GN3 Study of Environmental Impact Inventory of Greenhouse Gas Emissions and Removals – Poznań Supercomputing and Networking Center

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Table of Contents

Table of Figures

Table of Tables

1 Introduction

1.1 The Reporting Organisation

The Poznań Supercomputing and Networking Centre (PSNC) is affiliated with the Institute of Bioorganic Chemistry of the Polish Academy of Sciences. Its mission is to integrate and develop the information infrastructure of science. PSNC is leading in the deployment of innovative network technologies in the national scientific network POL-34/155/622 and in PIONIER, the Polish Optical Internet network.

The activities of PSNC include:

- Providing calculation power and archive systems.
- Providing Internet and network services on international, national and local levels.
- Managing the research and development centre within the field of new generation computing networks, modern applications, portals, parallel and distributed calculations or systems and network safety.
- Integrating and implementing scientific work results by developing services for public administration, medicine, education and the whole social sphere.
- Acting as a computing calculation centre in the meta-computer environment.
- Promoting modern information structures: networking and calculating.

PSNC is also the operator of:

- The metropolitan network, POZMAN.
- The national network, PIONIER (Polish Optical Internet).

Within this framework, the Centre provides the education society with the following services:

- Great power calculation.
- Communication services (email, teleconferences, www, news, etc.).
- File archives.
- Local databases (for libraries and scientific information).
- Specialised services (multimedia laboratories for visualisation and animation).

- Software distribution and service.

PSNC employs approximately 250 people at the following locations:

PSNC (Main office)
Instytut Chemii Bioorganicznej PAN –
Poznanskie Centrum Superkomputerowo-Sieciowe
ul Z. Noskowskiego 12/14
61-704 Poznań
Poland

PSNC
Instytut Chemii Bioorganicznej PAN –
Poznanskie Centrum Superkomputerowo-Sieciowe
ul. Dabrowskiego 79a
60-529 Poznań
Poland

1.2 Report Creators

This GHG report has been prepared by Artur Binczewski, Robert Pękal, and Rafal Sowiński from PSNC.

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1.3 Reporting Period Covered

The GHG audit report covers the period from 1st of January to 31st of December 2009.

2 GHG Inventory

2.1 Organisational Boundaries

2.2 The report takes into account the greenhouse gas emissions by the PIONIER network equipment deployed throughout the length of the network (the whole of Poland), and also offices located at PSNC in Poznań. The report includes both direct emissions associated with the use of means of transport that belong to PSNC, indirect emissions from electricity and heat suppliers, and indirect emissions associated with means of transport that do not belong to PSNC.Direct GHG Emissions

PSNC directly emits greenhouse gases only through the use of cars. A negligible amount of greenhouse gases is also produced through the use of oil-powered electricity generators. Since these are run mainly to verify their state of readiness, these values were not included in the report. The total working time of generators does not exceed 30 hours per year, and the power of these concerns only a fragment from a network (the server room in Poznań).

GHG sources

2.3 The source of GHG emissions included in the calculation of GHG emission is unleaded gasoline used in

cars.Treatment of Biomass CO_2 Emissions in the GHG Inventory

PSNC does not directly emit GHG through the use of biomass for energy production. However, its energy suppliers are using biomass to generate electricity and heat power. The share of biomass in the total heat production is 2.5% [1], and in total electricity production 2.25%. For electricity, the total use of renewable energy sources is 4.79% [4]. These values are included in the rates of GHG emissions adopted in the report from energy suppliers.

2.4 GHG Removals

PSNC do not perform any GHG removals.

2.5 GHG Sources or Sinks Exclusion

No GHG sources or sinks have been excluded from this quantification.

2.6 Indirect GHG Emissions

Indirect greenhouse gas emissions are related to the purchase of electricity and heat from external suppliers. They are also connected with the use of transport provided by third parties, for example, rail travel or flights.

GHG sources

The sources of GHG emissions included in the calculation of GHG emission are:

a) Due to the use of electricity supplied by “ENEA” company:
   - Renewable energy sources: 4,79% (biomass: 2.25%, hydro 1.37%, wind energy 1.17%)
   - Coal 72.34%
   - Lignite 19.66%
   - Natural Gas 1.35%
   - Other 1.86%

b) Due to the use of heating supplied by “Dalkia” company:
   - Biomass 2,5%
   - Coal 97%
   - Other (heavy fuel oil - heating oil) 0.5%

c) Due to air travels:
   - It is probably aviation fuel (The emission was calculated on the calculator provided by Lufthansa, and there is not listed the information on energy sources)

d) Due to train travels:
   - Diesel
   - Electrical Power (It is not possible to determine the energy required to produce electricity)

2.7 Base Year

This report includes greenhouse gas emissions in 2009. It is the first report prepared by PSNC for the operation of the PIONIER network.

2.7.1 Base Year Changes and Recalculations

This report covers 2009 and no changes or recalculations are anticipated within the auspices of the GN3 project.

3 GHG Emissions

Below are presented the results of calculations of greenhouse gas emissions by the PIONIER network. Tables 3.1-3.4 present the data related to indirect GHG emissions. The only direct emission is associated with the use of cars belonging to the PSNC, and the information have been highlighted in Table 3.2."

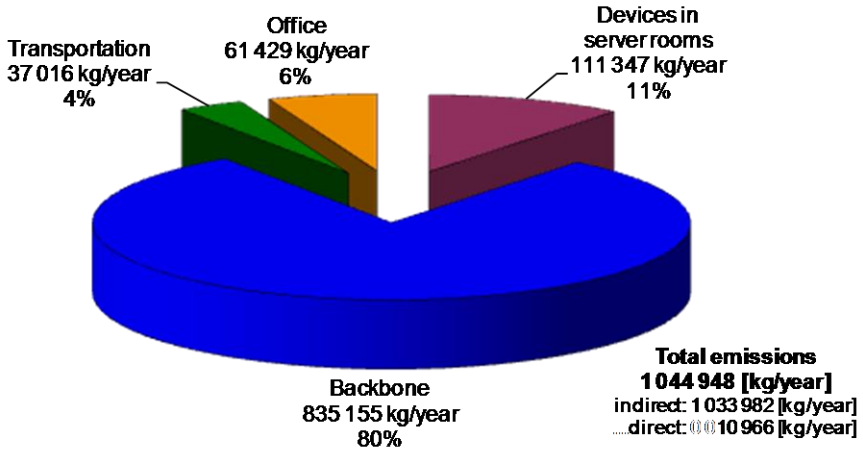

Figure 3.1: Structure of the greenhouse gas emissions by the PIONIER network in 2009.

Backbone and server rooms in PIONIER network					
GHG Factor		**CO2 (g/kWh)**	**CH4 (g/kWh)**	**N2O (g/kWh)**	
Poland		891			
Germany		590			
Slovakia		1 012			
GHG Emission	**kWh/year**	**(kg/year)**	**(kg/year)**	**(kg/year)**	**Subtotal GHG (kg/year)**
Devices in server rooms (Poland)	124 969	111 347			111 347
Backbone in Poland	918 590	818 463			818 463
Backbone in Germany	25 023	14 764			14 764
Backbone in Slovakia	1 905	1 928			1 928

Backbone and server rooms in PIONIER network	
Total GHGe (kg/year)	**946 502**

Table 3.1: Greenhouse gas emissions by the various elements of the PIONIER network in 2009.

Transportation					
GHG Factor		**CO2 (g/kWh)**	**CH4 (g/kWh)**	**N2O (g/kWh)**	
Flight (factor depends on the route)		99-108			
Train		47			
Cars (factor depends on the type of engine)		187-196			
Taxi		n/a			
Bus		n/a			
GHG Emission	**kWh/year**	**(kg/year)**	**(kg/year)**	**(kg/year)**	**Subtotal GHG (kg/year)**
Flight (factor depends on the route)	245 036	24 750			24 750
Train	27 672	1 301			1 301
Cars **The only direct emissions of greenhouse gases** (factor depends on the type of engine)	58 146	10 966			10 966
Taxi	n/a	n/a			0
Bus	n/a	n/a			0
Total GHGe (kg/year)					**37 016**

Table 3.2: Greenhouse gas emissions by PIONIER network in 2009 associated with business trips.

Offices					
GHG Factor		**CO2 (g/kWh)**	**CH4 (g/kWh)**	**N2O (g/kWh)**	
Electricity		891			
Air conditioning (powered by electricity)		891			
Central heating		345			
GHG Emission	**kWh/year**	**(kg/year)**	**(kg/year)**	**(kg/year)**	**Subtotal GHG (kg/year)**
Electicity	28 660	25 536			25 536
Air conditioning	7 325	6 526			6 526
Heating	85 232	29 367			29 367
Total GHGe (kg/year)					**61 429**

Table 3.3: Greenhouse gas emissions by PIONIER network in 2009 related to the functioning of the office.

Backbone and server rooms in POZMAN					
GHG Factor		**CO2 (g/kWh)**	**CH4 (g/kWh)**	**N2O (g/kWh)**	
Poland		891			
GHG Emission	**kWh/year**	**(kg/year)**	**(kg/year)**	**(kg/year)**	**Subtotal GHG (kg/year)**
Server room	121 202	107 991			107 991
Backbone	192 156	171 211			171 211
Total GHGe (kg/year)					**279 202**

Table 3.4: Greenhouse gas emissions by the POZMAN network in 2009.

(The data in Table 3.4 does not relate to the functioning of NRENs (PIONIER).)

4 Quantification Methodologies

The report is prepared in accordance with ISO 14064 and that it has undergone a non-accredited verification with a limited assurance level. PSNC have chosen as a control approach the consolidation method.

The report includes the following energy providers:

- Electricity: ENEA SA, Termoelektrarna Sostanj, and for Germany it is not possible to determine, since the emissions data come from a general report prepared by Umwelt Bundes Amt for whole Germany.
- Heat: Dalkia SA
- Energy associated with travelling by car: PSNC
- Energy associated with travelling by air: Lufthansa
- Energy associated with travelling by train: it is not possible to determine, since the emissions data come from a general report on the state of the railways in the European Union

For calculation was used the following factors in greenhouse gas emissions:

No	Subject	Factor	Source
1	Emissions associated with energy production in Poland	891 [g/kWh]	The raport published by energy supplier for the year 2008: http://www.enea.pl/img/struktura_paliw.pdf. A report for the year 2009 has not yet been published yet.
2	Emissions associated with energy production in Germany	590 [g/kWh]	The raport published by Umwelt Bundes Amt. The data was taken from prediction for the year 2008 mentioned in the head of the document page no1: http://www.umweltbundesamt.de/energie/archiv/co2-strommix.pdf
3	Emissions associated with energy production in Slovakia	1 012 [g/kWh]	The raport published by energy supplier with prediction for the year 2009: http://www.te-sostanj.si/filelib/ebrd/eia_final_slo.pdf (page 89)
4	Emissions associated with central heating supplier	345 [g/kWh]	The raport published by heat supplier for the year 2008: http://www.dalkia.pl/dalkia-p/getFile.php?fileID=27. A report for the year 2009 has not yet been published yet.
5	Emissions associated with air travels	99-108 [g/km]	Factor re-calculated on the basis given by the Lufthansa of total CO2 emissions for the flight paths. (Used CO2 calculator has been published on the website http://lufthansa.myclimate.org/EN)
6	Emissions associated with train travels	47 [g/km]	The raport for the year 2005, "Energy Efficiency for Railway Managers" published by International Union of Railways

No	Subject	Factor	Source
			(UIC) - Paris, 2008: http://www.uic.org/IMG/pdf/uic_process_power_people.pdf (page 41) A report for the more acctual year has not been bublished yet.
7	Emissions associated with travels by car	187-196 [g/km]	The date published bEurope's Energy Portal for different types of cars. http://www.energy.eu/car-co2-emissions
8	PUE factor	1,45 (=145%)	The factor consists of two factors: value 1,3 for cooling system and 1,15 for UPS system. Detailed explanation is given in Section 4.1

Table 4.1: GHG emission factors used in the calculation

To calculate the quantity of greenhouse gases emitted by PIONIER, the calculations were divided into 4 areas:

- PIONIER network devices.
- POZMAN (Metropolitan Area Network for the City of Poznań) equipment (for information only).
- Transportation.
- Office.

The architecture of how end users are connected to the PIONIER NREN in Poland differs from other NRENs. In Poland, end users are connected directly to the Metropolitan Area Network (MAN). Then the MANs are connected to the NREN. For this reason it was decided that calculations of energy consumption would concern only the PIONIER network (NREN) and not the 21 Polish MANs. To illustrate the scale of GHG emissions by MANs, it was decided to calculate and report greenhouse gas emissions by 1 of 21 MANs. These results are presented separately and are not subject to auditing.

The ISO 14064 standard for greenhouse gases includes:

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

Because the electricity supplier publishes only some data about the substances emission during power generation [1][2][3], it is currently only possible to determine the emission of CO_2 in Poland, and the emission of other substances which are not greenhouse gases (such as NOx, SO_2, dust or radioactive waste). Therefore, the calculations show only data on CO_2. To be able to supplement the report in the future, the GHG Emissions tables (see Table 3.1, Table 3.2, Table 3.3 and Table 3.4) present the basic data on the volume of energy consumption and the factors value, allowing an update when data concerning emissions of other greenhouse gases becomes available.

All upgrades of the report will be made available online [8].

In the case of preparing the next version of the report it is necessary to read the document “PIONIER Recommendation for Green House Gases report actualization”, The document contains information on quantities of network devices taken into account in the final version of the report.

The uncertainties related to the emission data

To ensure maximum precision of the study adopted a procedure in which on the first place the data of energy consumption was gathered using measurements. Only where this was not possible, energy consumption was calculated based on the technical documentation of the equipment devices (e.g. the number of cards installed). The calculations are made taking into account all the devices installed on the network. Takes into account the actual data for electricity and heat which was read from the counters installed in office buildings. Calculations in the transportation category have been made taking into account the actual routes, flight and the number of people on the trips. All these activities show that measurement error should be minimal. However, the estimation error is extremely difficult. The report's authors believe that due to some approximations used in calculations, the error should not be greater than 5% of the value.

4.1 PIONIER Network Devices

Separate calculations were made for the facilities in Poznań (in the server rooms) and the equipment deployed on the line (outside the server rooms). The backbone was isolated in Poland, a separate backbone line placed in Germany, and another separate backbone in Slovakia. (see Figure 4.1)

Figure 4.1: Geographical deployment of the PIONIER network.

Each of the countries hosting a part of the PIONIER network has adopted separate rates of greenhouse gas emissions [1][2][3].

The calculations do not include the use of an emergency power supply which is used 30 hours per year, and therefore does not significantly influence the results of the calculations.

Where possible data on energy consumption was gathered using measurements (read from the meters or the command line device). Where this was not possible, energy consumption was calculated based on the equipment devices' technical documentation (e.g. the number of cards installed).

If the network devices were identical (had the same configuration) then the calculations were performed for only one of the devices, then the values were multiplied by the number of identical devices installed in the network. The quantities of equipment and energy consumption values are stored in the internal document "Recommendation for PIONIER Green House Gases report actualization" and the Excel file "DataPSNC-v6.xls"

For the PIONIER network, the measured data (read from the meters) comprises 64.9% of energy consumption, and the data calculated on the basis of technical documentation 35.1%.

Apart from the GHG emission related to the functioning of basic network devices in the report is also included emissions associated with operation of air conditioners and Uninterruptible Power Supply System(UPS). If it was not possible to measure the real value of energy consumed by the air conditioners and UPS it was used a power factor taking into account the energy used by these devices. It was +30% for air conditioning and separately a further +15% for the UPS. It gave a total value of the factor = 1.45 (1.45 = 1+0,.3 + 0.15). The value of 30% was calculated on the basis of power consumption measured of the entire server room and the measured power consumption by devices installed in the server room. The value of 15% was calculated on the basis of efficiency of UPS devices presented in the technical documentation. Because the air-conditioning system is not connected to the UPS hence the PUE factor is calculated as the sum of both factors, and each of them as a basis takes the energy consumption by network devices installed in the server room.

It should be noted that in the case of one line PIONIER network a few devices is not in air conditioned spaces. However, because of the negligibly small number of these and a negligible share of energy consumption by these devices when emissions for the entire network PIONIER was calculated the PUE factor was taken into account for all devices in the network. It does not affect the final result GHG emissions.

4.2 POZMAN (Metropolitan Area Network for Poznań) equipment

The GHG emissions of the 21 MANs connected the PIONIER network are not included in the calculation of the NREN's greenhouse gas emissions,, as they do not formally belong to the NREN. To illustrate the scale of greenhouse gas emissions by the MANs, calculations were made for 1 of 21 networks (for POZMAN operating

in the city of Poznań). As this is not representative of the other MANs in Poland, the data is included for information only. The full picture of the greenhouse gas emissions associated with the operation of the Internet in each country may include additional factors not considered in the presented methodology.

The calculations of greenhouse gas emissions by POZMAN are not subject to auditing.

As in the calculations for the PIONIER network (see *PIONIER Network Devices* on page 14), where possible data on energy consumption was gathered using measurements (read from the meters or the command line device). Where this was not possible, energy consumption was calculated based on the technical documentation of the equipment devices (e.g. the number of cards installed).

If the network devices were identical (had the same configuration) then the calculations were performed for only one of the devices, then the values were multiplied by the number of identical devices installed in the network. The quantities of equipment and energy consumption values are stored in the internal document "Recommendation for PIONIER Green House Gases report actualization" and the Excel file “DataPSNC-v6.xls”

For the POZMAN network, the measured data (read from the meters) comprises 8.4% of energy consumption, and the data calculated on the basis of technical documentation 91.6%.

Apart from the GHG emission related to the functioning of basic network devices in the report is also included emissions associated with operation of air conditioners and Uninterruptible Power Supply System(UPS). If it was not possible to measure the real value of energy consumed by the air conditioners and UPS it was used a power factor taking into account the energy used by these devices. It was +30% for air conditioning and separately a further +15% for the UPS. It gave a total value of the factor = 1.45 (1.45 = 1+0.3+ 0.15). The value of 30% was calculated on the basis of power consumption measured of the entire server room and the measured power consumption by devices installed in the server room. The value of 15% was calculated on the basis of efficiency of UPS devices presented in the technical documentation. Because the air-conditioning system is not connected to the UPS hence the PUE factor is calculated as the sum of both factors, and each of them as a basis takes the energy consumption by network devices installed in the server room.

4.3 Transportation

The calculation of GHG emissions related to the business trips was divided into travel by:

- Plane
- Car
- Taxi
- Bus
- Train

4.3.1 Travel by Plane

The calculations were made based on the amount flights, specific routes and the amount of delegated persons. Three selected events directly related to the functioning of the PIONIER network in 2009 was choosen.It was: trips to supercomputing conferences, to Internet 2 meetings and to the Terena Networking Conferences. Greenhouse gas emissions are calculated by multiplying the number of meeting participants with the number of kilometers traveled during the indicated flights. For this, the calculator provided by Lufthansa was used. The link to the calculator is possible to find under the No [6] in References. Detailed data, taken for the calculations is described in the internal PSNC document "Recommendation for PIONIER Green House Gases report actualization" and in the excel file "DataPSNC-v6.xls"

4.3.2 Travel by Car

To calculate the GHG emissions of car journeys, the total annual mileage of two official company cars (Peugeot 406 and Honda CRV) was used. The Vehicle mileage data are registered monthly in the administration section of PSNC. For each of the cars the GHG emission was calculated separately, according to the emission factors given by [5]. For the Honda CRV, the emission factor for an engine capacity of 2.0, petrol, was used. For the Peugeot 406, the factor for an engine closest to a capacity of 1.8, petrol, was used.

4.3.3 Travel by Taxi and Bus

These means of transport have not been used.

4.3.4 Travel by Train

Greenhouse gas emissions associated with rail travel were calculated based on the estimated mileage of trips. The CO_2 emission factor was adopted from the documentation published at [7]. The calculations take into account the amount of travel in 2009, estimated number of kilometers (depending on destination) and the number of people participating in the trip. Detailed data, taken for the calculations is described in the internal PSNC document "Recommendation for PIONIER Green House Gases report actualization" and in the excel file "DataPSNC-v6.xls"

4.4 Office

Greenhouse gas emissions associated with the operation of the office was calculated in three categories:

- Electricity for power devices (personal computers, lighting, etc.).
- Electricity power consumption associated with the air conditioning.

- Collection of energy needed to heat the building.

4.4.1 Electricity for Power Devices and Air Conditioning

Values were determined on the basis of energy bill. Calculations are based on accounts from the eleventh and twelfth month and are estimated for the whole year (multiplied 6 times).Values were recalculated in proportion to the number of staff directly related to the PIONIER network service. The factor determining the number of administrative staff per core business workers is also considered. Detailed data, taken for the calculations is described in the internal PSNC document "Recommendation for PIONIER Green House Gases report actualization" and in the excel file "DataPSNC-v6.xls"

4.4.2 Energy Needed to Heat the Building

The office building is heated by the central heating system. The energy required to heat the building has been read from the counters located at the inlet of the building to the central heating. Then the data were divided in proportion to the number of floors in the building occupied by PSNC and in proportion to the number of staff involved in the operation of networks. In addition, the factor was included increasing the number of core business workers to the appropriate number of administrative staff. Data on greenhouse gas emissions per unit of energy supplied to heat the building have been read from the reports published by the energy supplier [4]. Detailed data, taken for the calculations is described in the internal PSNC document "Recommendation for PIONIER Green House Gases report actualization" and in the excel file "DataPSNC-v6.xls"

5 Conclusions and Recommendations

To obtain accurate results the following should be considered:

- Measurements thsat are read from energy meters should be sampled at least once a month (12 times per year). For the calculation of GHG emissions the results should be averaged. Alternatively, another method should be used which takes into account the amount of energy and time between measurements.

- In each country there may be independent factors to be taken into account when calculating the greenhouse gas emissions. In Poland, attention should be drawn to a different network architecture connecting the NREN with the end user through the MAN. Other factors may be, for example:
  - Frequent use of emergency power sources.
  - The use of heat from servers to heat office buildings.

- A number of human activities can be carried out in the real world or virtually. Actions using virtual NREN networks, contributing to reducing greenhouse gas emissions. (eg, through video conferencing to replace business trips). With the results of this report, you can try to estimate the savings in GHG emissions associated with the use of NREN networks as an alternative to the activities carried out in the real world. Creators of the report indicates that in that case it should also be taken into account the emissions associated with the use of terminal equipment - such as individual PCs, printers, monitors, etc., which is not covered by this report.

References

[1] http://www.enea.pl/img/struktura_paliw.pdf
The GHG emission factors published by one of Polish energy supplier. (A report for the year 2009 has not yet been published).

[2] http://www.umweltbundesamt.de/energie/archiv/co2-strommix.pdf
The GHG emission factors used for the PIONIER backbone in Germany.

[3] http://www.te-sostanj.si/filelib/ebrd/eia_final_slo.pdf
The GHG emission factors used for the PIONIER backbone in Slovakia.

[4] http://www.dalkia.pl/dalkia-p/getFile.php?fileID=27
The GHG emission factors published by a Polish heat energy supplier.

[5] http://www.energy.eu/car-co2-emissions
Table of GHG emission factors for different brands of cars.

[6] http://lufthansa.myclimate.org/EN
Calculator of GHG emissions emitted during passenger flights.

[7] http://www.uic.org/IMG/pdf/uic_process_power_people.pdf (page 41).
The GHG emission factors adopted for travels by train.

[8] http://www.geant.net/Media_Centre/Media_Library/Pages/Deliverables.aspx

Glossary

CH_4	Methane
CO_2	Carbon dioxide
GHG	Greenhouse gas
HFC	Hydrofluorocarbon
kWh	kilowatt-hour
MAN	Metropolitan Area Network
N_2O	Nitrous Oxide
NREN	National Research and Education Network
PFC	Perfluorocarbon
POZMAN	Metropolitan Area Network for the City of Poznań
PSNC	Poznań Supercomputing and Networking Centre
SF_6	Sulphur hexafluoride