 Scope and Exclusions

The ISO 14064 standard defines the scope of a GHG audit as quite comprehensive. For instance, it refers to facilities such as Points of Presence (PoPs) which are not on the NREN premises and may be shared with other parties, and it defines accounting options for the GHG emissions and absorptions of such facilities. The standard is silent, however, on the question of embodied energy. This is the energy that goes into the manufacture, marketing, delivery and ultimate disposal of products. NRENs have significant levels of such products in the form of routing and general IT equipment. Indirect GHG emissions due to the use of electrical energy in operating such equipment are of course recorded as part of the audit, but there is no requirement to factor in the embodied energy.

The team considered this, as equipment such as high-end routers and switches could have high levels of embodied energy. Some research was carried out to see whether any relevant standards existed in the area of embodied energy. While there are recognised values for the energy involved in the production of raw materials, there are no recognised standards for the production of composite products. As a result, and as the audits were baseline in nature, it was decided not to try to measure the levels of embodied energy in the networks.

2.6 Networks Audited Relative to Total Population

As previously indicated, the work is confined to the GHG audits of three NRENs, one regional Research and Education Network (REN) and a pan-European REN. The latter interconnects 37 national RENs, directly or through the NORDUnet network. In this context, the set of audited networks (5) is quite small relative to the total population of 39 (37 NRENs, NORDUnet and GÉANT). It does not pretend to be a representative sample. For that, a much larger sample size would be needed. Even then, there are several independent factors which would have to be represented in any such sample for it to be statistically significant. For instance, there is the size and makeup of the physical network, the NREN as an organisation, and the mix of technologies involved in generating the electricity used in the network.

In this sense, the absolute results of these audits, in terms of the amount of GHG emissions, should not be taken as representative, nor should they be scaled up or down relative to other NRENs. The result of each audit is sui generis, and is intended as a baseline figure for the NREN. It can be used to set targets for reductions in emissions over a specified time period. What the audits have in common are the adopted standard and the methodologies used to carry out the measurements. It is hoped that these will be of wider value in the NREN community.

2.7 Base Years

This is the first GHG inventory for the networks involved. It was felt that all should use the year spanning 2008 and 2009 as the base year (i.e. the year being reported). This period will serve as the historical base year (i.e. the historic datum, which can be a specific year or an average over multiple years, against which an organisation’s emissions are tracked over time) as well as the base year for this inventory.

2.8 Validation

As indicated above, the ISO 14064 standard involves a validation phase in GHG audits. The team agreed that for each of the networks audited, external validation would be sought. In the interests of economy and cohesion, it was decided to seek a single qualified body to conduct the validation of all five of the GHG audits. To this end, a call for proposals was carried out by the activity leader. The proposals received were evaluated against an agreed set of criteria, and FORCE Technology [FORCE] of Denmark were selected as the validators of the five network audits. They were formally contracted by TERENA [TEREN] to do the requisite work within 2010.

3 Inventory of Greenhouse Gas Emissions and Removals – GÉANT network

3.1 Introduction

3.1.1 Reporting Organisation

DANTE [DANTE] was established in 1993 in Cambridge, UK. It is a limited liability company and a "Not for Profit" organisation. It was set up, and is owned, by a group of National Research and Education Networks (NRENs). It has played a pivotal role in four consecutive generations of pan-European research networks: EuropaNET, TEN-34, TEN-155 and now GÉANT.

The GÉANT network [GÉANT] is the fast and reliable pan-European communications infrastructure serving Europe's research and education community. DANTE provides overall project management and co-ordinates the project's various activities. It is responsible for financial and administrative work, including delivering progress reports to the EC. As the project co-ordinator, DANTE is also responsible for public relations, and for overall communications between the project and the EC.

Co-funded by European NRENs and the EC, the GÉANT network and project (also known as GN3) is entering its third generation, along with associated development activities. The GÉANT network and associated programme of activities is co-funded by the European Commission within the GÉANT Project (GN3) contract, which is part of the EC's Seventh Research and Development Framework Programme (often referred to as FP7). This contract between the project partners and the European Commission provides total funding from the EC of 93 million Euro for four years from 1 April 2009. Matching funding is provided by the NREN project partners connected to the network.

The project partners are 32 European NRENs, DANTE and TERENA; plus an additional four Associate NRENs.

DANTE currently has 50+ members of staff, most of whom work at DANTE's main office:

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Transportation and electrical power consumption data for the report were provided by Guy Roberts, DANTE's Network Engineering and Planning team.

The reporting period covers the period from 1st of January to 31st December 2009.

3.2 GHG Inventory

3.2.1 Organisational Boundaries

The GHG emissions of DANTE are consolidated into four components, in accordance with the agreed model (see Section 2.3 *Organisational Components for the GHG Inventory* on page 4). In each of these, the scope, as per the ISO 14064 standard, is defined by all facilities over which DANTE has financial or operational control. The emissions comprise the direct and indirect GÉANT-related emissions of the offices, data centres, and network links owned or leased by DANTE, as well as the emissions produced by business and commuting travelling by the employees.

3.2.2 Direct GHG Emissions

DANTE does not own any car or other transportation vehicle or any other source of direct emission of the GHGs listed below. Therefore, the direct Carbon Dioxide equivalence (CO2e) emission is 0.

List of GHGs:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur hexaflouoride (SF_6)

3.2.3 Treatment of Biomass CO2 Emissions in the GHG Inventory

N/A – GÉANT/DANTE does not cause any CO_2 emissions from the combustion of biomass.

3.2.4 GHG Removals

N/A – GÉANT/DANTE does not provide any GHG removals.

3.2.5 GHG Sources or Sinks Exclusion

N/A – no GHG sources or sinks have been excluded from the quantification.

3.2.6 Indirect GHG Emissions

Indirect “scope two” GHG emissions are associated with the generation of imported electricity, heat or steam. For DANTE/GÉANT indirect “scope three” emissions are linked to business and commuting transportation.

Table 2.1 details the energy consumption of DANTE/GÉANT classified and itemised into:

- Office
- Data centres
- Backbone
- Transportation

The corresponding GHG emissions, totalling 2032 tons CO_2e, are calculated from published emission factors for each of the three contributing GHGs:

- CO_2
- CH_4
- N_2O

DANTE/GÉANT Climate Accounting							
Accounting item	**Units**	**Supplementary information**	**CO2 factor**	**CH4 factor**	**N2O factor**	**Emission**	**Subtotal**
			(g CO2 per kWh)	(g CO2e per kWh)	(g CO2e per kWh)	(kg CO2e)	(tons CO2e)
Office	**kWh/year**	**Office space (m2)**					
City House 126-130 Hills Rd, Cambridge		650 + shared area					
Heating	267082		183,58	0,28	0,11	49135	
Electricity	228074		665			151669	
NOC		270					
Electricity (including heating)	64184		665			42682	
							243
Data centre power consumption	**kWh/year**		**(g/kWh)**	**(g/kWh)**	**(g/kWh)**	**(kg CO2e)**	
AT-Austria	92330		308			28438	
BE-Belgium	26806		400			10722	
BU-Bulgaria	65525		904			59235	
CH-Switzerland	90841		86			7812	
CY-Cyprus	0		0			0	
CZ-Czech Republic	78928		802			63300	
DE-Germany	90841		709			64406	
DK-Denmark	78928		766			60459	
EE-Estonia	43187		1593			68797	
ES-Spain	105733		636			67246	
FI-Finland	0		416			0	
FR-France	90841		148			13444	
GR-Greece	78928		1165			91951	
HR-Croatia	26806		328			8792	
HU-Hungary	78928		675			53276	
IE-Ireland	40208		849			34137	
IL-Israel	13403		0			11567	
IS-Iceland	0		23			0	
IT-Italy	90841		704			63952	
LT-Lithuania	43187		177			7644	
LU-Luxembourg	13403		602			8069	
LV-Latvia	43187		563			24314	
ME-Montenegro	0		0			0	
MK-F.Y.R.Macedonia	0		0			0	

DANTE/GÉANT Climate Accounting							
Accounting item	**Units**	**Supplementary information**	**CO2 factor**	**CH4 factor**	**N2O factor**	**Emission**	**Subtotal**
			(g CO2 per kWh)	(g CO2e per kWh)	(g CO2e per kWh)	(kg CO2e)	(tons CO2e)
MT-Malta	0		0			0	
NL-Netherlands	90841		721			65496	
NO-Norway	0		29			0	
PL-Poland	78928		1184			93451	
PT-Portugal	13403		749			10039	
RO-Romania	78928		1085			85637	
RS-Serbia	0		0			0	
RU-Russia	13403		0			9637	
SE-Sweden	0		80			0	
SI-Slovenia	13403		603			8082	
SK-Slovakia	13403		352			4718	
TR-Turkey	0		0			0	
UK-United Kingdom	104244		665			69322	
							1094
Backbone	**kWh/year**	**Length (km)**	**(g/kWh)**	**(g/kWh)**	**(g/kWh)**	**(kg CO2e)**	
AT-Austria	48101		308			14815	
BE-Belgium	32197		400			12879	
BU-Bulgaria	0		904			0	
CH-Switzerland	76113		86			6546	
CY-Cyprus	0		0			0	
CZ-Czech Republic	39702		802			31841	
DE-Germany	123782		709			87761	
DK-Denmark	39702		766			30412	
EE-Estonia	0		1593			0	
ES-Spain	60700		636			38605	
FI-Finland	0		416			0	
FR-France	106895		148			15820	
GR-Greece	15577		1165			18147	
HR-Croatia	28533		328			9359	
HU-Hungary	39032		675			26347	
IE-Ireland	22412		849			19028	
IL-Israel	0		0			0	
IS-Iceland	0		23			0	
IT-Italy	47922		704			33737	
LT-Lithuania	0		177			0	
LU-Luxembourg	15577		602			9377	
LV-Latvia	0		563			0	

DANTE/GÉANT Climate Accounting							
Accounting item	**Units**	**Supplementary information**	**CO2 factor**	**CH4 factor**	**N2O factor**	**Emission**	**Subtotal**
			(g CO2 per kWh)	(g CO2e per kWh)	(g CO2e per kWh)	(kg CO2e)	(tons CO2e)
ME-Montenegro	0		0			0	
MK-F.Y.R.Macedonia	0		0			0	
MT-Malta	0		0			0	
NL-Netherlands	63336		721			45665	
NO-Norway	0		29			0	
PL-Poland	15577		1184			18443	
PT-Portugal	15577		749			11667	
RO-Romania	0		1085			0	
RS-Serbia	0		0			0	
RU-Russia	15577		0			11200	
SE-Sweden	0		80			0	
SI-Slovenia	25406		603			15320	
SK-Slovakia	29382		352			10342	
TR-Turkey	0		0			0	
UK-United Kingdom	65301		665			43425	
Leased wavelengths	101101		700			70771	
							582
Transportation	**km/year**	**Of this commuting (km/year)**	**(g/km)**	**(g/km)**	**(g/km)**	**(kg CO2e)**	
Taxi	4096	0	158,35	0,06	1,24	654	
Own car (lower medium)	153750	150000	193,71	0,27	1,83	30106	
National train	84000	84000	57,74	0,08	3,31	5135	
International Train (Eurostar)	67000	0	17,65	0,01	0,12	1191	
Flight (95204)	959332	0	98,26	0,01	0,97	87317	
							124
Grand Total (kg CO2e/year)						389566	**2042**

Table 3.1: DANTE/GÉANT energy consumption.

Note: Except for transportation, the CO2 factor column includes CH4 and N2O values.

3.2.7 Base Years

This is the first GHG report from DANTE, covering the full year 2009. Year 2009 will serve as the historical base year as well as the base year of the current GHG inventory.

3.2.7.1 *Base Year Changes and Recalculations*

This report covers 2009. No changes or recalculations are anticipated within the lifetime of the GN3 project.

3.3 Quantification Methodologies

Only recurrent emissions are covered. No effort has been made to include carbon emissions from buildings or producing facilities and products. No direct emissions are produced by DANTE, as DANTE owns no cars or other type of direct emission sources. The indirect emissions are calculated from:

- Office emissions from heating, air conditioning and electricity.

  The DANTE main office values are based on bills from the electricity and gas providers covering the consumption for the period 1 July 2008 – 30 June 2009. The NOC values are estimated from bills covering the quarter August–November 2009.

- Data-centre emissions from electricity to computers, routers, switches and cooling equipment.

  The electricity consumption figures for the data-centre-hosted equipment are based on detailed data sheet specifications. The flat equipment consumption is multiplied by a Power Usage Efficiency (PUE) factor accounting for the contribution from cooling equipment. The resulting values are finally multiplied by the country-specific CO2e emission factors.

  PUE factors are in general not yet available from most data centres and therefore a common PUE factor of 1,7, stemming from measurements at UNI-C's data centre during 2009, has been used for all sites.

  Contributions to GHG emissions from any standby power generator have been ignored, anyway being deemed insignificant.

- Emissions from the backbone network, including Point of Presence (PoP) equipment and optical amplifiers along the fibre stretches.

  DANTE presently does not provide measuring metres on most of its equipment and facilities, and the values are based on detailed equipment specifications. Again, a PUE factor of 1,7 has been applied to the theoretical values.

  Leased lines amounting to a total length of 69130 km provide a considerable part of the GÉANT connectivity, accounting for an estimated 10% share of the backbone electricity consumption. To calculate the emissions from these leased wavelengths, a "European mean" of 700 CO2e/kWh has been used. Hopefully, the providers of these lines will be able to improve the accuracy of these emission values in the future.

- Employee business and commuting transportation emissions.

  These, so-called "scope three" emissions, are partly estimated (commuting), partly traced back from company records (business travelling). For transportation by car, taxi, bus or train, the distance travelled is multiplied by the matching GHG emission coefficients published from the public national information source specified in Section 3.3.2 below. For flight transportation, the emission by each trip has been calculated using the International Civil Aviation Organisation's (ICAO's) CO2 calculator [ICAO_CO2_Calc].

3.3.1 Change to Quantification Methodologies

N/A – no previously used quantification methodologies were changed.

3.3.2 GHG Emission and Removal Factors

The following factors were used in calculating emissions:

- Electricity emission factors.
- Heating and transportation emission factors.

3.3.2.1 *Electricity Emission Factors*

The key figures for electricity consumption have been derived from the European Life Cycle Database (ELCD core database) version II, established and published by the EU Commission through the Joint Research Centre in Ispra, Italy. More information on the database can be found on the home page [ELCD].

The inventory figures are available from the same site [ELCD_Elec].

The basic data has been recalculated, using the most recent recommendations from the Intergovernmental Panel on Climate Change (IPCC) regarding the global warming potential of methane and nitrous oxide (factor 25 and 298, respectively).

It is noted that the key figures relate to the full fuel cycle, i.e. also including extraction and transportation of fuels to their final destination. This approach gives a significantly higher contribution to global warming than when only the combustion of fuels is included. The figures thus give a comprehensive (and conservative) estimate, compared to the key figures published by national energy agencies.

The emission factor of Israel is based on "Israel Electric Corporation Statistical Report Year 2007" [IEC2007].

The emission factor of Croatia is based on "Hrvatska Elektroprivreda and the Environment 2005 – 2006" [HEE2005-06].

3.3.2.2 *Heating and Transportation Emission Factors*

The heating and transportation factors have been calculated using the following:

- 2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting [DEFRA/DECC].
- Flight CO2 calculator [ICAO_CO2_Calc].

3.3.3 Accuracy of GHG Emission and Removals Data

DANTE’s GHG information management procedures are still in their infancy. Most of the current data depends on information from the energy and heat suppliers and has not been verified directly by in-house measurements. The power-consumption values of the network equipment are based on a small number of “typical” equipment configurations. The power of any given router may vary considerably, but on average they should be the same as a typical (average) router and the same holds for other types of equipment. Therefore, DANTE is confident that the GHG values calculated in this report present a reasonably accurate picture of DANTE/GÉANT’s current emission impact.

Except for Croatia and Israel, the electricity emission key figures are very consistent, being derived in exactly the same way for each country. The main uncertainty in the electricity data is their age, being based on 2005-2006 statistics. Since then, the carbon footprint of electricity production has decreased in most countries, e.g. as a consequence of the use of more renewable fuels. This can, however, only be included in the GHG calculations made by companies and institutions when more recent data is published by the EU Commission.

The Defra transportation coefficients are deduced from statistical averages of a number of different transportation vehicles. The “real” values of a certain individual journey may vary considerably from these average values. This same reservation is true also for the results of the ICAO CO2 calculator.

3.3.4 ISO Compliance

This GHG inventory report has been prepared in accordance with part 1 of the ISO 14064 standard.

3.3.5 Verification Statement

This GHG report will be submitted for external verification. As this is DANTE’s first GHG report and the internal GHG measuring procedures are still under development, it will be submitted for a limited assurance engagement only.

4 Conclusions

From the process of planning and conducting the GHG audits, the team has come to a number of conclusions. First, the adoption of a standard, in this case ISO 14064, has provided a discipline and cohesion within the team which have been very helpful. With reference to the standard, consensus can be achieved on common challenges such as setting the scope of the audit and agreeing on named exclusions. Moreover, the standard enables the results to be asserted and compared with those of other networks and other organisations. Results can also be compared over time.

The decision of the partners to conduct the audit themselves rather than outsourcing the measurement, calculation and reporting stages has had tangible benefits. Partners were able to appreciate the standard by applying it directly to measurements of GHG emissions. As part of the measurement process, they were able to see areas where reductions in GHG emissions – and savings in time and money – could be made, without a reduction in the level of service or its resilience.

The ISO 14064 standard has three components:

- Guidance on carrying out a GHG inventory at an organisational level.
- Guidelines for identifying and carrying out projects to reduce GHG emissions.
- The verification and validation process for the ISO 14064 standard.

Measuring and reducing emissions are closely interwoven within the standard. In quantifying and measuring the levels of GHG emissions, the team inevitably came across areas where improvements could be made, and others that needed further and separate investigation.

Also, during the course of an inventory, several uncertainties in quantifying GHG emissions would be encountered. In such cases, more accurate means of monitoring and measuring could be identified and taken into account in operational and environmental policies.

The common model used to categorise the sections of an NREN proved to be a reasonably good fit across a range of research and education networks – national, regional and continental. This is something which could be adopted by other NRENs, with perhaps some local modifications.

The common spreadsheet tool used to record and calculate measurements was applicable across all the networks audited. Again, this could be adopted by other NRENs for their own GHG audits, with due regard to localising the emission factors.

Finally, the concept of external validation can add value to an audit by providing an independent critical review, and a corrective to any errors and omissions.

The team sees it as important to capture all such ancillary insights and results from the inventory process in each of the networks concerned. These will be reported by each of the partners and consolidated in Deliverable DN3.5.3 “Study of Environmental Impact: Final Results” (due month 36).

The team will also publish the results of audits of greenhouse gas emissions that its members have carried out at NREN and regional network level. Analysis and comparison of the results will be undertaken and the findings made available to the NREN community. They will also inform the next two deliverables of this Task:

- DN3.5.2 “Comparison of Network Services’ Environmental Impact to Alternatives” (due month 24).
- DN3.5.3 “Study of Environmental Impact: Final Results” (due month 36).

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Glossary

Acronyms

CO2	Carbon Dioxide
CO2e	Carbon Dioxide equivalence
CH4	Methane
CPE	Customer Premises Equipment
CTO	Chief technical officer
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
ELCD	European Life Cycle Database
EU	European Union
GHG	Greenhouse Gas
HFC	Hydrofluorocarbon
ICAO	International Civil Aviation Organisation
ICT	Information Communications Technology
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
IT	Information Technology
kWh	Kilowatt-hour
N2O	Nitrous Oxide
NA	Network Activity
NA3 T5	Network Activity 3: Status and Trends; Task 5: Environmental Impact
NOC	Network Operations Centre
NREN	National Research and Education Network
PDU	Power Distribution Unit
PoP	Point of Presence
RREN	Regional Research and Education Network
REN	Research and Education Network
SF6	Sulphur Hexafluoride

Terms

Base year	The year being reported/audited.

Baseline	A hypothetical scenario for what GHG emissions, removals or storage would have been in the absence of the GHG project or project activity.
Embodied energy	The energy that goes into the manufacture, marketing, delivery and ultimate disposal of products.
GHG Protocol	The Greenhouse Gas Protocol (GHG Protocol) is the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions. A decade-long partnership between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), 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. It serves as the foundation for nearly every GHG standard and program in the world - from the International Standards Organization to The Climate Registry - as well as hundreds of GHG inventories prepared by individual companies. [GHGProtocol]
Historical base year	The historic datum, which can be a specific year or an average over multiple years, against which an organisation's emissions are tracked over time.
Limited assurance engagement	A limited-level assurance is distinguishable from a **reasonable level assurance** in that there is less emphasis on detailed testing of GHG data and information supplied to support the GHG assertion. For limited level assurance, it is essential that the validator or verifier do not lead the intended user to believe that a reasonable level of assurance is being provided.
Power Usage Efficiency	A measure of how much additional electrical power is needed for cooling to deliver computing power. A PUE of 1 means all power is being used for computing and none for cooling.
Reasonable assurance engagement	For a reasonable level of assurance, the validator or verifier provides a reasonable, but not absolute, level of assurance that the responsible party's GHG assertion is materially correct.
Scope 3	The GHG Protocol divides emissions into 3 scopes or sections: Scope 1 is heat; Scope 2 is electricity; Scope 3 is business travel (by plane, car and/or train); employees commuting to and from work; and outsourced activities.
Sink	A natural or artificial reservoir that accumulates and stores all or part of the commodity in question (e.g. carbon, GHG) for an indefinite period.