eCO$_2$meter

Author Manual for the eCO$_2$meter

online tool for the collection of data calculating the yearly energy consumption and greenhouse gas (GHG) emissions of NRENs.

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1 GENERAL INFORMATION

Rising energy consumption of ICT equipment will be one of the **main challenges that National Research and Educational Networks (NRENs)** will have to address to promote a **sustainable environment**. The amount of data transported over NRENs' networks will continue to rise and energy consumption will rise with it. As the cloud and mobile devices become more important in our daily lives, the mobile, access and core networks required to support these services do too. Where energy consumption of networks currently is not regarded as a high priority, this will change in the near future in a business-as-usual scenario due to these trends related to massive increase in network activities. Similar to datacenters, lowering energy consumption is not only good for the environment, but it will make financial sense as well.

Adoption of energy efficient practices in setup, management, support and decommissioning our networks combined with the use of ICT technology to measure the success of reducing of the energy consumption in various sectors is thus considered crucial for the future of networks. NRENs can provide specific **guidance to policy makers** based on the conduction of **detailed national studies** of the GHG abatement potential in a set of countries.

The GÉANT project is committed to promoting energy-saving and ecologically sound applications layered over the GÉANT infrastructure. A team known informally as the "GÉANT Green team" was established in 2008 with the objective to help NRENs work towards greener networks, services, policy and practice.

1.1 "GÉANT GREEN TEAM"

The "GÉANT Green team" was established in 2008 with the objective to help NRENs work towards greener networks, services, policy and practice.

This is being achieved through a three-staged process:

- Performing ISO standards-based audits of the green-house gas emissions of the participating NRENs

- Building a collection of best practices for NRENs to adopt to lessen their environmental impact

- Formulate proposals and recommendations to encourage and guide the policies of NRENs and GEANT in the pursuance of "greener" performance.
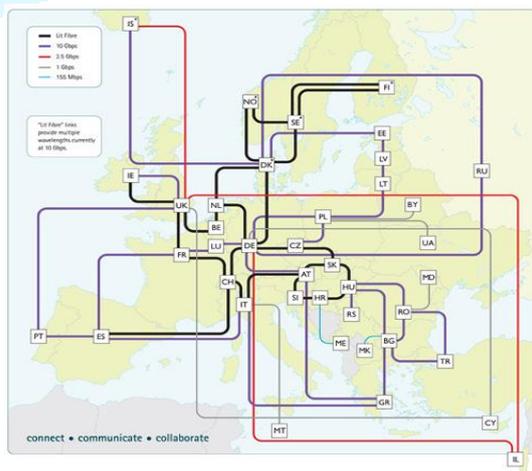
GÉANT Network Topology

1.2 GÉANT GREEN TEAM AND eCO$_2$METER

The "GÉANT Environmental Green team" has undertaken the initiative for the design and development of an online tool – **eCO$_2$meter** - for the collection of data calculating the yearly energy consumption and greenhouse gas (GHG) emissions of NRENs.

eCO₂meter may serve as an international database with energy consumption and GHG emissions data from NRENs This will cover a wide geographical area, with the provision of statistics demonstrating the energy consumption of the IT equipment in various networks and associated computing infrastructures' parts.

eCO₂meter allows network managers to deduce useful conclusions regarding the more energy-hungry parts of the NRENs infrastructure. In addition, it can be used to help measure the environmental impact when applying energy efficiency techniques (e.g. energy efficiency achieved through virtualization techniques, reduction in energy consumption based on behavioural analytics approaches).

1.3 DESCRIPTION

eCO₂meter is based on the - international widely used - ISO 14064 standard for reporting GHG emissions. An adaptation of this standard fitted for use for NRENs was developed in the GN3 programme and this formed the basis on which the **eCO₂meter** was developed.

For NRENs, GHG emissions can be consolidated into four categories:

i. **Office**

Indirect emissions in the office area originate from: a. Electricity usage for the office itself. (Electricity is used for lighting, air conditioning and ventilation, desktop/laptop computers (not the network), coffee machines, displays, beamers, etc.), b. Electricity for building services. Outside the offices, energy is spent in lifts, lighting and security.

Emissions may derive either from a smart meter installed in NREN's premises or from an overview of the service costs for the NREN premises (a file with all the power utility operator bills – or whatever is available – for justification purposes may be uploaded).The NREN must add the number of units used per bill for the corresponding year to arrive at the yearly amount. Then the total amount will be automatically converted to tons CO_2-eq based on how many kg CO_2-eq correspond to 1 KWh for the NREN's country in the specific year. The procedure is similar for all sources of energy.

ii. **Network,**

The network (or backbone) includes all the PoPs where network equipment, owned by the NREN, is located. This equipment may consist of:

- Optical network equipment consisting of optical amplifiers, (de)multiplex devices, wavelength switches, optical controllers and DWDM equipment

- IP network equipment consisting of routers

- Layer2 network equipment consisting of switches

In case that the Total energy consumption in the PoP, including the networking and the supportive infrastructure, is available the corresponding value may be declared and no further calculations will be done. Otherwise, the NREN must state all of its PoPs and the network equipment in each PoP. For the network equipment, energy consumption values result from given device specifications or from real time measurements.

iii. **Data-Centers,**

In the data centres, energy consumption and emissions are caused from storage, computing and

networking equipment and the supportive infrastructure. Energy consumption data for each Datacentre (IT and supportive infrastructure) is based on real time measurements (if monitoring infrastructure is available) or on typical energy consumption of the hosted equipment, as detailed in the manufacturer's datasheets.

iv. **Personnel Travels (incl. commuting).**

In the latter category, GHG emissions result from personnel's daily transportation and from travels on mission as part of one's duties to the NREN.

For transport associated with commuting to and from work, all employed staff may be able to answer an online questionnaire regarding how they reach office based on the area where each employee lives. The approximate distance for each staff member's daily journey may be taken from maps.google.com and categorized by car, motorbike, subway, bus, and tram. Daily kilometres are multiplied by the working days to get the annual figure and then the CO_2-eq are automatically calculated.

Each category is measured using a predefined structure. GHG emissions reports **must be created on an annual basis.**

In all areas, some extra values are requested for the extraction of meaningful statistics such as: Total Network Traffic (incoming and outgoing) served by NREN's network, minimum and maximum values of the real time energy consumption, number of racks in a DC.

Advanced functionalities are available, such as the automatic creation of the final reports based on the input provided (these reports can be used for verification by an external body – this is a requirement to report an official ISO 14064 compliant report). automatic estimation of data based on predefined values (e.g. CO_2 emission factors per country, tons of emissions per mile in international flights), provision of advanced statistics with useful (longitudinal) comparisons based on a diverse set of criteria (e.g. geographical area, energy consumption per sector of the NREN's infrastructure, GHG emissions per number of PoPs) and comparisons with other NRENs.

1.4 SUPPORTED FUNCTIONALITIES

- **User-friendly interface** for the realization of online reports.

- Each form follows the structure of each section of a GHG report.

- Special page **per country** (each NREN is responsible for inserting/updating/validating country-specific data) and **per report**. Each NREN is responsible for inserting/updating/validating country and report specific data like the reporting period covered, the preferable metric for distance values, the base years, the responsible person and the contributors if any, the different emission factors for the specific year, documentation files etc. "Documentation" area serves as a "storage area" allocated to each NREN for uploading files used for the realization of the report (e.g. energy consumption bills etc).

- Specific **guidelines**, URLs to existing GHG emission calculators, section for references

- Ability to insert data based on predefined choices or on a free text field, to upload images/graphs

- **Automatic estimation of data based on predefined values** (e.g. CO_2 emission factors per country) and automatic conversion to CO_2-equivalent.

- Generation of a **summary table** depicting the consumption and the emission per section.

- **Automatic creation of final reports** based on the provided input.

- Final reports may be used for **verification by an external body** through the realization of **ISO 14064 compliant reports**. The data from the "report emissions" subsection are not included in the pdf report and thus unauthorized users are able to see only the provided descriptive texts, the emissions sum of each subsection and the summary table. In case of verification, the author is strongly advised, to conform to all the requirements of the ISO standard. In such a case, all of the fields are mandatory and justification needs to be provided in the external body.

- Provision of **advanced statistics** with useful (longitudinal) **comparisons** based on a **diverse set of criteria** (e.g. geographical area, energy consumption per sector of the NREN's infrastructure, GHG emissions per number of PoPs).

- **eduGAIN** service will be supported, for the trustworthy exchange of information related to identity and authentication. Authenticated and authorized users from each NREN will be able to edit and finalize the reports. Unauthorized users will be able to see only the finalized reports. Connection with social media will be supported.

1.5 GOAL – OBJECT

- **Realization of all the NREN GHG emissions reports online.**

- Extraction of **useful conclusions** to be used towards the provision of **environmental-friendly guidelines to NRENs**.

- **Dissemination of best-practices** within the academic and research community.

- Definition of a **unified sustainability policy** for all the NRENs and development of a **Maturity Model to help NRENs assess how sustainable** their organization really is in their operational environment.
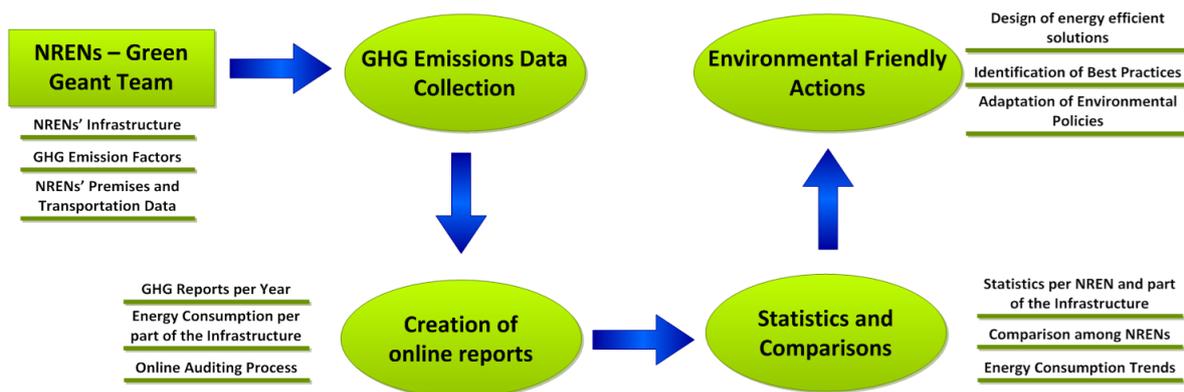
The purpose of the eCO$_2$meter is to promote sharing experiences and best practices and collaborate with peers to reduce GHG emissions. It provides a common language among NRENs to discuss solutions for energy efficiency and energy awareness in networking and computational infrastructures. Such knowledge will then be used by NRENs for further promotion in the R&E community. eCO$_2$meter provides the basis for further collaboration. For example to facilitate the GÉANT community towards the definition of a shared sustainability policy for NRENs and to develop a Maturity Model to help NRENs and R&E institutions assess how sustainable their organization really is in their operational environment.

Data from the eCO2meter and statistics may be disseminated to relevant stakeholders in the area of analysis of environmental impact of IT infrastructure and the use of ICT solutions for environmental friendly purposes (e.g. statistics based on the GHG reports may be proven very useful to UNFCC or environmental committees in standardization bodies).

1.5 ACKNOWLEDGEMENT

2 GETTING STARTED – MAIN MENU

After having successfully logged in, the user is redirected in the page with the main menu. In this page the user can either access and edit his profile or his NREN's specific data, or see the Reports list page.
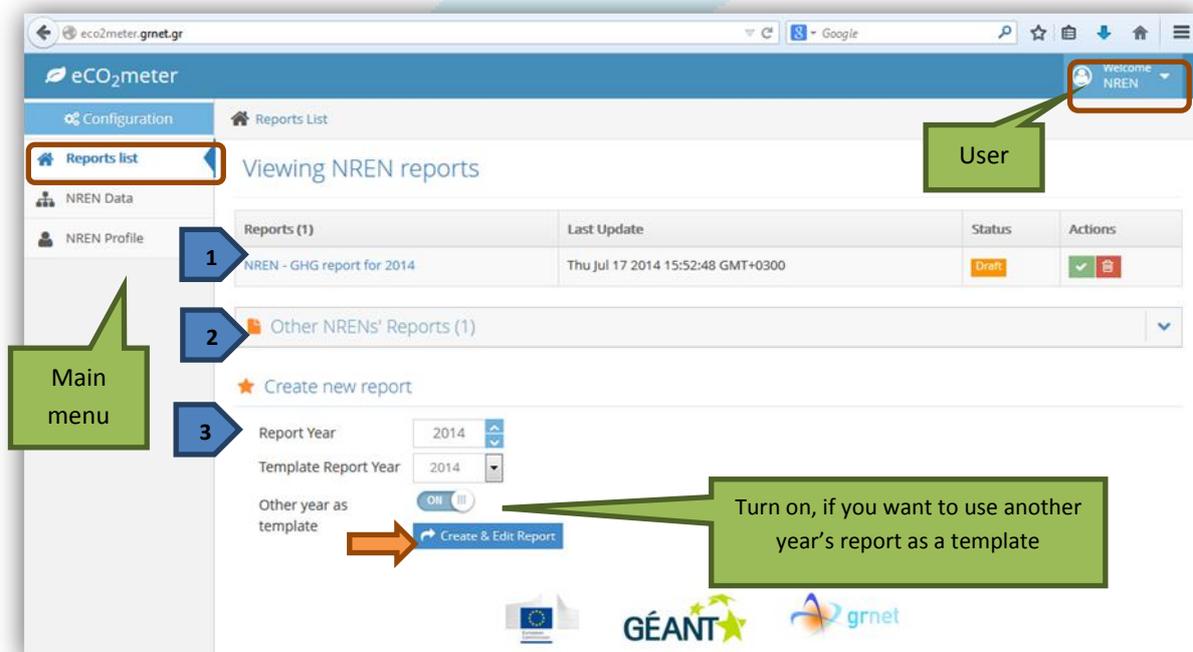
2.1 REPORTS LIST

In the reports list page (picture 1), the user is able to:

1. See all of his **NREN's annual GHG reports** (draft or finalized). Ability to:
   - Edit a specific GHG report,
   - Finalize or Undo Finalize a specific report (depending on the current status of this report),
   - Save a GHG report in a pdf format (available only for finalized reports)
   - Delete
2. See **other NRENs' reports**. Here the user can see and download GHG reports (only finalized ones and thus in a pdf format) from other NRENs.
3. Create **new report:**

   In order to create a new report, the user must first select and define the year that will be covered in this report.

   There is also the ability to create a new report based on a previous one of his NREN. This means, that some crucial data are duplicated (initialized) in the new report. The user can benefit from this ability if his NREN has data that are common through time (Offices, Data Centers, PoPs and equipment models installed).
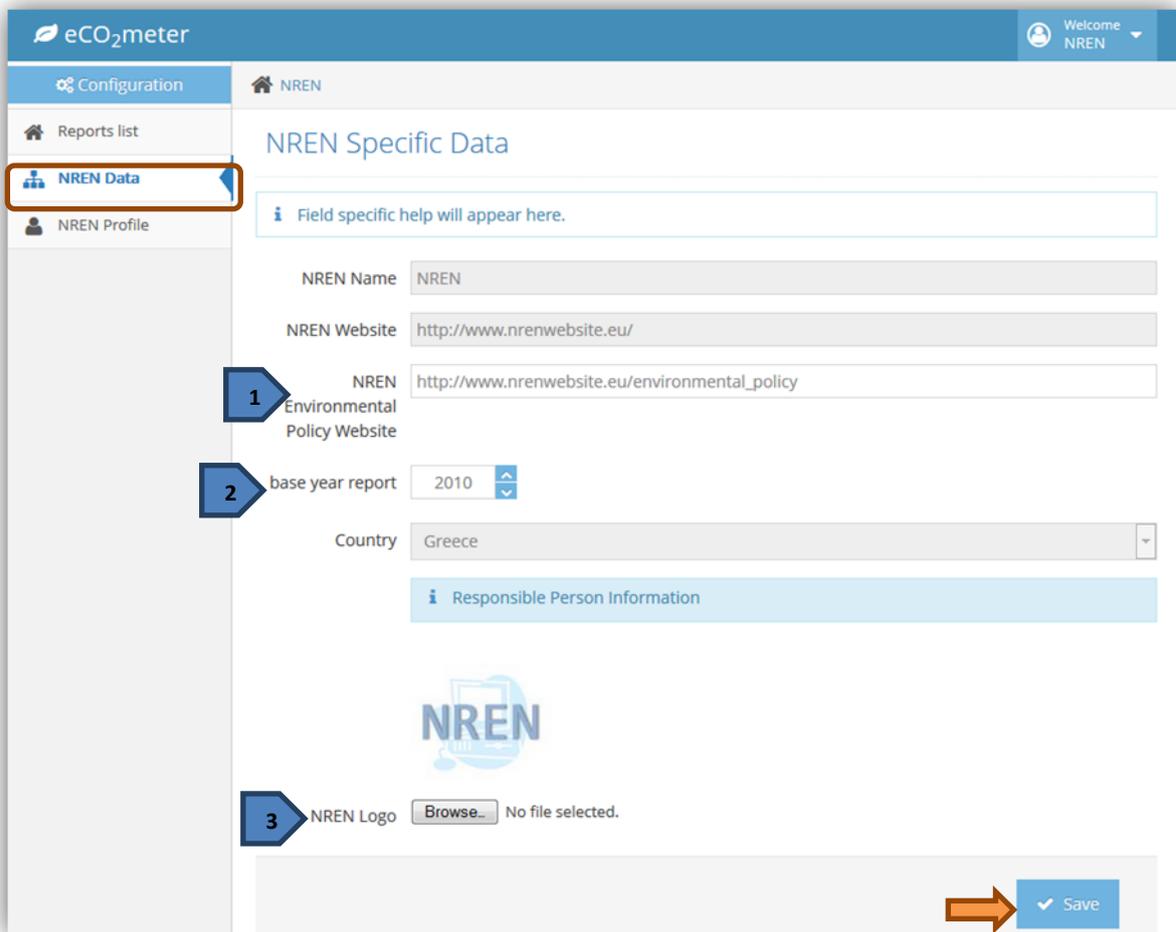

Picture 1. Reports List

2.2 NREN Specific Data

In the "NREN Specific Data" page (picture 2), the user is able to see information regarding his NREN. NREN's Name, Website, Country and Responsible Person, are fields that cannot be altered by the user.

The user is able to input data regarding:

1. The URL of the published environmental policy (in case the NREN has established one)
2. Define the first year that a GHG report conducted for his NREN. This is the Base year report and will serve as an historical base year.
3. The logo of his NREN. The logo will be used in the pdf file that is automatically created by the tool. This file can be used at the verification process or just for publishing on the NREN's website.
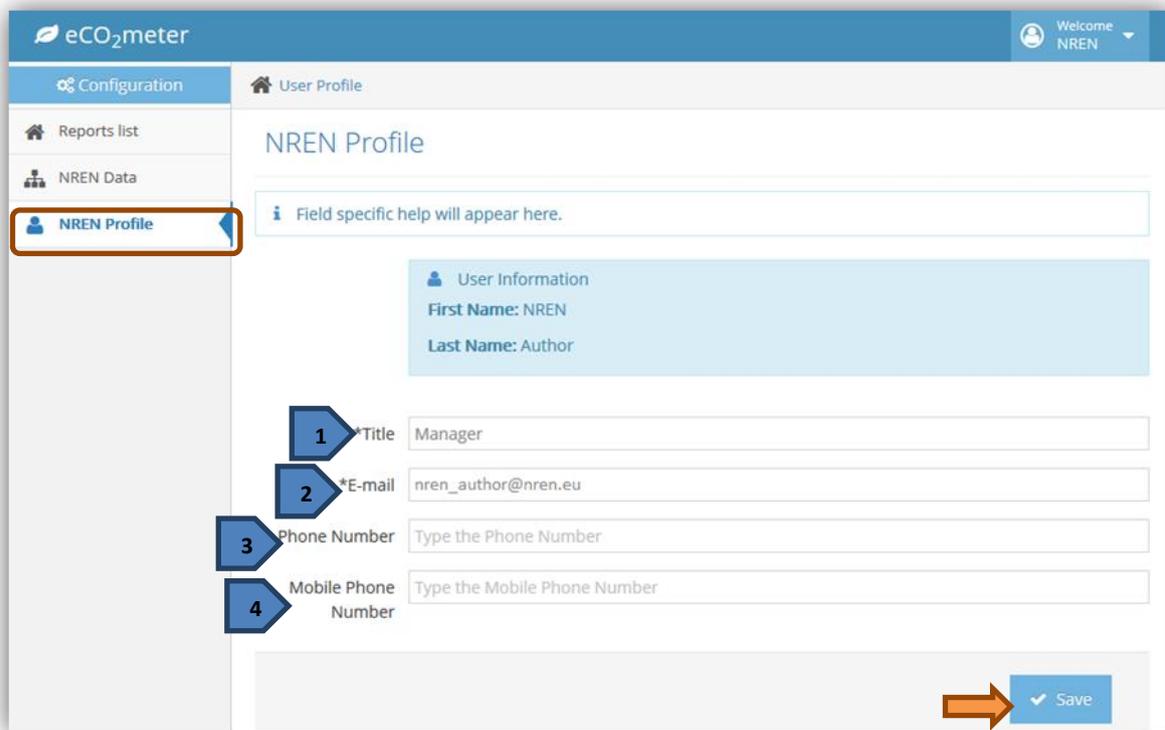

Picture 2. NREN Specific Data

2.3 USER PROFILE

In the "User Profile" page (picture 3), the user is able to see the "User Information" box. In case the user needs a change in already filled fields, please contact eco2meter@grnet.gr. Fields marked with an **asterisk** are **mandatory.**

1. *The title of the person that is responsible for the conduction of the Green House Gas Emissions Report for the NREN.
2. *The e-mail of the person that is responsible for the conduction of the Green House Gas Emissions Report for the NREN.
3. The telephone number of the person that is responsible for the conduction of the Green House Gas Emissions Report for the NREN.
4. The mobile telephone number of the person that is responsible for the conduction of the Green House Gas Emissions Report for the NREN.

Picture 3. User Profile

3 CREATE A REPORT

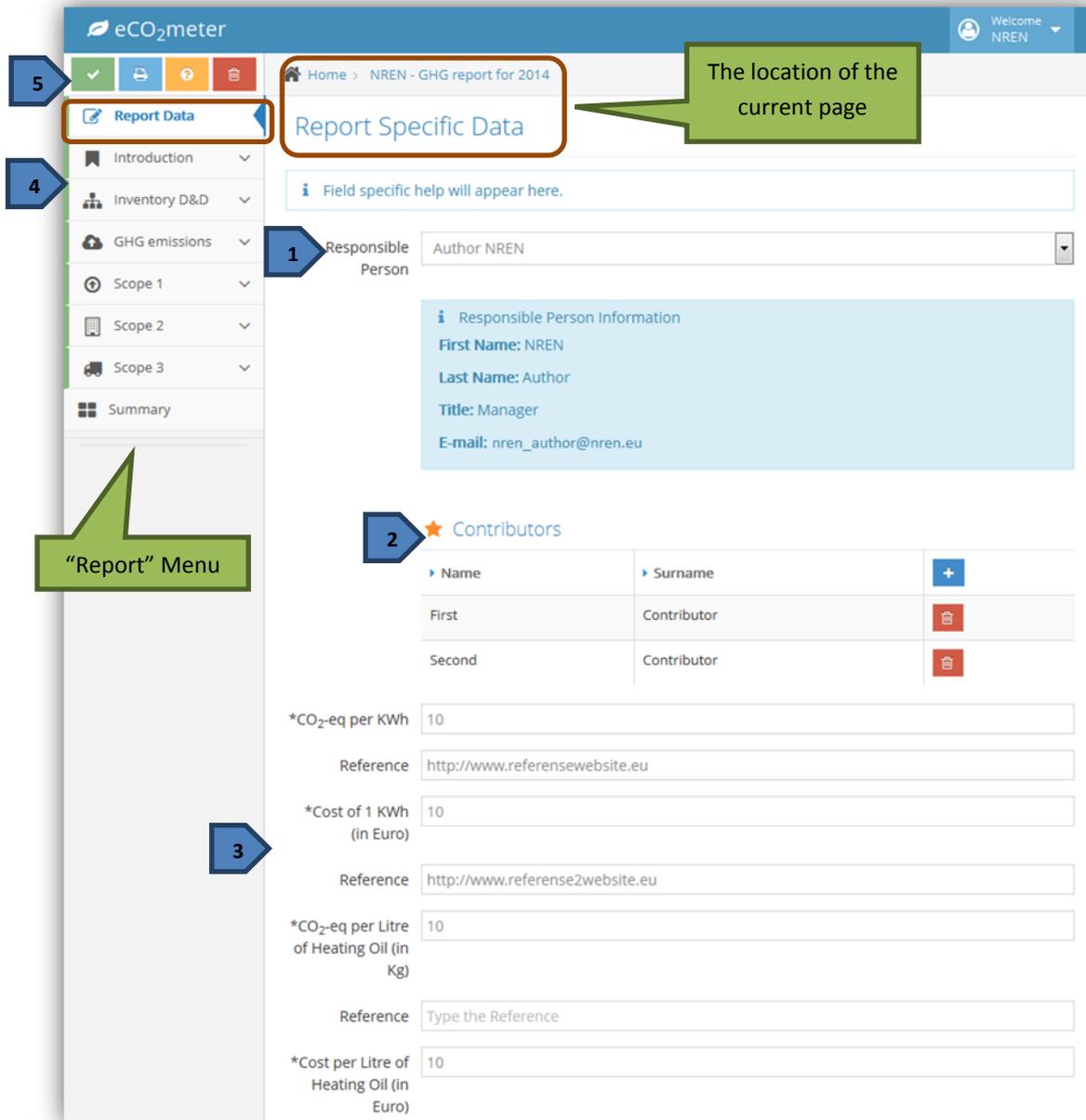This chapter contains all the details about the creation of an annual GHG report for a NREN.

3.1 REPORT SPECIFIC DATA

In the "Report Specific Data" page (pictures 4 & 5), the user inputs data regarding this year's GHG report.
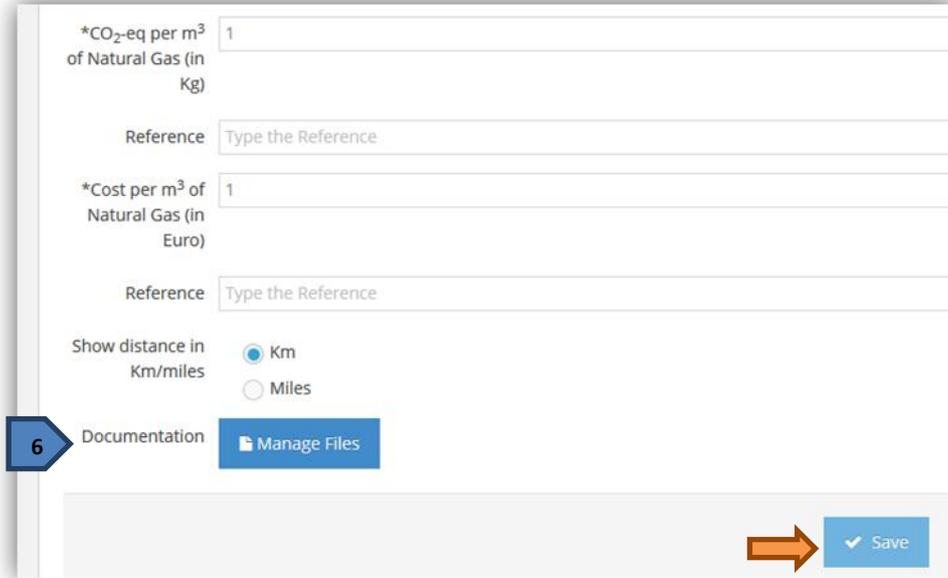
1. First, the user must identify the responsible person for this GHG report. The user is able to choose one person from the provided list (only users associated with his NREN are listed).

2. If applicable, name(s) and surname(s) of one or more contributors may be added

3. The user should insert the mandatory (marked with an *) data that will be used from the eCO_2meter in order to perform the necessary calculations. References are not obligatory, but may be used to provide justification.

   - *CO_2-eq per KWh: The electricity emission factor for the country at the specific year. Note: The effect of CO_2 is 1, since by definition effect of CO_2 is 1 CO_2-eq.

   - Reference: The URL justifying the electricity emission factor for the country at the specific year (for example the corporate social responsibility and sustainability report of the utility operator).

   - *Cost of 1 KWh (in Euro): The cost of 1 kWh in the country at the specific year. Note: This info is necessary only if the user has bills that do not correspond to kWh and the user needs to assume them from the cost.

   - Reference: The URL justifying the cost of 1 kWhr in the country at the specific year (for example the corporate social responsibility and sustainability report of the utility operator).

   - *CO_2-eq per Litre of Heating Oil (in Kg): The emission factor for the country at the specific year. Note: The effect of CO_2 is 1, since by definition effect of CO_2 is 1 CO_2-eq.

   - Reference: The URL justifying the emission factor for the country at the specific year (for example the corporate social responsibility and sustainability report of the utility operator).

   - *Cost per Litre of Heating Oil (in Euro): The cost of 1 lt of Heating Oil in the country at the specific year. Note: This info is necessary only if the user has bills that do not correspond to lts and the user needs to assume them from the cost.

   - Reference: The URL justifying the cost of 1 lt of Heating Oil in the country at the specific year (for example the corporate social responsibility and sustainability report of the utility operator).

   - *CO_2-eq per m^3 of Natural Gas (in Kg): The emission factor for user's country at the specific year. Note: The effect of CO_2 is 1, since by definition effect of CO_2 is 1 CO_2-eq.

   - Reference: The URL justifying the emission factor for the country at the specific year (for example the corporate social responsibility and sustainability report of the utility operator).

   - *Cost per m^3 of Natural Gas (in Euro): Please provide the cost of $1m^3$ of Natural Gas in the country at the specific year. Note: This info is necessary only if the user has bills that do not correspond to m^3 and needs to assume them from the cost.

   - Reference: The URL justifying the he cost of $1m^3$ of Natural Gas in the country at the specific year (for example the corporate social responsibility and sustainability report of the utility operator).

4. Color Coding: The left edge of the "Create Report Menu" has coloration. The color coding is shown in Picture 6.

5. Menu Buttons: There are four buttons:

   - Finalize: if selected, the GHG report is finalized and thus it is available to other users in a pdf format.

- Preview pdf: Ability to see a preview of the produced pdf format of the GHG report as it is at the moment.
- Help: Ability to download the user manual
- Delete: deletes the current report

6. Documentation: a storage area that is allocated to each NREN for uploading files used for the realization of the report (e.g. energy consumption bills etc). By pressing the "Manage Files" button a small window pops-up. (Pictures 5, 7 & 8).
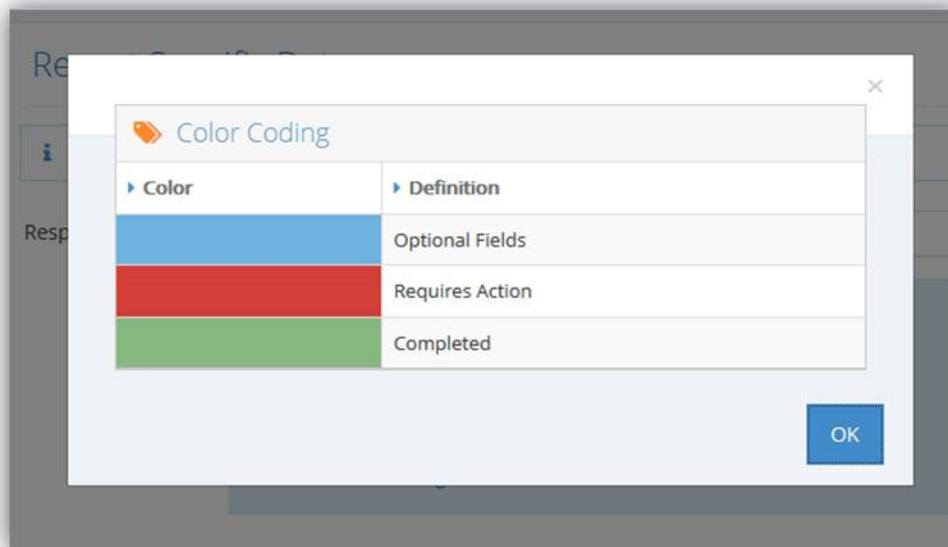

Picture 4. Report Specific Data 1/2

Picture 5. Report Specific Data 2/2

Picture 6. Color Coding

In the "manage files" pop up window, the user is able to:

1. See the added files, their names and description
2. Edit the entry (a) or delete each file (b)
3. Press the "+" button to add a new file. The window will change to a new one, where the user can
4. Add name and description for the new file
5. Select it for uploading
6. And finally submit it
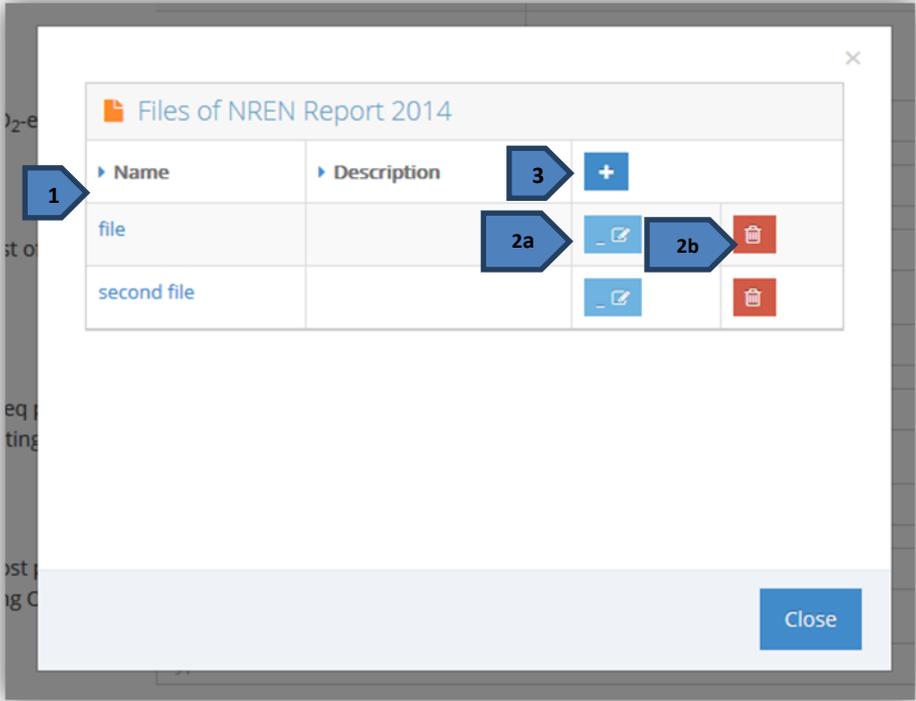
Picture 7. Manage Files ½
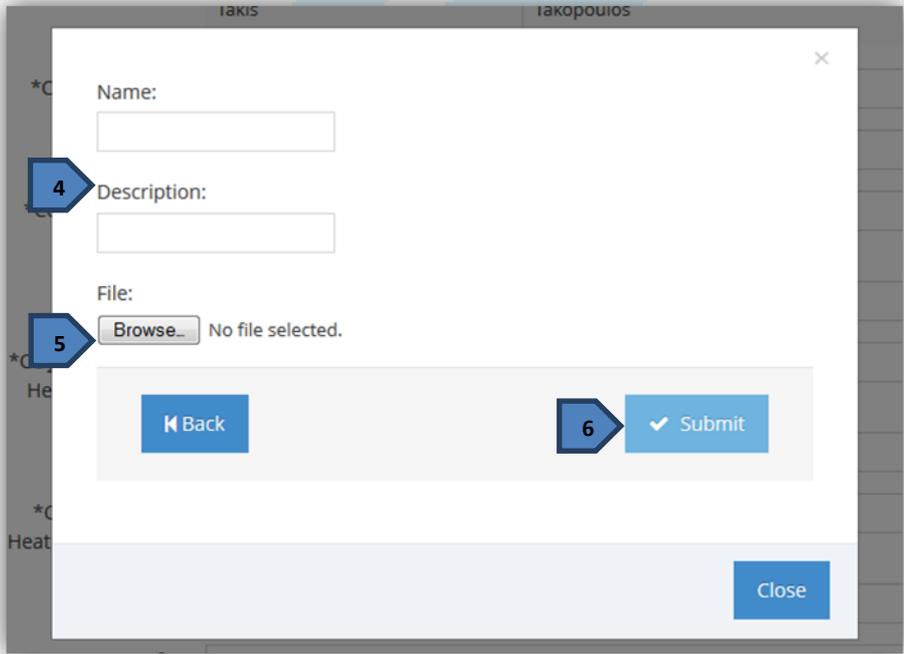
Picture 8. Manage Files 2/2

3.2 INTRODUCTION

The section includes the motivation that led to the conduction of the report and its scope, an extend description of NREN's purpose and profile with emphasis to green activities. In each subsection, the user may **instruct the Guideline** regarding what he is required to state. In several cases, there is available a **Sample** text that the user may use. The user is strongly advised to **check** whether the Sample text complies with his NREN. The Sample text, can be used either as it is or it may be edited accordingly. Note that if a box is left blank, it will not be included in the automatically produced pdf file. Fields with * are required.

3.2.1 INTRO TEXT

Throughout the eCO_2meter there are textboxes where the user is able to enter text. The user may instruct the Guideline regarding what he is required to state or to use – where available – the Sample text.

Additionally, the user has the option to add and manage references (picture 9).

Picture 9. Introduction

3.2.2 BACKGROUND

The user is able to provide information for his NREN and reason for selecting ISO 14064.

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 NRENs, it is important to adhere to recognized standards. In this instance, the ISO standard is the set of documents under ISO 14064 (ISO 14064-1, ISO 14064-2, ISO 14064-3). These documents are used to guide the form and content of the inventory process.

3.2.3 SCOPE

The user may provide information for the scope.

The primary goal of this assessment is to account for the Green House Gas (GHG) emission according to the ISO 14064:2006 part 1 standard. This information can be used for comparison with other NRENs, and for use by *[NREN]* for GHG assessments the following years.

3.2.4 NREN'S PURPOSE AND PROFILE

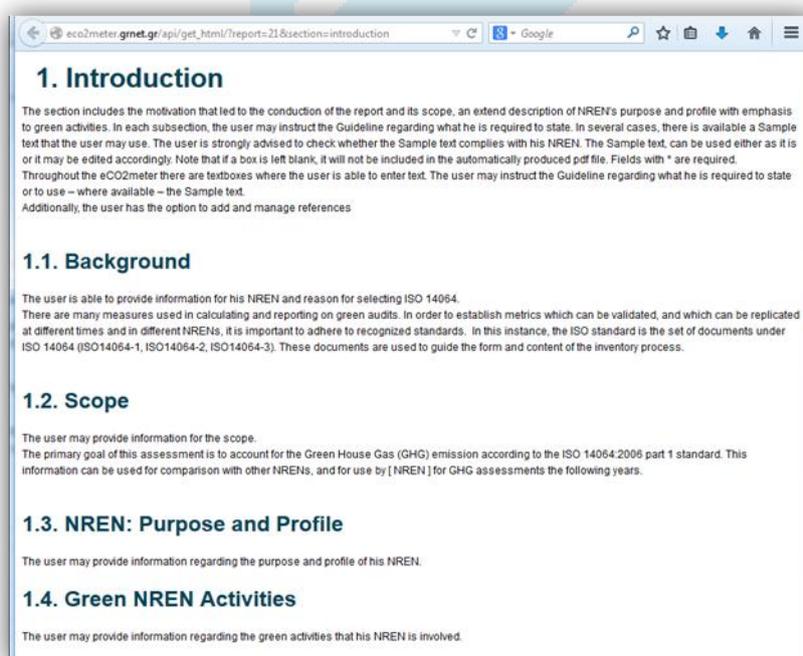The user may provide information regarding the purpose and profile of his NREN.

3.2.5 GREEN NREN'S ACTIVITIES

The user may provide information regarding the green activities that his NREN is involved.

3.2.6 PREVIEW

The user is able to see an HTML-coded preview of the current section, as it will be shown in the final pdf forma of the GHG report, on browser (picture 10).

Picture 10. Introduction Preview

3.3 INVENTORY DESIGN AND DEVELOPMENT

The section includes information regarding the organizational and operational boundaries, the responsible party, the reporting period covered, the base years and their changes and recalculations, and details regarding the compliance and verification statement. The user is advised to fill in the fields in each sub section accordingly.

In several cases, there is available a **Sample** text that may be used. The user is strongly advised to **check** whether the Sample text complies with his NREN. The Sample text, can be used either as it or it may be edited accordingly.

Note that if a box is left blank, it will not be included in the automatically produced pdf file. Fields with * are required.

3.3.1 INTRO TEXT

In this subsection, the user may add an introductive text.

3.3.2 ORGANIZATIONAL BOUNDARIES

Boundaries for a GHG inventory include both the organizational boundaries and the operational boundaries. Organizational boundaries refer to defining which facilities are recognized as part of organization conducting the inventory and should be included within this inventory. Operational boundaries refer to which operational activities at a facility are included in the inventory.

3.3.3 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.

3.3.4 VERIFICATION STATEMENT

This section describes whether the GHG inventory, report or assertion has been verified, including the type of the verification. If left empty, this subsection will not be included in the automatically produced pdf file.

Sample: This report was submitted for independent validation by "_......_" to assure that the report is in accordance with ISO 14064.

This resulted in a positive evaluation statement on [**_Date_**] of [**_Month_**] [**_Year_**].

3.3.5 PREVIEW

The user is able to see an HTML-coded preview of the current section, as it will be in the final report, on browser.

3.4 CALCULATING GHG EMISSIONS

3.4.1 INTRO TEXT

In this subsection, the user may add an introductive text.

3.4.2 GREENHOUSE GASSES AND CO_2-EQ DEFINITION

The greenhouse gasses (GHGs) are:

- Carbon dioxide (CO_2),
- Methane (CH_4),
- Nitrous Oxide (N_2O),
- Hydro fluorocarbons (HFCs),
- Per fluorocarbons (PFCs),
- Sulphur Hexafluoride (SF_6)

When GHG emissions are calculated, the impact of each GHG is transformed to a CO_2 equivalent. This is done by multiplying the emissions of a GHG by a factor that represents the effect of the GHG on climate change. These effects are based on the IPCC GWP100 factors. The effect of CO_2 is 1, since by definition effect of CO_2 is 1 CO_2-eq.

3.4.3 DATA USED FOR CALCULATING GHG EMISSIONS

The user is advised to describe in detail the different data sources used in order to calculate the GHG emissions of the distinct categories: office, data centers, backbone network and transportation.

3.4.4 IMPACT OF UNCERTAINTIES ON THE ACCURACY OF THE DATA

The user is advised to describe the impact of uncertainties on the accuracy of the GHG emissions and removals data. It is a section of **high** importance where specific percentages for each uncertainty, should be provided. One typical uncertainty exists in the estimation of emissions that are due to transportation, since the accurate and updated emission factors per type of transportation are not available. Thus, emission factors are based on existing carbon footprint calculators.

Another typical uncertainty appears when real time monitoring of energy consumption of the computational, storage and networking equipment is not available. In these cases energy consumption is based on their typical energy consumption, as detailed in the manufacturer's datasheets and therefore deviations may be present between the estimated and the real energy consumption. In specific cases that data is available for a specific node (e.g. a grid node) assumption can be made in similar nodes in other areas where power monitoring infrastructure is available.

3.4.5 PREVIEW

The user is able to see an HTML-coded preview of the current section, as it will be in the final report, on browser.

3.5 Scope 1: Direct GHG Emissions

3.5.1 Intro Text

In this subsection, the user may add an introductive text.

Direct (Scope 1) GHG emissions are defined as emissions caused by the combustion of fuels or direct emissions of GHGs. These emissions are characterized as Scope 1 according to ISO 14064. The section also includes information regarding GHG removals, possible exclusions and direct CO_2 emissions from the combustion of combustion of biomass.

3.5.2 GHG Removals

The user is advised to provide information on any removals of GHG by NREN. Normally NRENs do not directly cause such GHG emissions.

3.5.3 Exclusions

The user is advised to provide information on any exclusions.

3.5.4 Direct CO_2 Emissions from the Combustion of Biomass

The user is advised to provide information on any direct emissions due to combustion of biomass. Normally NRENs do not directly cause such GHG emissions.

3.5.5 Total CO_2 Emissions under Scope 1

The user inserts the number of total CO_2 Emissions under Scope 1, if any.

3.5.6 Preview

The user is able to see an HTML-coded preview of the current section, as it will be in the final report, on browser.

3.6 SCOPE 2: INDIRECT GHG EMISSIONS

This section covers the methodology used to quantify energy-indirect GHG emissions, by sector, within NREN boundaries. Indirect GHG emissions are caused by using energy produced by others (e.g. electricity or heat).

This section provides the Scope 2 GHG emissions for the offices, the data centers and the backbone network.

The user must fill in the fields in each sub section accordingly.

In several cases, there is available a Sample text that may be used. The user is strongly advised to check whether the Sample text complies with his NREN. The Sample text, can be used either as it is or it may be edited accordingly.

Note that if a box is left blank, it will not be included in the automatically produced pdf file). Fields with * are required.

3.6.1 INTRO TEXT

In this subsection, the user may add an introductive text.

3.6.2 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. Indirect emissions are calculated from activities in three main categories and for each category the NREN should provide information regarding: the facilities, the measurement method, sample and possible exclusions:

1. The office:

Indirect emissions in this area originate from: a. Electricity usage for the office itself. (Electricity is used for lighting, air conditioning and ventilation, desktop/laptop computers (not the network), coffee machines, displays, beamers, etc.), b. Electricity for building services.

(Notice: If the NREN as part of its office has a computer room (where are hosted servers/network components needed for the daily operation), the consumed energy there should be included in the office electricity usage or measured separately and then abstracted from the total amount in order to avoid double counting.)

All GHG emissions are indirect, and may be resulting from the consumption of electricity for power, lighting, heating and cooling and/or from the consumption of oil for heating. Additionally, it is calculated the electricity for building services. Outside the offices, energy is spent in lifts, lighting and security. The NREN must add the number of units used per bill for the corresponding year to arrive at the yearly amount. Then the total amount will be converted to tons of CO_2-eq based on how many kgr of CO_2-eq correspond to 1 KWh for the NREN's country in the specific year. The procedure is similar for others sources of energy.

2. Backbone Network:

This section regards energy consumption and emissions related to the backbone network. The network (or backbone) includes all the PoPs where network equipment, owned by the NREN, is located. This equipment may consist of:

- Optical network equipment consisting of optical amplifiers, (de)multiplex devices, wavelength switches, optical controllers and DWDM equipment

- IP network equipment consisting of routers
- Layer2 network equipment consisting of switches

For the network equipment, energy consumption values may be derived from existing documentation or from real time measurements.

3. Data centers:

This section regards energy consumption and emissions from Data centers that are caused from the storage, computing and networking equipment as well as supporting infrastructure such as cooling, ups, etc.

Energy consumption data for all the types of equipment is based either on real time measurements (in cases that it is possible) or in their typical energy consumption, as detailed in the manufacturer's datasheets. The total amount of KWhs is converted into tons of CO_2-eq based on how many kgr of CO_2-eq correspond to 1 KWh for the NREN's country in the specific year and on the PUE factor.

3.6.3 REASONS FOR SELECTION OF INVENTORY SECTORS

The user is advised to provide justification for the selection of the distinct categories.

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

3.6.4 THE OFFICE

Emissions may derive either from a smart meter installed in NREN's premises or from an overview of the service costs for the NREN premises (the user may also append a file with all the power utility operator bills – or whatever is available – for justification purposes).

The user must add a record for each of his NREN's premises. For each record, sources of energy must be added: electricity, heating oil, natural gas or services electricity, as appropriate and fill in the relevant fields. (Services electricity refers to the electricity for building services. Outside the office, energy is spent on lifts, lighting and security.)

At any point, the user can alternate between inserting the energy consumption (from smart meter values or utility operator bills) and the cost of that energy source.

The user can either insert a record for every bill/month/quarter and the calculations will be done automatically to arrive at the yearly amount or the user may insert the yearly amount (select the appropriate period each time).

Algorithm for the calculations:

- Energy consumption from smart meter or utility operator bills: tons of CO_2–eq = (Energy consumption (in kWh) * kgr of CO_2–eq per kWh) / 1000
- Cost from utility operator bills: tons of CO_2–eq = [(Cost for energy source (in euros) / cost of 1 unit of source of energy) * kgr of CO_2–eq per unit)] / 1000
- Consumption of oil/natural gas: tons of CO_2–eq = (Consumption (in liters/m3) * kgr of CO_2–eq per liter of oil/m3 of natural gas) / 1000

kgr of CO_2–eq per unit (KWh, liter of oil, m3 of natural gas) and cost of 1 unit (KWh, liter of heating oil, m3 of natural gas) derive from the values given in the "Report Specific Data".

3.6.4.1 INTRO TEXT

In this subsection, the user may add an introductive text.

3.6.4.2 GHG EMISSION OF THE NATIONAL RESEARCH AND EDUCATION NETWORK'S OFFICES

In this page, the user is able to add details about his NREN's premises GHG emissions (picture 11).

1. First of all, the user must click the "Add Office" button, to add a record for each premise.
2. Then, he must input info in the required fields , and click save
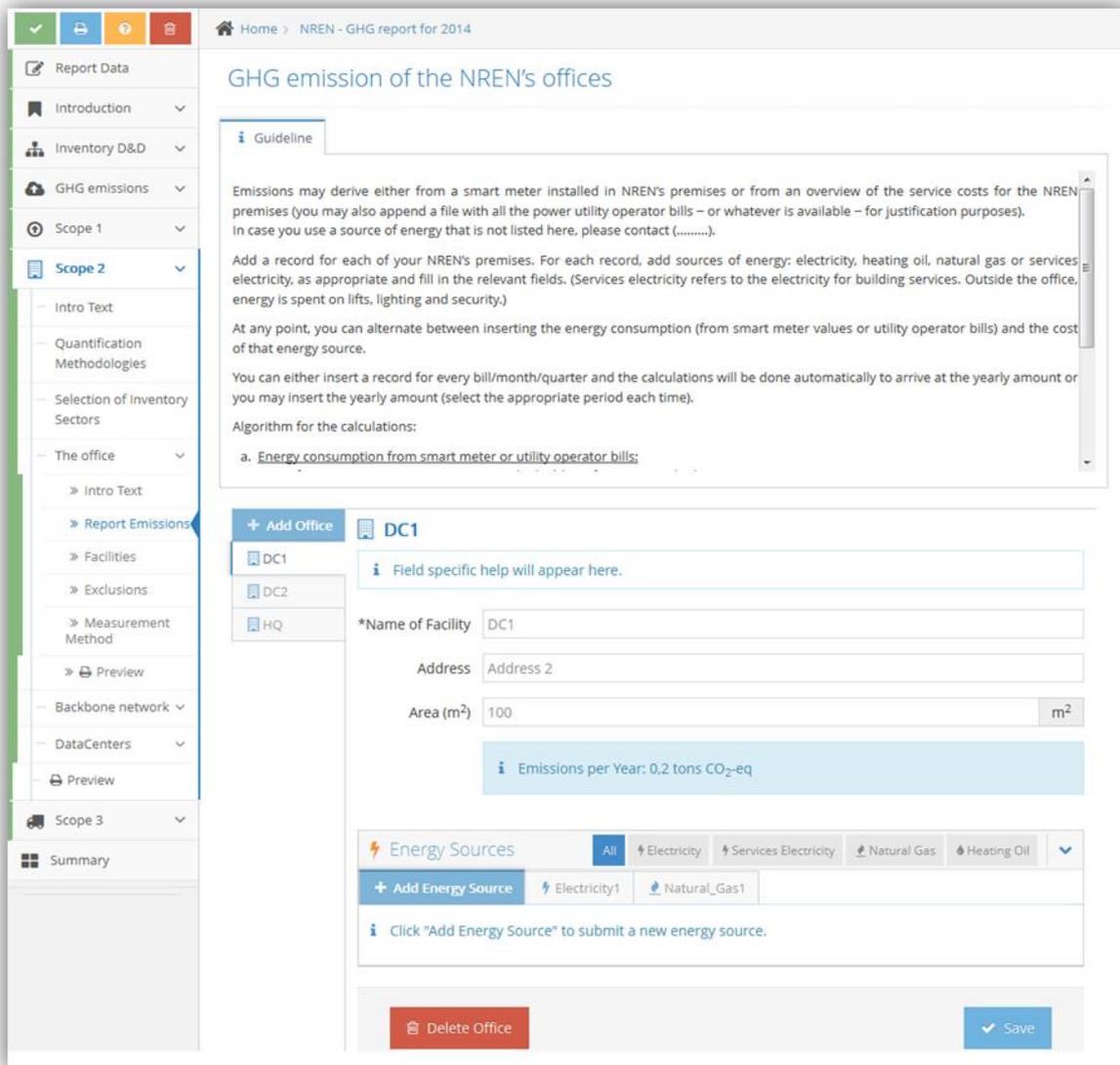
3. In each office's window, there is an "Add Energy Source button"
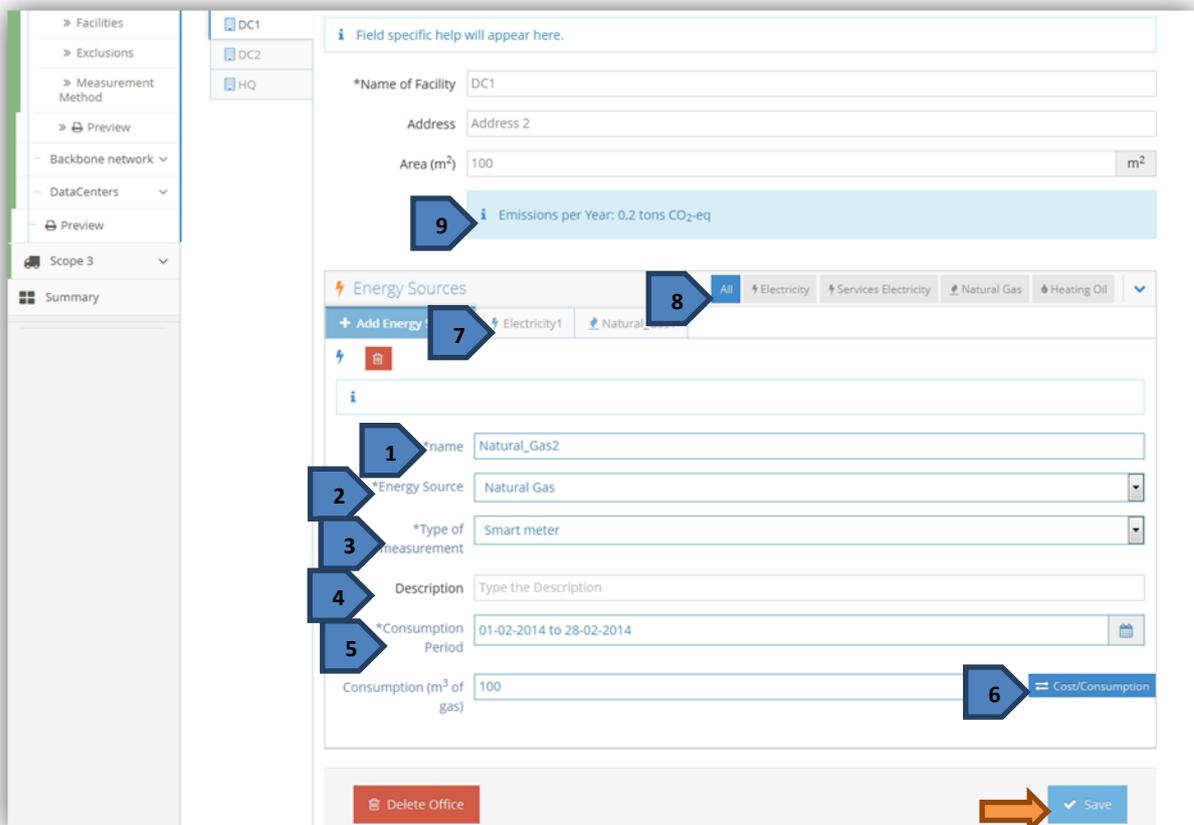
Picture 11. Add Office

Next, the user is able to add details about energy consumption (picture 11).

1. *Enter a discrete name
2. *Choose energy source from the list:
   - electricity

- Services electricity (refers to the electricity for building services. Outside the office, energy is spent on lifts, lighting and security)
- natural gas
- heating oil

In case the user uses a source of energy that is not listed there, please contact eco2meter@grnet.gr .

3. *The user must choose the type of measurement (either smart meter or bill from utility operator)
4. Optionally a description may be added
5. The user must define the consumption period from the calendar provided
6. At any point, the user can alternate between inserting the energy consumption (from smart meter values or utility operator bills) and the cost of that energy source.
7. In this page, the user is able to see the older entries , and may choose to see the entries from each energy source (electricity, services electricity, natural gas and heating oil) or all the entries(**8**)
8. In the blue box, the user is able to see the overall emissions per year for each office (**9**)

Picture 12. Add Consumption

3.6.4.3   FACILITIES

In this subsection, it is calculated the electricity for building services. Outside the offices, energy is spent in lifts, lighting and security. The NREN must add the number of units used per bill for the corresponding year to arrive at the yearly amount.

3.6.4.4   EXCLUSIONS

The user is advised to provide information on any facilities excluded.

3.6.4.5 MEASUREMENT METHOD

This should be in accordance with the sources and the type of measurements the user has provided above.

3.6.4.6 PREVIEW

The user is able to see an HTML-coded preview of the current section, as it will be in the final report, on browser.

3.6.5 BACKBONE NETWORK

This section regards energy consumption and emissions related to the backbone network. The network (or backbone) includes all the PoPs where network equipment, owned by the NREN, is located. This equipment may consist of:

- Optical network equipment consisting of optical amplifiers, (de)multiplex devices, wavelength switches, optical controllers and DWDM equipment
- IP network equipment consisting of routers
- Layer2 network equipment consisting of switches

For the network equipment, energy consumption values may result either from real time measurements if monitoring infrastructure is available or from existing documentation.

The user must add a record for each of his NREN's PoPs. For each record the user must insert the equipment information, and fill in the relevant fields. At any point, the user can alternate between inserting real time measurements and maximum values from existing datasheets. At any moment the user can add new equipment by selecting "Add equipment model" and providing the appropriate information. Any model that is added is inserted in the database for future use of his NREN.

In case that the Total energy consumption in the PoP, including the networking and the supportive infrastructure, is available the user can fill in the corresponding value. In this case, this value will be used for the calculation of the energy consumption in the PoP.

The user may also state the yearly Total Network Traffic (incoming and outgoing) served by his network. This value will be used for the extraction of meaningful statistics. The facilities (PoPs) and equipment used in the previous report are already available. The calculation of the CO_2–eq will be done automatically, using values for conversion from the "Report Specific Data" Page.

The calculation process is as follows:

1. From Datasheet:
   Energy Consumption in KWh = [Max Power Consumption in W * Number of devices *24*365/1000]
   tons CO_2–eq = Energy Consumption in KWh * PUE * kgr CO_2–eq per KWh / 1000
   kgr CO_2–eq per KWh derives from the electricity emission factor given in the Report Specific Data.
2. If real time measurements exist:
   Energy Consumption in KWh = [Average real time energy consumption (in W) *24*365/1000]
   tons CO_2–eq = Energy Consumption in KWh * PUE * kgr CO_2–eq per KWh / 1000
   kgr CO_2–eq per KWh derives from the electricity emission factor given in the Report Specific Data.
3. If the Total Energy Consumption of the PoP is available:
   tons CO_2–eq = Energy Consumption in KWh * kgr CO_2–eq per KWh

kgr CO_2–eq per KWh derives from the electricity emission factor given in the Report Specific Data.

3.6.5.1 INTRO TEXT

In this subsection, the user may add an introductive text.

3.6.5.2 GHG EMISSION OF THE NATIONAL RESEARCH AND EDUCATION NETWORK

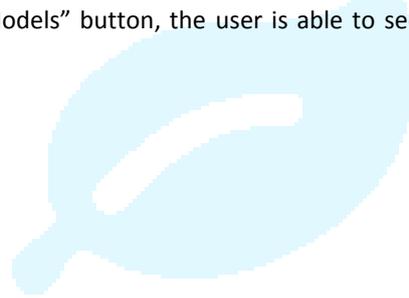In this page, the user is able to add all the PoPs where network equipment, owned by the NREN, is located.

1. When clicking the "Add PoP" button, form box is opened.
2. The user must insert the required values for each PoP :
   a. Name of Facility/Area: The name of each of the NREN's facility
   b. Location: Optionally state where the PoP is located,
   c. PUE: The Power Usage Effectiveness factor in the specific facility. Please note that PUE must be greater than 1.
   d. Monitoring Infrastructure: Select only, if the Total Energy Consumption in a PoP - including the networking and the supportive infrastructure is available
   e. If so, the user is prompt to type:
      i. Monitoring Infrastructure URI: The URI of the Monitoring Infrastructure (optional)
      ii. *Total Energy Consumption (KWh): Only if Total energy consumption in the PoP, including the networking and the supportive infrastructure, is available.
   f. In this case, no further calculations are made however the user may report equipment installed in this PoP for proper data collection and for statistical purposes.
   g. In the blue box, the user may see the total emissions per year for each PoP
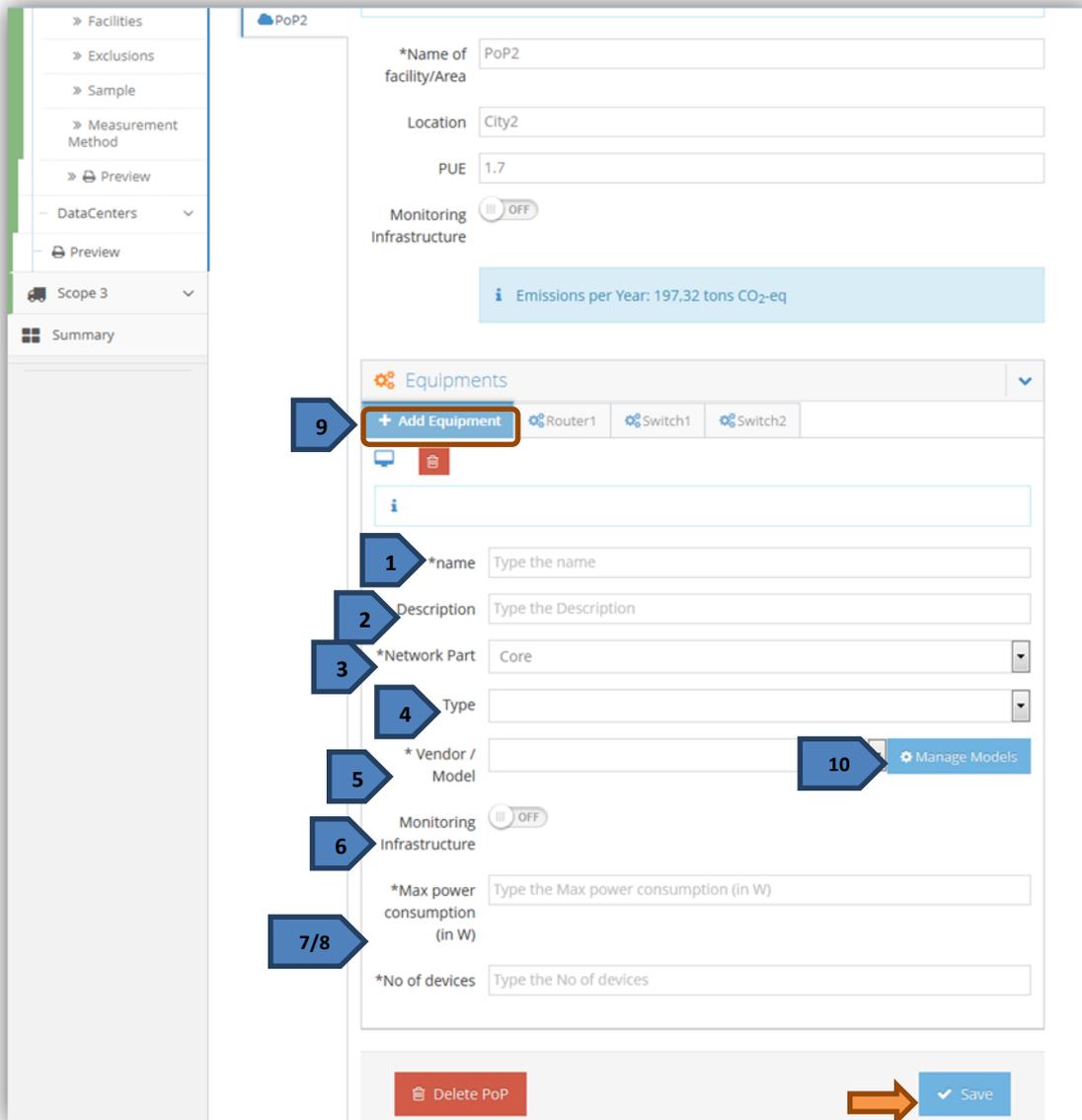   h. In this page, the user may also see or edit the rest of the registered PoPs
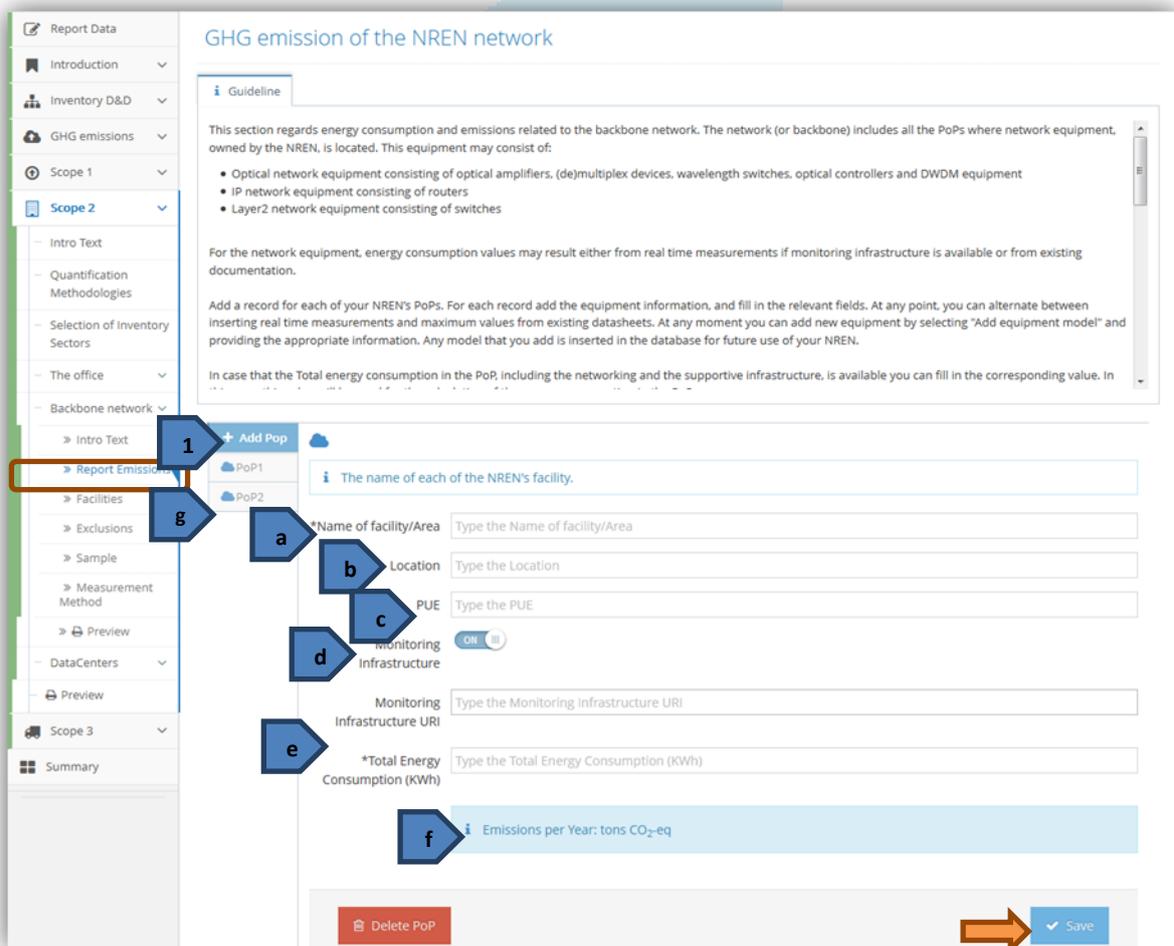
Picture 13. Add PoP

After adding a PoP, the user must add each PoP's equipment, by choosing a PoP, and clicking at the "Add Equipment" button (picture 14).

1. *Name: Add the equipment's name
2. Description: Description of the equipment. Useful in case of grouping multiple equipment of the same type. Optional field.
3. *Network part: Choose the part of the network, that this type of equipment belongs
    - Core
    - Access
    - Transport
4. Type: Choose the equipment's type
    - Layer 3 device
    - Layer 2 device
    - Optical equipment
5. *Vendor/Model: Choose the model of the equipment. (In case there are already submitted models. If not, see picture 15)
6. Choose if there is real time measurement for this equipment
7. If no, the user must add *number of identical devices. Maximum power consumption is automatically prefilled with the value that the user declared when registering the equipment model.
8. If yes, the user must fill the *Average Power Consumption (in W) and the Monitoring Infrastructure URI (optional)
9. In this page, the user is able to see all the equipment in the same PoP.
10. By clicking the "Manage Models" button, the user is able to see all the registered models, and add more (picture 15)

Picture 14. Add PoP's Equipment

In the "Manage Equipment" page, the user is able to see the registered models, or add a new equipment model (Picture 15).

1. *State the model
2. State the vendor
3. Enter the Maximum Power Consumption (W) based on manufacturer's datasheet (this value must be filled and will be used in calculations, if this equipment has no monitoring infrastructure)
4. Insert the Datasheet URL (optional)
5. Choose the type of model: a) Layer 3 device, b) Layer 2 device, c) Optical equipment
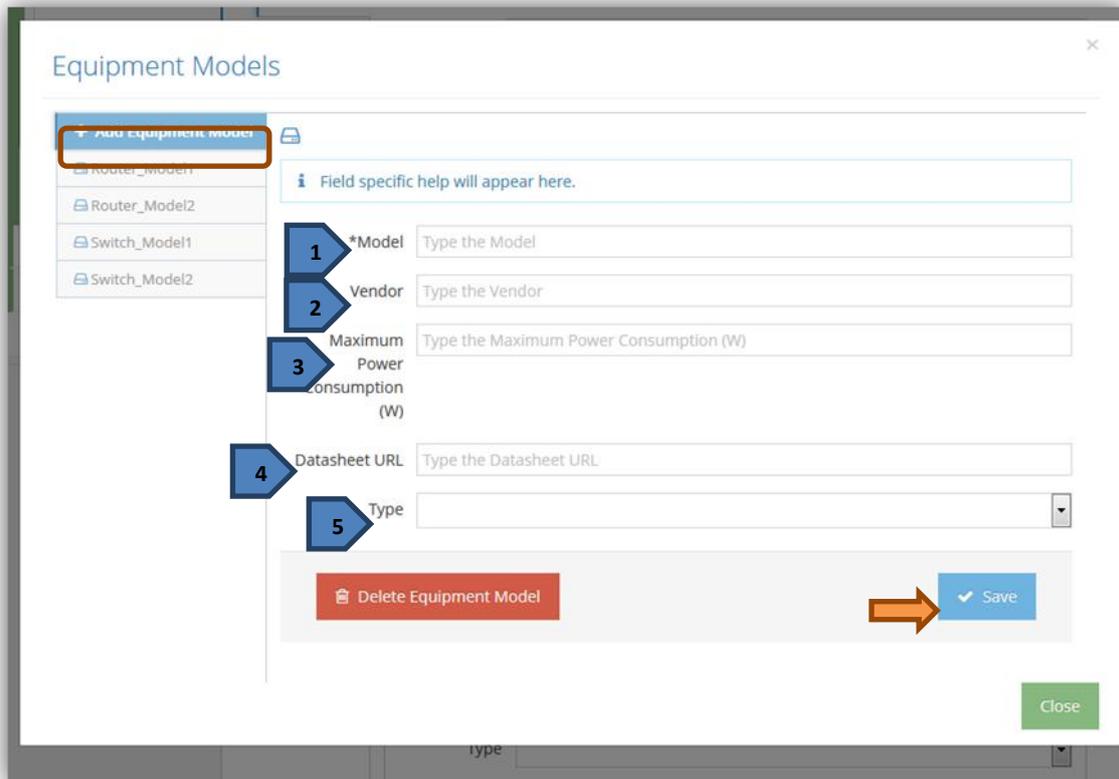
Picture 15. Manage Equipment

3.6.5.3   FACILITIES

The text provided must be in accordance with what the user has inserted above for calculation purposes.

3.6.5.4   EXCLUSIONS

The user is advised to provide information on any facilities excluded.

3.6.5.5   SAMPLE

The user is advised to provide information on any samples of measurements available.

3.6.5.6   MEASUREMENT METHOD

This should be in accordance with the sources and the type of measurements provided above.

3.6.5.7   PREVIEW

The user is able to see an HTML-coded preview of the current section, as it will be in the final report, on browser.

3.6.6 DATA CENTERS

This section regards energy consumption and emissions from Data Centers that are caused from the storage, computing and networking equipment and from the supporting infrastructure (such as cooling, ups, etc).

Energy consumption data for each Datacenter (IT and supportive infrastructure) is based on real time measurements (if monitoring infrastructure is available) or on typical energy consumption of the hosted equipment, as detailed in the manufacturer's datasheets.

There are two options for filling in the energy consumption of a DataCenter:

1. The total IT energy consumption and the PUE factor. Calculation process:
   tons of CO_2-eq = total IT energy consumption (in KWh) $*PUE*$kgr of CO_2-eq per KWh/1000)
2. The Total Energy consumption (IT + supportive infrastructure). Calculation process:
   tons of CO_2-eq = total energy consumption (in KWh) $*$kgr of CO_2-eq per KWh/1000)

kgr of CO_2-eq of CO_2-eq per KWh derives from the electricity emission factor given in the Report Specific Data.

The user may also fill in the minimum and the maximum values of the real time energy consumption and the number of racks in his NREN's DataCenters. These values will be useful for the extraction of meaningful statistics.

3.6.6.1 INTRO TEXT

In this subsection, the user may add an introductive text.

3.6.6.2 GHG EMISSION OF THE NATIONAL RESEARCH AND EDUCATION NETWORK

In this page, the user is able to enter details about his NREN's DataCenters (Picture 16).

1. *Name of Facility: The name of each of the NREN's facility.
2. *Location (City): The name of each of the NREN's DataCenter.
3. Area (m^2): The area of the facility. Optional.
4. No of Racks: The number of the facility's Racks. Optional. Will be used for the extraction of meaningful statistics
5. Minimum/Maximum Power Consumption (W): The minimum/maximum value of the real time energy consumption in NREN's DataCenter. Will be used for the extraction of meaningful statistics
6. The user must state if there is monitoring infrastructure installed
7. If there is no monitoring infrastructure, *total IT power consumption and the *PUE must be filled.
8. If there is monitoring infrastructure installed, the Monitoring Infrastructure URI and the *Total Energy Consumption (KWh) must be filled
9. In this page, the user is able to see the list with the other registered DataCenters
10. In the blue box, the user may see the total emissions per year for the specific DataCenter.
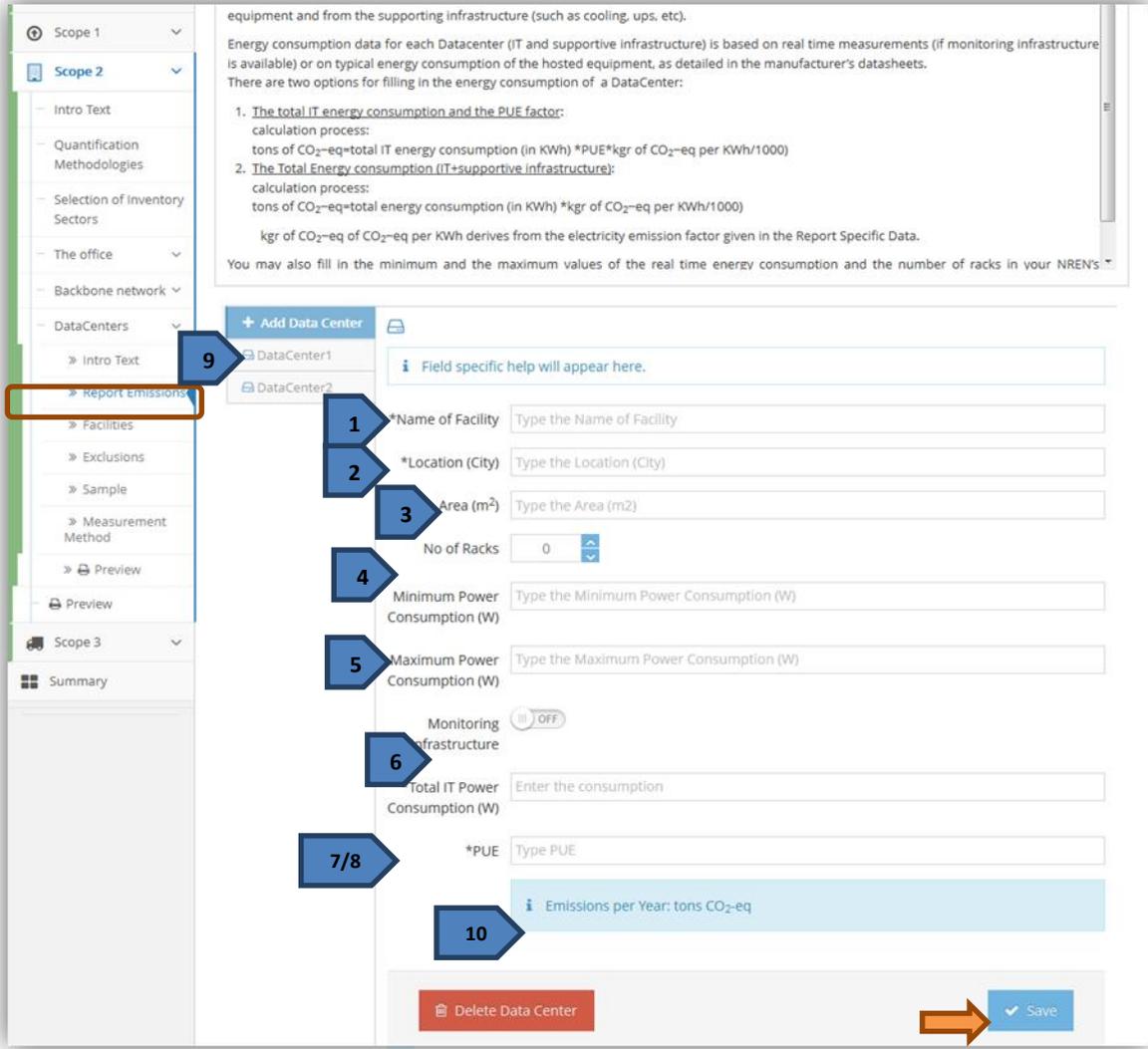
3.6.6.3 FACILITIES

The text provided must be in accordance with what the user have stated above.

3.6.6.4 EXCLUSIONS

The user is advised to provide information on any facilities excluded.

3.6.6.5 SAMPLE

The user is advised to provide information on any samples of measurements available.

Picture 16. Add DataCenter

3.6.6.6 MEASUREMENT METHOD

The text should be in accordance with what the user have stated above.

3.6.6.7 PREVIEW

The user is able to see an HTML-coded preview of the current sub-section, as it will be in the final report, on browser.

3.6.7 PREVIEW

The user is able to see an HTML-coded preview of the current section, as it will be in the final report, on browser.

3.7 SCOPE 3: OTHER INDIRECT GHG EMISSIONS

Transport is necessitated for NREN staff in commuting to and from work, and in the normal course of work. Transport "on mission", for instance, is involved in attending projects' meetings, 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 categorized 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

3.7.1 INTRO TEXT

In this subsection, the user may add an introductive text.

3.7.2 TRANSPORT

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

3.7.2.1 INTRO TEXT

In this subsection, the user may add an introductive text.

3.7.2.2 GHG EMISSION OF NATIONAL RESEARCH AND EDUCATION NETWORK'S TRANSPORTATION – COMMUTING

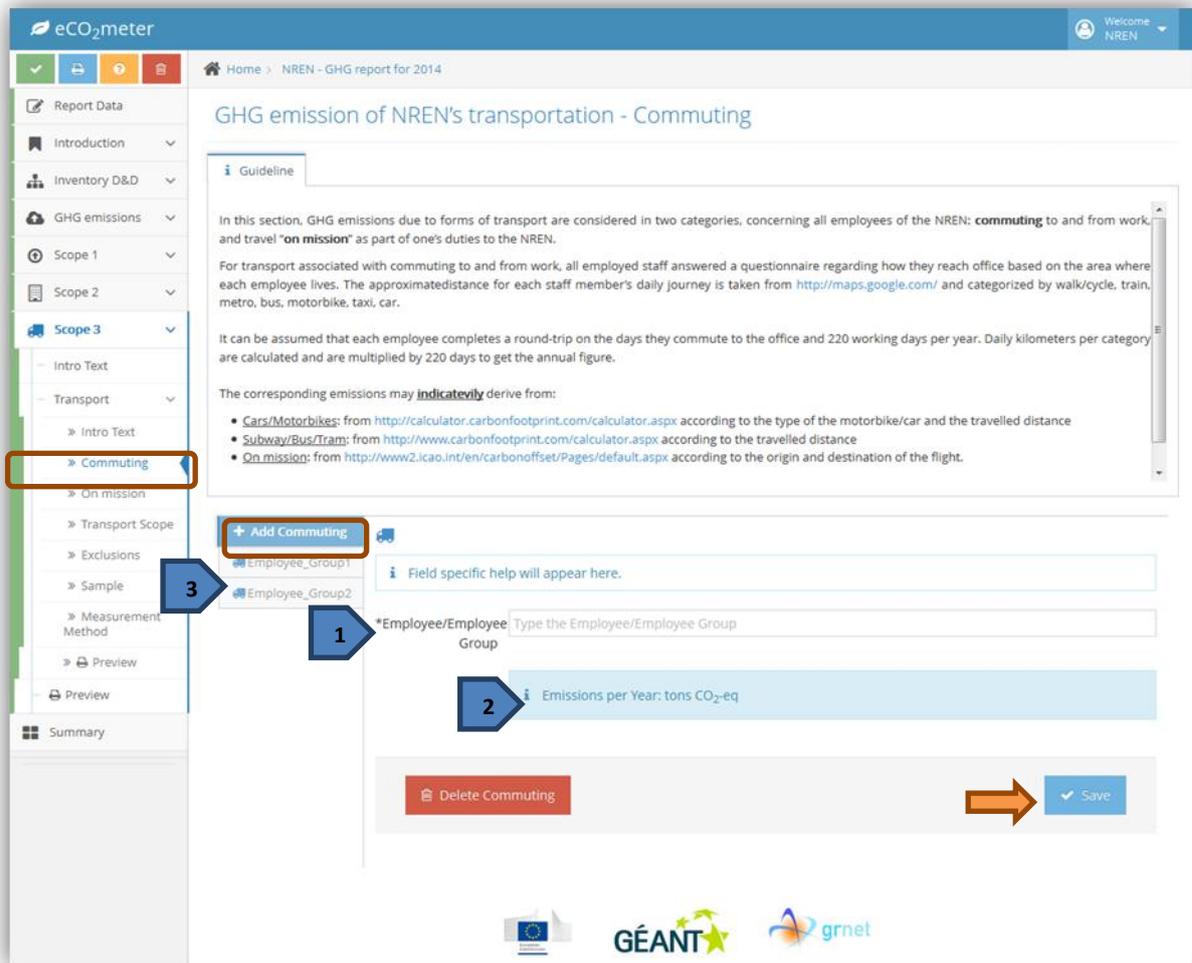In this page, the user can add information regarding his personnel's commuting (Picture 17).

1. The name of the employee or of a group of employees
2. The total emissions per year for each commuting.
3. The list of all registered commuting

For transport associated with commuting to and from work, all employed staff may answer a questionnaire regarding how they reach office based on the area where each employee lives. The approximate distance for each staff member's daily journey is taken from http://maps.google.com/ and categorized by walk/cycle, train, metro, bus, motorbike, taxi, car. It can be assumed that each employee completes a round-trip on the days they commute to the office and 220 working days per year. Daily kilometers per category are calculated and are multiplied by 220 days to get the annual figure.

The corresponding emissions may **indicatively** derive from:

- Cars/Motorbikes: from http://calculator.carbonfootprint.com/calculator.aspx according to the type of the motorbike/car and the travelled distance
- Subway/Bus/Tram: from http://www.carbonfootprint.com/calculator.aspx according to the travelled distance

eCO₂meter

- On mission: from http://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx according to the origin and destination of the flight.

Picture 17. Add Commuting

After clicking save, the user can add the type of transport used by each employee or a group of employees (Picture 18).

1. *Name: A descriptive name for the specific transport
2. Type of transport:
    - Car
    - Motorbike
    - Subway
    - Bus
    - Tram
3. Days per Year: The Working Days for the specific employee/employee-group per Year. This value will be used in the calculation for the Yearly Emissions.
4. Km per Day: The approximate distance for each staff member's daily journey is taken from http://maps.google.com and categorized by Car, Motorbike, Subway, Bus, and Tram.
5. The sum of Km done per year on each transport
6. *Emissions per Year (Kg CO_2-eq) By using a GHG calculator, (there are three indicates above) and the sum of Km per year, calculate the yearly emission of the specific employee
7. The list of the registered transports for each commuting
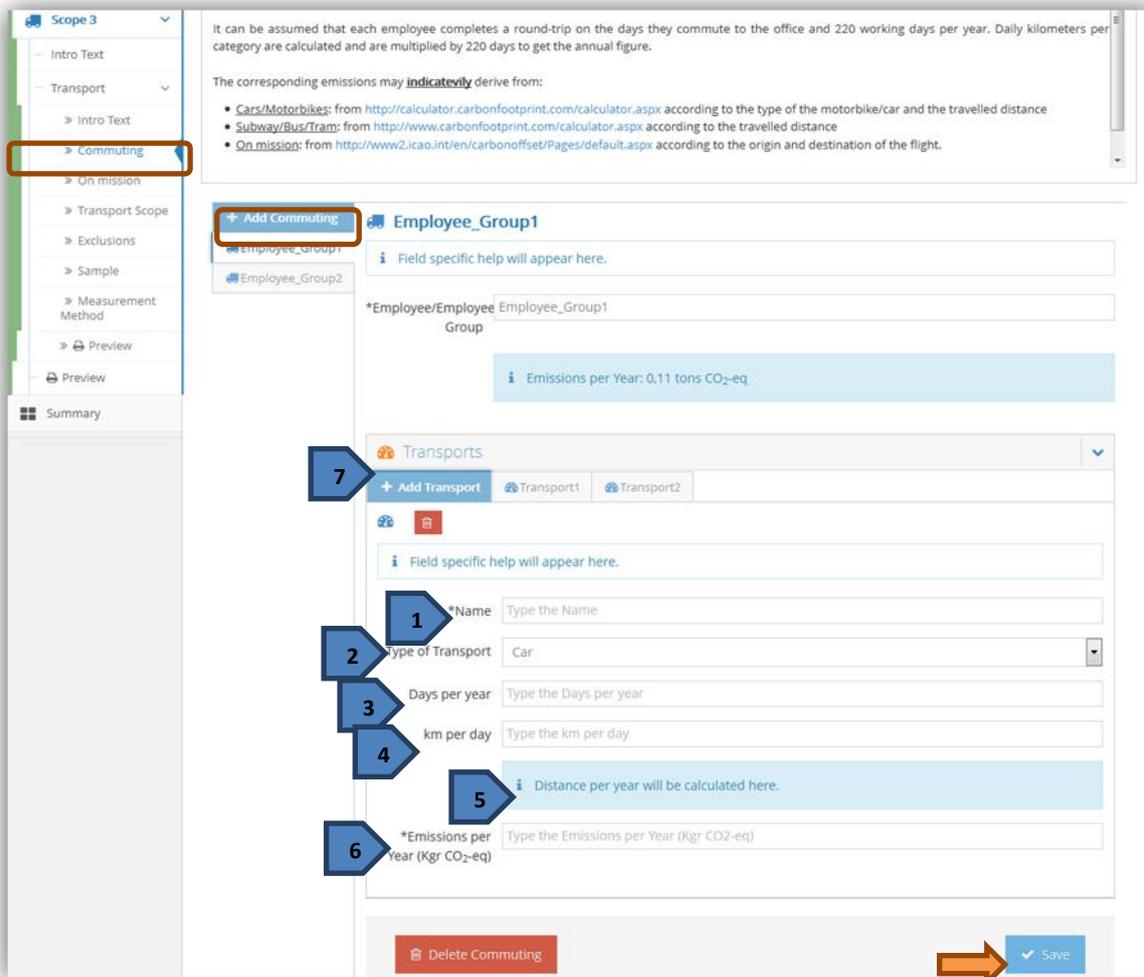
Picture 18. Add Transport - Commuting

3.7.2.3 GHG EMISSION OF NATIONAL RESEARCH AND EDUCATION NETWORK'S TRANSPORTATION - TRANSPORTS

In the case of transport used while on mission, the approximate emission of each flight is calculated from: http://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx (Picture 19).

1. *Trip Description: A descriptive name of each of the trip.
2. *No of Trips: Useful when a specific trip is performed several times per year by the same or different employees
3. *Origin: The Origin of the Trip
4. *Destination: The Destination of the Trip
5. Distance (km): The distance in km per round trip. Optional field.
6. *kg CO_2 equivalent per trip: The emission per round trip from the appropriate calculator. This value will be multiplied by the number of trips to arrive at the total amount. This calculation will be done automatically.
7. A list of registered trips.
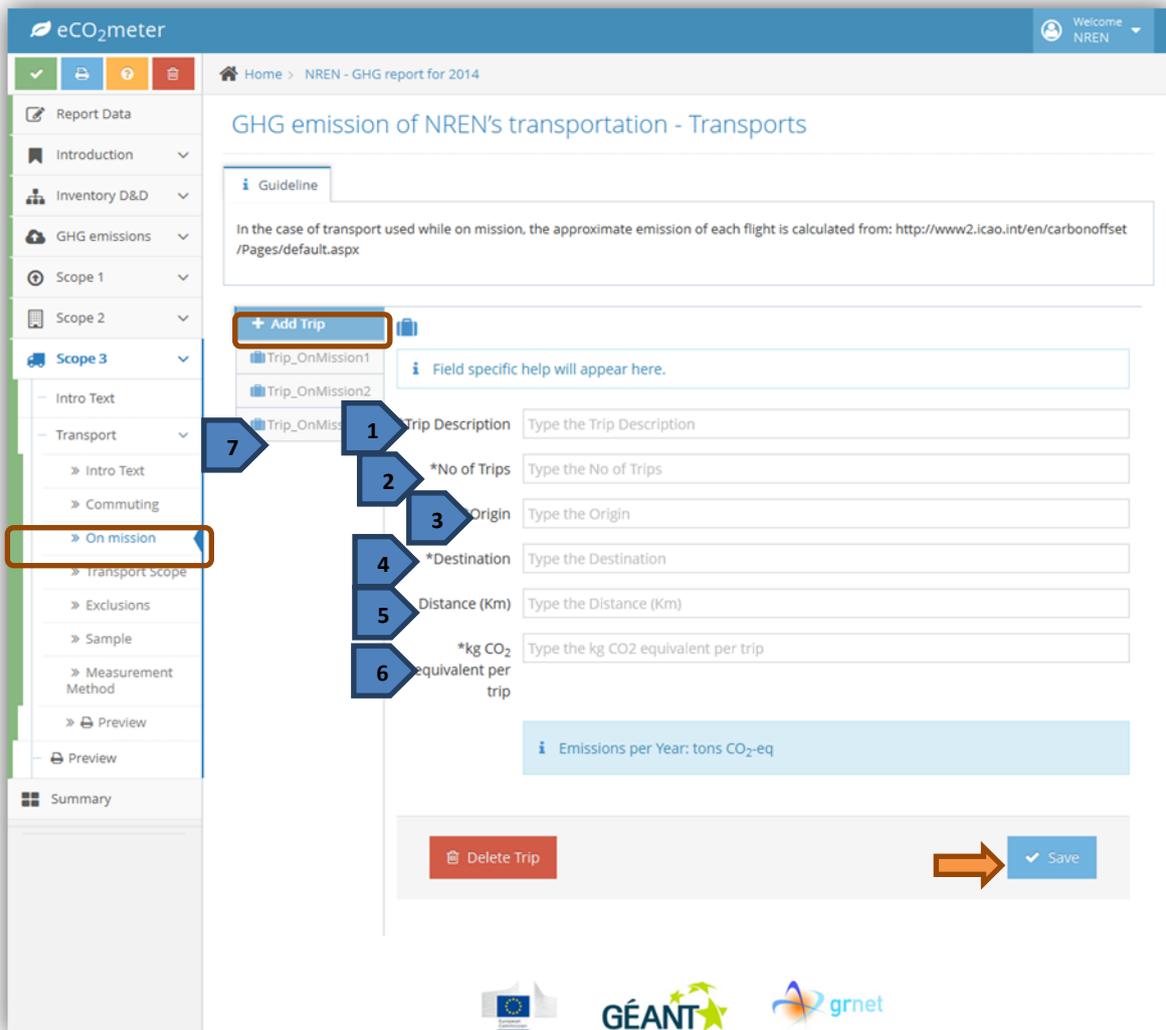
Picture 19. Add Trip – On mission

3.7.2.4   SCOPE OF TRANSPORT

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

3.7.2.5   EXCLUSIONS

The user is advised to provide information on possible exclusions.

3.7.2.6   SAMPLE

The user is advised to provide information on any samples of measurements available.

3.7.2.7   MEASUREMENT METHOD

For transport associated with commuting to and from work, all employed staff answered a questionnaire regarding how they reach office based on the area where each employee lives. The approximate distance for each staff member's daily journey is taken from http://maps.google.com/ and categorized by walk/cycle, train, metro, bus, motorbike, taxi, car.

It can be assumed that each employee completes a round-trip on the days they commute to the office and 220 working days per year. Daily kilometers per category are calculated and are multiplied by 220 days to get the annual figure.

The corresponding emissions may indicatively derive from:

- Cars/Motorbikes: from http://calculator.carbonfootprint.com/calculator.aspx according to the type of the motorbike/car and the travelled distance
- Subway/Bus/Tram: from http://www.carbonfootprint.com/calculator.aspx according to the travelled distance
- On mission: from http://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx according to the origin and destination of the flight.

3.7.2.8 PREVIEW

The user is able to see an HTML-coded preview of the current sub-section, as it will be in the final report, on browser.

3.7.3 PREVIEW

The user is able to see an HTML-coded preview of the current section, as it will be in the final report, on browser.

3.8 SUMMARY OF GHG EMISSIONS

In this page (Picture 20), the user can see a summary of all of his NREN's GHG emissions.

By completing all the previous steps, the color coding on the left of the "Create Report" menu should be green on each category, and the user can **finalize** the report by clicking the green box above the menu.

Picture 20. Summary Table of GHG emissions