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Deliverable D3.3
Annual Report Green Team

Deliverable D3.3

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Abstract
This deliverable describes a wide range of initiatives undertaken by the partners in GN4-1 Networking Activity 3 (Status and Trends), to reduce environmental impacts in general, and emission of greenhouse gases (GHGs) in particular. It builds on the previous initiatives undertaken in GN3plus.

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Executive Summary

This Annual Report describes a wide range of initiatives undertaken by the partners in GN4-1 Networking Activity 3 Status and Trends, Task 3 The GÉANT Green Team (NA3, T3), to reduce environmental impacts in general, and emission of greenhouse gases (GHGs), in particular.

The work plan of NA3 T3 is to build initiatives around the following set of objectives and topics, including:

- Provide a forum for sharing information on green policy and practice.
- Publish baseline and longitudinal studies of NRENs' GHG-reduction performance.
- Develop and adopt standards to measure overall NREN network environmental performance.
- Set targets for efficiency and for use of carbon offsets.
- Increase the uptake of services that are based on or that generate carbon-reduction effects, such as virtualisation, teleworking, videoconferencing, etc.
- Develop NREN insights and practices on Green ICT, so that others may benefit.
- Start to investigate the impact of climate change in the NREN operational workspace.

The work plan (outlined in Section 2) had to accommodate five new National Research and Education Network (NRENs) joining the team, and significant effort was expended to transfer knowledge gained from previous iterations of this Task and to build the competencies of these welcome new team members. The effort and lessons learned from this knowledge-sharing was also used to inform students from universities in Macedonia and Montenegro, as well as to coach additional staff from those two NRENs. External feedback showed the students' appreciation of the valuable knowledge transfer that was achieved.

In the past, the GÉANT Green Team's approach to NA3 T3 has been to generate a number of tools that will help NRENs to build their competence in environmental sustainability. New team members were encouraged to use these tools, such as the template created to help NRENs to quickly generate an environmental policy. An environmental policy typically describes the philosophy of an organisation and why it considers environmental sustainability to be an important process that should be supported. Such aims must then be translated into activities or areas of focus, and a set of energetic action statements developed to indicate how each NREN will pursue its corporate responsibilities. All the new NRENs have used this approach to generate their environmental policies, which are published on the GÉANT website [ENV_POLICY].

To improve daily work practices and target areas where energy usage can be reduced, it is vital to measure current activities and establish energy usage patterns. It is difficult to target a single set of equipment types or locations; the total network architecture and users' needs must be considered as

a whole. One of the tools to provide this background information is the greenhouse gas emissions GHG-audit-style report, which measures how much impact on the Earth's atmosphere is caused by the NREN's daily activities [GN-GHGAUDITS]. To simplify the reporting of this impact, in GN3plus the team developed an online audit support tool, eCO_2meter [eCO_2meter], and database based on the GHG audit template developed as part of the work undertaken in GN3. This allows easy report creation and enables benchmarking of results between NRENs. eCO_2meter and its supporting documentation and training aids have been reviewed by a third-party auditor who is in the process of certifying that it is a valid tool to help NRENs prepare for third-party certification audit. This tool has now been enhanced to produce comparison reports for NREN activity, which help highlight whether there are nominal differences in each NREN's energy usage, taking into account the different size and maturity of the NRENs. The report-generation facility is interactive and can compare NRENs' performance for each measurement category. It can also produce a graphical output report of an NREN's performance over a number of years.

Support initiatives by the GÉANT Green Team cover many areas of an NREN's daily business, and campus best practice-style documents and test cases are being created to disseminate this knowledge. Synopses of a selection of these documents, as well as a sample of the test cases, are provided in Section 3.2.

Communication is vital to the success of the team, and much activity is concentrated on making other NRENs aware of the team's work, which includes showcase and webinar training sessions as well as presentations at relevant conferences.

As environmental sustainability is such a large subject, with challenges that ICT specialists cannot always envisage but that are vitally important for users to address, the team works with other organisations that promote environmental awareness, such as the Green Campus Eco-University initiative [ECOUNIVERSITY]. Such initiatives indicate that it is possible to demonstrate ICT competence and show how ICT, with increased user awareness of sustainability procurement and disposal practices, can have a positive influence against the effects of climate change. Such effects will influence the architecture and direction of NRENs. The team will pursue and build competencies to identify the characteristics of such change, which will help NRENs to model new or re-engineered business-continuity plans. HEAnet has been successful in its pursuit of Green Campus Partner status and were awarded certification in November 2015.

Rather than lose the momentum of the past work, the Green team liaised with other groups to see how the sustainability awareness efforts could be supported and extended in future work / initiatives of GÉANT. The team has helped found the new Special Interest Group Sustainable Community Practices in Europe (SCOPE), which will carry on the work of both the Green Team and the Campus Best Practice team after GN4-1. A manifesto to determine the best ways to publicise the new team has been developed, and the charter for this group is now available [SCOPE-SIG].

1 Introduction

The United Nations General Assembly Resolution *Transforming Our World: the 2030 Agenda for Sustainable Development* [UN-Transform] states: “We are determined to protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations.”

Seventeen goals have been identified, each of which focuses on an aspect of sustainable development. At least eight of the goals offer examples of where ICT can be used to promote this sustainability, providing opportunities to reduce the impact of climate change through the use of renewable energy resources as well as promoting education and business practices.

The Global e-Sustainability Initiative (GeSI) reports in 2008 and 2015 also show the direct impact of the ICT sector, and assess the enabling abatement effects of ICT. The most recently published SMARTer2020 report, issued in June 2015, has emphasised that the ICT sector’s greenhouse gas emissions are expected to account for 2% of the global greenhouse gas emissions by 2030, and data centres would also account for a future 4%. However, in the same timeframe, ICT can enable a 16% reduction of global CO_2 emissions. In other words, the emissions by other industry sectors that could be reduced through the use of ICT could be nearly 10 times larger than the emissions generated by deploying these same ICT solutions.

As the world witnesses the explosion of traffic volumes in communications and data networks caused by the expansion of the worldwide broadband subscriber base and the increasing number and diversity of connected applications, services, devices and objects account for most of the increase. The increased traffic volumes and connectivity requirements necessitate continuous development and deployment of new technologies and infrastructures to deliver the expected performance and user experiences. The resulting energy consumption and energy cost of the broader communications infrastructure (including communication networks, connected devices and data centres) are quickly becoming one of the major challenges for the ICT industry. The benefits of ICT are undisputed. It enables a more prosperous, more accessible and more sustainable future for all. It is nevertheless also the responsibility of the ICT sector to effectively manage its own impact on the environment.

“The Greening of ICT” is the theme that the NA3 T3 team has continued to pursue as part of the GN4-1 Status and Trends Activity, and the approach has been to develop awareness of how an NREN should develop its own method and implementation strategy to promote sustainability in its daily work practices. Five new NRENs have joined the team in 2015, and have been encouraged to develop environmental policies and work with their management teams to define strategies and operational plans to implement their policies in their work environment. This also involves knowledge dissemination to their clients. GÉANT has produced an environmental policy [ENV_POLICY] and generated a New Ideas Form (NIF) to sustain the first year of operational support for their work activities.

The GÉANT Green Team [GREENGÉANT] recognises that business pressures, such as the demand for continuous connectivity to the activities of their clients, especially to support e-learning facilities, are counteractive to trying to reduce energy usage in ICT networks and services. Awareness of a global climate change has increased the need to change operating practices, and while energy reduction will help reduce the impact of global warming, strategies to mitigate against disruptions caused by severe weather require NRENs to build more complex resilient networks to ensure network availability for their users.

In October 2014, the International Telecommunication Union (ITU), United Nations Framework Convention on Climate Change (UNFCCC) and Deutsche Telekom released a report, *Resilient Pathways: The adaptation of the ICT sector to climate change* [RPICT]. The report emphasises:

…the need to adopt resilient pathways of action in order to effectively respond to the challenges posed by climate change. This report provides proposals to foster the adaptation of the ICT sector, and provides concrete examples of the way in which ICT companies are responding to these challenges. (See Figure 1.1.)

Climate change is a fact. According to UNESCO, the world has been experiencing continuing, extreme weather events. The UNESCO Climate Change Initiative seeks to reinforce the scientific, mitigation and adaptation capacities of EU Member States. It brings together four thematic areas: science, education, ecology and ethics to address climate change.

NRENs must lead initiatives to cultivate a more sustainable society from within their organisations. Furthermore, an NREN can promote the use of Green ICT services in higher education through dissemination activities with users and other interested parties. Sector and local action results from optimising equipment deployment and maximising its reach and impact.

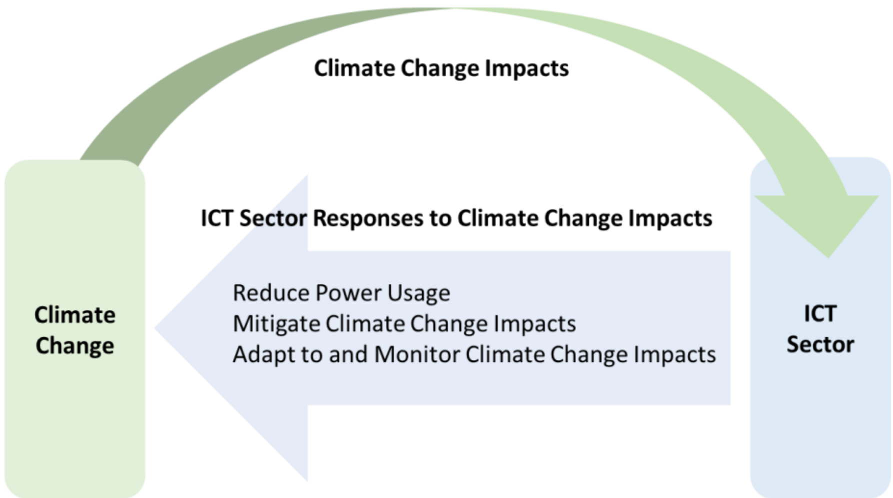

Figure 1.1: ICT sector responses to climate change impacts *Source: [RPICT]*

Many generic ICT solutions require central coordination, brokering or infrastructure, which some of the larger NRENs are particularly well placed to offer, and smaller NRENS are analysing how they may have to provide brokerage or similar types of shared services. Through the facilitation of NRENs, the research and education sector can set an example for the broader society. This is not something that is undertaken lightly, and it is important for the NREN community to develop a step-by-step approach.

The GÉANT Green Team's activities for Greening ICT Services in GN4-1 make use of NRENs' contributions at international, national, sector and local levels. Considerable focus was placed on training the new NREN members of the team so that they were in a position to generate environmental policies and GHG emission reports. The new team members brought new project ideas, which are reflected in the variety of areas covered by the test case documents that are being produced by the group in 2015 and 2016.

1.1 In This Document

This report presents a range of partner initiatives to extend and implement the reach of sustainable development and energy reduction within an NREN environment.

Section 2 presents a work plan that takes on board feedback on the Green Team's previous work and stimulates best practice on Green ICT adoption.

Practical examples from test cases that cover policy, tools development and practical approaches to reduce energy use are found in Section 3.

Section 4 discusses the use of the CO_2meter tool and provides updated GHG energy audits and a comparison of results.

Section 5 highlights a range of training material developed and delivered during the course of the project as well as information on the Team's dissemination actions.

A summary of GN4-1 accomplishments and future activities are collected in Section 6.

2 Work Plan

2.1 Background

At the end of GN4-1, the GÉANT Green Team has completed the work plan produced at the start of the project, developing and capitalising on the work carried out in GN3 and GN3plus by the "Study of Environmental Impact" and "Greening of ICT" Tasks, respectively. NRENs occupy a unique position that can be exploited to stimulate ideas and promote best practice on the adoption of Green ICT for and by society, including: research centres, the higher education community, as well as industry and government. The team realised that in order to maximise the positive impact NRENs can have, collaboration is needed between all parties: higher education, industry and government. It is also the responsibility of the team to stimulate, form and support such collaborations. The work undertaken in GN4-1 is to promote the meaning of Green ICT for its NREN team members. This is to study how to minimise the impact of daily work practices on the environment and minimise carbon footprint while promoting collaboration amongst all NRENs and the HE community, in this respect. Therefore, most of the work in this Task has been focused on stimulating collaborations and disseminating approaches to environmental sustainability for the NREN community, higher education, industry and government.

As of March 2016, the following NRENs are members of the GÉANT Green Team, with five new NRENS joining for GN4 Phase 1 (indicated with an asterisk):

- AMRES (Serbia)
- ASNET (Armenia)*
- CARNET (Croatia)*
- CESNET (Czech Republic
- CyNet (Cyprus)
- GÉANT (organisation: UK and the Netherlands)*
- GRNET (Greece)
- HEAnet (Ireland)
- MARNET (Macedonia)*
- MREN (Montenegro)*
- NIIF/HUNGARNET (Hungary)
- SURFnet (Netherlands)UNINETT (Norway).

2.2 GÉANT Green Team Objectives

The team's work plan at the start of GN4-1 included the following objectives

- Provide a forum for sharing information on green policy and practice.
- Publish baseline and longitudinal studies of NRENs' GHG performance.
- Develop and adopt standards to measure overall environmental performance.
- Set targets for efficiency and for reducing emissions or compensation against future emissions of carbon dioxide or GHG.
- Increase the uptake of services that are based on or generate carbon reduction effects, such as virtualisation, teleworking, and videoconferencing.
- Develop local NREN insights and practices on Green ICT, so that others may benefit.
- Recruit NRENs in a positive drive to reduce greenhouse gas emissions.

2.3 Applying Previous Feedback

Feedback

Feedback from the reviewers of previous environmental Task deliverables in GN3 and GN3plus suggested that the team should pursue the following objectives:

- Raise environmental impact issues, to both the European Commission and European Institutions, and participate in all relevant initiatives and events.
- Increase the actions of GÉANT partners within their own countries in order to promote the ideas of mitigating environmental impact.
- Ensure that ICT professionals have the required knowledge to handle the environmental impact issues and are capable of designing solutions and operating systems in accordance with the Green ICT rules.
- Mobilise the end users of ICT products in order to change habits and to ensure that they purchase and use ICT devices that are compatible with Green criteria and are more environmentally friendly.
- Recognise (reward) enterprises or organisations that adopt and apply Green ICT.
- Promote good practices on environmental impact by adopting a Green ICT certification or a Green ICT mark/sign.
- Include more end-user use cases in the report (e.g. universities/campuses experience when adopting Green Team recommendations). This could also include future plans regarding the adoption of next generation networking technologies, such as the use of SDN/NFV technologies and their potential energy efficiency within an NREN infrastructure.
- Include a short section at the end of use cases describing "Results" or "Recommendations". Even if the use case is in a primary stage, initial feedback regarding the results based on existing work is meaningful.

- Undertake a study with statistics/comparisons among NRENs taking into account location (e.g. clustering per geographical areas), model for provision of services (e.g. hosting of services in own infrastructure), etc.
- Carry out an impact analysis showing the environmental and cost impact of the adoption of the Green Team's tools and best practices from NRENs during the next five years would be recommended to help enforce policy making and international collaboration.

The GÉANT Green Team proactively develops tools and materials that can be shared with peer NRENs and users. Environmental policy, including the environmental impact of the GÉANT backbone, has been one of the key focus areas for GN4-1 as a whole. Each NREN will have its own organisational remit, but overarching objectives and continued knowledge sharing will help to strengthen project outcomes. Plans were developed to set up an active monitor on the GÉANT backbone in summer 2015; these were later adapted to use sampled recording of power usage for reasons relating to cost, the low opportunity to get a return on investment from energy savings, and the complexity of the setup impacting the live production network.

Response to Feedback

Since last year, NRENs that are GÉANT Green Team members have been working within their organisations to promote their environment policies and encouraging the development of working strategies such as the HEAnet, CyNet and GÉANT environmental strategies. Part of this activity has been to facilitate induction training for new employees or to hold knowledge dissemination events. Some of the test cases included in Section 3 show how the NRENs are now considering the ways in which their users' work environment changes, such as the Raspberry Pi client utilisation in the classroom, and the Digital Examinations process analysis and procedure development. NREN users are also exposed to the decision criteria of why their network needs a technology refresh, and that this equipment replacement is expected to bring energy savings as well as the capability to increase bandwidth capacity and increased service support capability. Users are also being briefed on any environmental benefits that result from technical changes to the equipment supporting their network connectivity such as CPE Aggregation and evaluation of power cycling smaller clients CPE to save on energy costs.

eCO_2meter has been enhanced to allow NRENs to compare their performance versus that of their peer NRENs. During discussions between Green Team members, it emerged that most differences in the four categories being modelled in the GHG Emissions reports are usually explained in terms of how an NREN carries out its business, its size, the services that the NREN supports and the particular services that are being expanded during that period of time. All test case studies now include results and recommendation sections in both their short descriptions and the more detailed documents uploaded on the Green Team's Wiki page [GREENWIKI].

The Green Team has had to consider how it will continue its work program as part of the new SCOPE SIG and has actively promoted training with all the NREN members to help sustain their interest to promote and disseminate knowledge about Green activities supported within their own organisations.

2.4 Scope of the GÉANT Green Team

The above feedback aligned with the team's own GN4 objectives, and a work plan was created with the following tasks for the duration of the project:

- Encourage NRENs to generate environmental policies and to live by such policies, where practical.
- Challenge NRENs to evaluate their energy usage and the sources from which they obtain their energy supplies.
- Promote good practices of such equipment usage and reduction of waste in support offices, data centres and the network deployment locations.
- Actively demonstrate the advantages of ICT to users to help reduce their environmental impact.
- Engage staff to assess environment impact of technology selection and solution deployment reflected in their procurement and tender documents.

By the end of the project this work plan will have been delivered and will be enhanced by any future work programs in this subject area.

2.5 Benefits

The GÉANT Green Team has successfully delivered the following benefits for Team participants. Note that these benefits are expected to grow beyond the Team NRENs and reach the whole NREN community.

- Competency in good work practices for sustainability.
- Best practice guidelines to aid business implementations on top of the normal networking considerations for the NREN community.
- Ability to query the impact of energy consumption in lifecycle costing when selecting equipment.
- Promotion of waste-reduction policies for energy usage.

2.5.1 Supporting Actions

A team workshop was held in April 2015 to identify specific actions to progress and support the work during GN4-1. These have been completed and are listed below:

- Increased the new GÉANT Green Team members' knowledge of previous GÉANT Green Team activities, while encouraging co-operation between team members.
- Developed an action plan for test cases and research studies for 2015–16 that will be reported as individual test cases and summarised in the GN4-1 Report to Reviewers (Periodic Report). Each NREN has undertaken to produce at least one test case study during the lifetime of the project. These studies will be of similar form/extent to the Campus Best Practice studies. (These are discussed in more detail in Section 3.2.) Test cases, which are described in more

detailed documents are shown in the links '[TESTCASE NAME]', included at the end of each short description section in Section 3.

- Increased use of the template developed for creating NREN environmental policy documents to stimulate all NRENs to think about Green ICT and sustainability. NRENs were also able to carry out a GHG Audit / Emissions Report for 2015 and use the eCO_2meter tool [eCO_2meter].
- Disseminated the GÉANT Green Team's work at several NREN gatherings (such as GÉANT symposia and GÉANT Association (formerly TERENA) Task Force meetings, TNC, I2GS, NORDUnet conference), as well as outside the NREN community at research, practitioner and policy conferences.
- During 2016, the team was informed that its work will not be funded in future, and therefore focused effort on consolidating the training materials for use by NRENs as required. The team members have also participated in discussions and a meeting to set up a Special Interest Group (SIG), along with colleagues from Campus Best Practices (Task 2 of NA3) [SCOPE-SIG].

3 From an Environmental or Sustainability Policy to NREN implementation

3.1 Migrating the Environmental Policy into a Working Strategy

Translating an environmental policy into operational activities requires long-term strategic thinking from the NREN Management team, as well as an organisation following a strategic plan that maps out its activities for a number of years and is endorsed by stakeholders. Most organisations want an implementation strategy based on its own policy, and the one example of approach is shown by the activities at GÉANT to agree an environmental policy and implementation strategy [ENV_POLICY]. In the style of the environmental policy template [ENV_POL_TEMPL]. This approach is very action-oriented. The key statements in an NREN's environmental policy should reflect strategic principles, correspond to day-to-day activities that promote sustainability in all three focus areas: in-house, national, and international activities.

Short Task Description

In trying to create a centralised GÉANT Environment Policy and to facilitate its adoption in the organisation, this test case shows the process to get GÉANT management approval. This is usually a multi-stage process, before a policy can be disseminated to staff members. Concrete steps have been taken to implement measures, where practically feasible taking into consideration business needs and budgetary requirements, from Environment Policy guidelines.

Purpose and Contribution Towards Team Goals

It is of paramount importance that GÉANT, as an organisation, shows its commitment towards developing and using Green ICT services, and also exhibits environment awareness in carrying out its business activities. Hence, the adoption of the GÉANT Environment Policy is an important step in ensuring that goals for environmental sustainability are set and can be used as a model of best business practice when considering environmental issues and taking positive steps to address them.

Results from Trial / Implementation

Post-adoption of an Environmental Policy in GÉANT, a New Ideas Form (NIF) was produced to furnish details about how the guidelines set in the policy document should be implemented within the organisation. The aim of such as policy document is not just adoption, but also implementation. In the NIF, a new project called 'Breaking Green' was introduced, which is about using ICT services for making a positive impact on the environment, and also make our office areas more environmentally friendly. The project, set to run from January to December 2016, is divided into three phases:

- Phase 1 (duration: 3 months): information-gathering exercise.
- Phase 2 (duration: 3 months): recommendations on how use of resources can be improved.
- Phase 3 (duration: 6 months): implement, in a phased manner, recommendations as given at the end of Phase 2.

One of the activities organised as part of the 'Breaking Green' project was the observation of 'Earth Hour' in GÉANT's Cambridge (UK) and Amsterdam (Netherlands) offices in March 2016. During this time, the lights were turned off in the office and a number of activities were held to increase awareness of a number of every-day, energy-saving practices.

3.2 Test Case Activities

As previously mentioned in this report, the work of EMAS has focused on business sectors that can dramatically help reduce carbon footprints by modification of daily work practices. A set of Best Environmental Management Practices (BEMPs) has been drawn up for each of these business sectors. These are not yet available for the telecoms sector, but includes the following areas of concentration:

- To improve the energy performance of telecommunications networks
  - Change of access network technology
  - Consolidating the location of network components
  - Consolidating data and optimise traffic using routing protocols
- To improve energy performance and to minimise the environmental impact of data centres
  - Better site location and planning of data centres
  - Optimising data centre utilisation and management
  - Efficient cooling technologies and systems
  - Airflow management and design and reuse of heat
- To improve energy performance of ICT equipment
  - Procurement for energy efficient equipment and installation
  - Improving energy efficiency of ICT equipment
- Cross cutting measures for minimising energy consumption and carbon footprint
  - Use of renewable energy sources
  - Reduction of energy usage due to electrical conversion
  - Energy monitoring and management
- Raw materials consumption and waste management
  - Improving life cycle asset management and waste prevention
  - Improving WEEE collection, recycling and recovery
- Environmental impacts of telecommunications and broadcast infrastructures
  - Reducing the impacts of ICT infrastructures on landscape
  - Reducing noise and electromagnetic radiations from networks
- Improving energy and environmental performance in other sectors
  - Reducing the impact of ICT Services

  - Reducing the environmental impact of other sectors through ICT services

The Green Team has worked on similar documents over the past two programmes and 14 test cases have been undertaken in GN4-1, which are categorised in three basic groups:

- **Policy or structured templates**: These activities involved the design of documents to mobilise work processes or further define communication practices to encourage environmental sustainability and future text-based research.
- **Tools**: These activities involved the design or use of software/hardware tools that can help measure the impact of policies introduced in NRENs' daily business activities.
- **Action**: These activities included an element of practical investigation order to assess the viability of approaches that NRENs are taking in trying to reduce energy usage or to develop a more sustainable work environment.

Policy

1. Digital Assessment in Norway
2. Investigate the Use of Renewable Energy Sources (RES)
3. Eco-Friendly Office Design
4. Recycling / Website - Phase 1 (research, idea, how it works)

Tools

5. GRNET Videoconferencing Services
6. PowMon POE Device Power Cycling Software Enhancements
7. Nagios monitoring and SMS based alerts in the academic network of the University of Montenegro

Action

8. Using Raspberry Pi as a Classroom Client Terminal
9. How a Network Technology Refresh can make an NREN'S Network Greener
10. How to Achieve Energy Savings by Functional Aggregation on Customer Premise Equipment CPE
11. Using ICT Design Guidelines to Improve Classroom Energy Efficiency
12. Moving Libraries to the Cloud in Serbia
13. Designing and Building an Environmental-Aware Data Centre
14. Power Cycling CPE at Small Clients to Save Energy
15. Power Consumption Measurements of a Photonic Testbed

Summaries of each of these test cases in the next section provide an overview of the investigations, with references for further reading. *The team will continually review the value of the test cases and present some of the findings as showcases / webinars, such as the lightning talk presented at the GN4-1 Symposium in Vienna, and invite feedback from a larger audience if there are any major changes required or if requests are received from interested parties.*

3.2.2 Policy or Structured Template Test Cases

3.2.2.1 *Digital Assessment in Norway*

Short Task Description

The task of de-materialisation is about moving away from old workflows, towards new digitised workflows, using digital solutions to work faster, smarter and to produce better-quality materials. The main goal of de-materialisation is to reduce the overall energy consumption by working smarter and support the move away from old workflows.

One area with an old and time-consuming workflow is assessment and grading of students. Today`s assessment practices in higher education are far from the digital advancements that are being developed and embraced in other areas of society. The digital ‘natives’ that attend higher education institutions today study and learn with their laptops/mobiles but when they turn up for their long-awaited examination, they are, in their own words, brought back to the stone age, and required to reproduce their knowledge with pen and paper.

UNINETT (the Norwegian research network) has established a national project to ensure that students have access to digital assessment, and that the whole workflow for digital assessment will be digitised. The project is operated in close collaboration with the educational institutions in the Norwegian higher education sector.

Purpose and Contribution Towards Team Goals

De-materialisation and digital assessment is about working smarter, moving from paper based procedures to digital procedures, reducing the time and energy spent, and improving the approach of the old written procedures.

The move to digital assessment will change the workflow for assessments, and thereby it will change the workload between stages of the assessment process. Phase 1 of digital assessment is about moving to digital procedures, later phases will include elements such as students taking their assessment test at home or at work, reducing the need for examination halls, assessment halls and travel.

Results from Trial/Implementation

Digital assessment is an immature technology area for Norwegian higher education institutions. Working together with UNINETT in a national project, a range of solutions for digital assessment were tested. The results from this testing is shared among the Norwegian institutions in the form of reports and Current Best Practice (CBP) documents. The content of the reports and CBP documents is also shared with the European community through the Green Team Working Group in GN4-1.

Recommendations

In this developing workspace, The Green Team suggested the use of CBP documents and other reports as pre-standardisation descriptions to generate a common terminology and a shared understanding of the needs and requirements for digital assessment. One of the positive aspects of the CBP process is the possibility to carry out an annual review of the CBP documents and update the standard approach as the market matures and further knowledge is gained about digital assessment solutions.

The CBP will also consider the legal aspects of moving to digital assessment and have sections focused on:

- Bring Your Own Device (BYOD).
- Risk assessment.
- Cloud services.
- Rights and responsibility in a digital world.

The use of commercial "cloud services" for running the digital assessment solution raise many questions, where the individual institution must undertake its own risk assessment.

Documents for the work process now include:

- CBP 43: Clients for digital assessment

  The working group looked at available client solutions for digital assessment, including the use of BYOD compared to institution-owned equipment.
  This document focuses on requirements and pro and cons of client solutions. It targets technical staff with responsibility for planning and hosting digital assessment at university.

- CBP 44: Architecture for digital assessment

  This CBP document is the combined work of two working groups, one on workflow for digital assessment and one on ICT architecture for digital assessment.
  The CBP documents describe an ICT architecture for a national solution for digital assessment and the consequences for the workflow at the university. The document targets the management and staff with responsibility for planning assessments at the universities.

- CBP 46: Integration for digital assessment

  A working group built on CBP44s identified key integrations. Data from existing systems should be reused in the assessment solution.
  The CBP document identifies six existing systems, defining which system hold the authorative data source, and describes integrations for exchange of data to/from the assessment systems.
  The document is targeting developers, system integrators and technical staff.

- CBP 45: Logging and monitoring of digital assessment

  While working with digital assessment, we discovered that the vendors of digital assessment solutions have a different approach to logging and monitoring.
  The CBP document defines and lists requirements for logging and monitoring, and describes policies for how to do logging and monitoring during digital assessment.
  The document is targeting management and technical staff with responsibility for planning and hosting digital assessment at universities.

- CBP XX (forthcoming): Legal issues regarding use of cloud services

  Several of the digital assessment software solutions are designed to be run as cloud services (private or public cloud). The CBP document lists the legal requirements and steps to follow for the successful use of public cloud services for assessment.
  This CBP document is generic and applies to cloud services for the university in general.
  The intended audience of the document is management and security staff responsible for moving services to public clouds [DIGITAL_ASSESSMENT].

3.2.2.2 *Investigate the use of Renewable Energy Sources*

Short Task Description

Renewable Energy Sources (RES) constitute the energy sources that exist in abundance in the natural environment. As they are inexhaustible and their use does not pollute the environment, RES have significant potential to reduce greenhouse gas emissions. However, the aim of this task is to briefly describe and promote a broader understanding of the Renewable Energy Sources, showing their benefits / drawbacks and how each of these technologies works. Reference is also made to the production of energy from renewable sources and the promotion of its use at a national level.

Purpose and Contribution Towards Team Goals

Recognising the positive aspects of the Renewable Energy Sources (RES), CyNet has decided to give greater emphasis to research RES, as they constitute the best way to reduce carbon emissions (in view of energy and power savings), and to investigate how the use of these power sources can be applied in order to achieve energy savings. In addition, in this task CyNet faced a challenge to investigate data centres use of solar energy through a photovoltaic (PV) system, in order to achieve a further reduction of energy/power used. The production of electricity from solar panels can significantly contribute to the reduction of carbon dioxide (CO_2) emissions, thus contributing to the fight against climate change. The most important feature of PV systems is that they do not emit CO_2 during their operation.

Results

In the light of the above, investing in a PV system to be deployed in a data centre, seems to be the most innovative idea for NRENs to start with, towards greener data centre infrastructure and operation. CyNet conducted a market survey and held discussions with some companies that deal with RES deployment and works in the field of solar energy and photovoltaic systems in order to find the best PV system for its needs.

Based on the 2014/15 energy usage of CyNet's data centre, it was found that a 227 kW PV system would suit its requirements. Given the average number of full-sun hours per day (which is 4.6 hours per installed kW of PV system), 1,680 kWh can be produced on an annual basis. As a result, a 227-kWp PV system could potentially produce 381,360 kWh per year. This means that it is possible to compute the approximate cost savings per year, which is over EUR 50,000, and the return is very feasible, as the cost can be recouped in approximately five years. Through the deployment of a PV system, CyNet can achieve significant reductions in both its energy usage and cost savings. In Cyprus, the average value for CO_2 emissions per kWh for power plants is estimated at 0,920 Kg CO_2 / kWh (with network losses). Briefly, each kilowatt-hour generated by solar panels, and therefore not from fossil fuels, means to prevent release of approximately 0.920 kg of CO_2 into the atmosphere.

Recommendations

CyNet will not proceed with the deployment of a PV system at present because it would need to be installed in the University of Cyprus's data centre. The size of the PV system would also require the use of land instead of rooftops. Finally, the high cost of the system means that CyNet cannot proceed with the deployment at this point in time. The process to deploy a PV system is time consuming, and requires approval and sponsorship to install the system or to proceed with this investment. In the near future, CyNet will investigate the opportunity to deploy its own data centre on its own land or building, and then this technology can be adopted for greener infrastructure. Nevertheless, and based on what has been investigated and examined in this task, it appears that installing a photovoltaic system in the medium to long-term future, will be a very good and innovative investment for CyNet. A full analysis of dimensioning the solar panel array, criteria about where it should be located, and a return on investment analysis are included in the full test case document [RES_SOURCES].

3.2.2.3 *Eco-Friendly Office Design*

Short Task Description

The phrase 'green offices' can conjure up images of uncomfortable and costly workplaces that make little difference to the environment. The reality is not quite so dramatic, since creating a sustainable and green office is more about minimising our impact on the environment through reducing energy use and wastage. This in turn, enhances the working environment, which delivers a comfortable, functional and durable space.

With this task, CyNet is seeking to show ways to transform offices or buildings into 'eco-friendly infrastructures'. Ideas that can help this transformation include: open plan offices, shared-working desks, reducing water demand with a rain harvesting system, smart cooling (focusing on a few racks instead of a whole computer room), noise reduction, improvements in indoor air quality, energy-saving computers, efficient windows and shades, smart lighting, use of renewable energy, smart room division, eco furnishing, etc.

Purpose and Contribution towards Team Goals

Buildings are responsible for 40% of energy consumption in the European Union. The telecoms and IT sector is expanding, which will certainly increase its energy consumption. Therefore, reducing energy consumption and the use of renewable sources in the construction industry constitute important measures needed to reduce greenhouse emissions and enhance energy security. Sustainable, or 'green building', design and construction provide an opportunity to use resources more efficiently, while creating healthier and more energy efficient homes and commercial buildings.

That concept of energy reduction and use of renewables extends beyond the walls of each building and can include site planning, community and land use planning issues as well. The ideal green building would be a building project that would enable the preservation of most of the natural environment around a construction site, while still being able to produce a useful and efficient structure. The construction and operation will promote a healthy environment for all involved, and it will not disrupt the land, water, resources and energy in and around the building.

Recommendations

Green offices will become a standard/baseline for future building work, although, there is no need to spend a lot of money to turn an office into a green haven. Beginning with simple things, such as switching off equipment when it is not in use, reducing unnecessary printing or installing energy-saving lighting, heating and ventilation, for example, could help to reduce the office's energy bill. An extension of this work is to consider how future work solutions will take into account behavioral aspects of the involved students/employees in order to achieve energy efficiency [ECO_OFFICEDESIGN].

3.2.3 Tools Test Cases

3.2.3.1 *GRNET Videoconferencing Service*

Short Task Description

The e:Presence service [EPRESENCE] offered to the Greek research and academic community allows its members to organise and conduct high-quality, interactive videoconferencing. The video quality in the virtual conference rooms is supported up to high definition (720p/30fps). e:Presence supports the dynamic adaptation of the real-time video quality, according to the end-user network connection, its terminal capabilities and the end user's preferences. Furthermore, the service illustrates a simplified approach to organising and participating in secure videoconferencing meeting rooms. This service is available for conducting special-purpose videoconferences, and it is freely available to those with a justified need for secure, high-quality videoconferences.

Between November 2011 and March 2016, more than 25,650 videoconferences have been conducted, with about 11,850 end users participating in these conferences. About half of these videoconferencing sessions were meetings that, until the offering of the e:Presence service as a secure and legitimate alternative for participation, required participants' physical presence onsite. The moderate estimated savings for all the organisations that deployed e:Presence as an alternative to physical presence for participation is about EUR67.5 million. The reduction in CO_2 emissions from avoiding travel is also important, but an accurate estimation of this saving is still pending.

A web videoconferencing service, e-conf, has been developed, and is currently in the testing and deployment phase. This service will facilitate every user in the GRNET community to establish and participate to videoconferencing sessions on demand, anytime, without requiring a reservation. In order to cope with the requirements imposed by the use of the service from many concurrent users, the e-conf videoconferencing servers is deployed in the cloud computing infrastructure as virtual machine instances. Based on this service, end users will be able to create ad-hoc videoconferencing rooms by using cloud resources and communicate with each other via their browsers.

Purpose and Contribution Towards Team Goals

This service is expected to cover all users' everyday videoconferencing needs. Since it will be freely accessible to all of the GRNET user community, it will create a significant request rate for videoconferences. It will be deployed in the cloud, and one of its main design objectives is to be able cope with the demand using as little energy as possible.

Furthermore, this service will also lead to reductions in CO_2 emissions from avoiding unnecessary travel.

Recommendations

e-conf should be actively promoted as a service and GRNET and the Green Team should explore how these learning experiences can be shared with other Green Team members for their videoconferencing service deployment [VIDEOCONFERENCING].

3.2.3.2 *PowMon PoE Device Power Cycling Software Enhancements*

Short task Description

PowMon software was designed within the previous phase of the Green Team project, it has been updated significantly and has now been completed [POWMON].

It is a simple, yet very efficient tool designed to save energy on PoE devices, and now also includes APC bars (providing power to rack-mounted equipment). PowMon enables the user to set the active time when the device or group of devices is powered and other periods of time when it is off, which saves the otherwise wasted energy. The consumption of PoE devices (IP phones, WiFi access points...) is relatively small, yet there are many large institutions (universities, regional offices, etc.) with significant numbers of these devices active non-stop and wasting energy (such as at night, and during weekends and holidays).

The update for APC bars is very important, as any device with higher energy consumption than a PoE device may also be plugged in/active. It can also save energy in an easier, more efficient way compared to stand-by modes used by PCs, printers, copiers, screens etc. The maximum stand-by mode consumption has been limited for various newly produced devices in the EU for several years, yet older devices are not under such limitations and still being used. In brief, PowMon sets zero consumption when the device is not active, no matter the age of the device plugged into the APC bar.

Purpose and Contribution Towards Team Goals

The goal for the PowMon 2015/16 update was mostly to complete the whole package to a professional format, which is now available under GPL [POWMON]. The following issues have also been solved:

- **Support for APC power bars:** A very important function, as previously mentioned. Use of PowMon for various devices (in addition to PoE) was significantly increased.
- **Software statistics with a graphical representation:** Such a professional approach enables easier start-up in organisational environment where no experience with such a saving tool.
- **Operate automatic email alerting:** The system sends an email to the administrator when something goes wrong.
- **Improve logging functionality:** Logging data makes the administrator´s job easier.

Some commercial producers are also interested in this issue. Cisco has developed a similar tool, the Cisco EnergyWise management suite. EnergyWise is a family of products and services that enable and support customers who want to reduce energy costs and optimise the energy consumption of their data centres and/or offices. However, this tool operates only with the Cisco device family. PowMon, on the other hand, is based on fully open approach so developers can include support for any type of device.

Results

Several members of the Green Team have shown their interest in testing and implementing PowMon, including GÉANT and NRENs CyNet and NIIF.

CESNET has carried out much testing, yet PowMon is not yet utilised throughout the whole organisation. All employees (several hundreds) must be familiar with the tool, which requires training.

Very recently, a simple 15-day trial on one IP phone (7 W consumption) was carried out to clearly show the savings (see Figures 3.1 and 3.2).

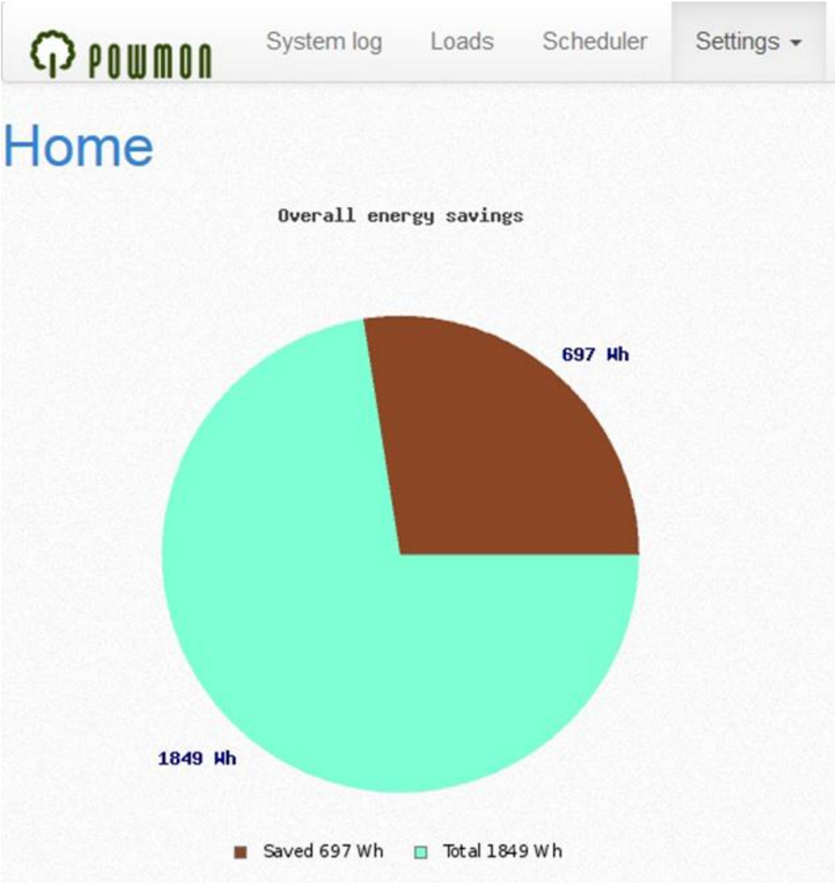

Figure 3.1: Display of energy savings

The time period when the device is turned off by PowMon, clearly shows the savings - The test of 1 IP phone (7 W) within 15 days (nights and weekends off).

Figure 3.2: Alternative load history display

The statistics also chart the period ON and OFF with the time and date, and the consumption of the device/group of devices (about 7 W or 0 W, in this case).

Recommendations

We fully recommend the PowMon tool to be utilised by any organisation. Larger entities have greater savings potential, as the tool can be used, with any device/group of devices. Such an effective tool for energy saving is an exemplary result of the Green Team's GN4-1 work [POWMON-ENHANCEMENTS].

3.2.3.3 *Recycling Website Phase 1*

Short Task Description

Recycling has been a common practice throughout human history. During periods when resources were scarce, archaeological studies of ancient waste dumps show less household waste (such as ash, broken tools and pottery), implying more waste was being recycled in the absence of new material. The main driver for recycling is the economic advantage of obtaining recycled feedstock instead of acquiring new material, as well as a lack of public waste removal in ever-more densely populated areas.

This report explores recycling as a general term, the benefits to the environment and updates recycling progress on a national level. The main purpose of this task, however, is to propose a website where participants can log in and offer any unwanted/unused items. CyNet is developing the documentation for the website, and at a later stage, can proceed with the concept's implementation (or any other NREN can be involved and proceed with the launch).

Purpose and Contribution Towards Team Goals

CyNet's vision is to develop a website, open to everyone, where people will be able to donate any unwanted items to people or companies. The website will be free for everyone and will follow the principle of 'Reduce - Recycle – Reuse'. People with unwanted items can login to the website and upload their items. Alternatively, people and companies can search for items of interest. Through this activity, waste can be reduced, there will be less recycling, and items in good working condition will be reused.

A target group has been chosen of 6- to 25-year-olds, from primary school to higher education. Young people will have familiarly with online systems and it will be easy for them to understand and use the website. Apart from this, the main reason for choosing this particular user group is because thinking about the environment should start from an early age.

Results

In general, it is hoped that by increasing recycling, there will be a decrease in the amount of waste and therefore, a decrease in the humans' impact to the environment. CyNet believes that promotion of both the recycling as well as the idea for the website will have a positive result [RECYCLE-WEBSITE].

3.2.3.4 *Nagios Monitoring and SMS-based alerts in the Academic Network of the University of Montenegro*

Short Task Description

The document describes monitoring and system notifications about the status of the servers and services in the academic network of the University of Montenegro, with the help of the Nagios core server and SMS servers. The need for high availability of servers and services stems from their importance in daily business activities and linkages with the work. Using tools for monitoring servers and services is of great importance for the smooth functioning of the system as a whole and providing high availability. The system and the network administrators for the adequate administration of the system use different monitoring tools. Monitoring tools follow a large number of system parameters and notify the administrators about tracked changes. The academic network of the University of Montenegro uses a Nagios core server for monitoring servers and services. Notifications about the status of client server and services are supplied to the server administrators. The notifications contain basic information about the service name and its current status. Notify the administrator via email and SMS messages.

The implementation of this monitoring tools has improved the availability of the academic network of the University of Montenegro (AMUCG) server. Servers in AMUCG are predominantly based on Ubuntu Linux server distribution. Ubuntu server distribution was selected because of proven stability, long-term support (LTS), ease of administration and the availability of numerous free tools. Timely notifications of changes to the system are crucial for increasing its availability. One of monitoring measurements is temperature in MRENs data centre.

Purpose and Contribution towards Team Goals

This work may serve as a good example of how to optimise network in order to achieve better functionality and energy savings through monitoring of temperature in the main data centre. Through this monitoring system we set alerts to be sent by email and SMS when temperature exceeds a certain temperature in the data room. Notice is sent to the engineer in charge of maintenance, to turn on the cooling system. This way of monitoring allows the energy efficiency and the using of the cooling system only when needed.

Results

The implementation of the described monitoring tools has improved the availability of the academic network of the University of Montenegro (AMUCG) servers. Servers in AMUCG are predominantly based on Ubuntu Linux server distribution. Ubuntu server distribution was selected because of proven stability, long-term support (LTS), ease of administration and the availability of numerous free tools. Timely notifications of changes to the system are crucial for increasing its availability. In order that the availability of the servers and services should be at a satisfactory level it is necessary to implement monitoring and information systems described in the detailed document linked below.

Recommendations

This study is to show a recommended way of monitoring which allows the energy efficiency and the using of cooling systems only when needed in data centres [NAGIOS-MONITOR].

3.2.4 Action Test Cases

3.2.4.1 *Using Raspberry Pi as a Classroom Client Terminal*

Short Task Description

Many techniques have been implemented to reduce workstation power bills, starting from powering off the monitors while not in use, entering idle modes, and even automatic powering off of the workstations at the end of the day. Still, more effort was required to the reduce power consumption, while in full operation and while not in use, is high.

To mitigate this problem, MARnet implemented a hybrid, power-efficient solution, using Raspberry Pi as dumb clients and a Microsoft Hyper-V server as virtualisation platform in the data centre. Using this solution, MARnet expects to drastically lower the amount of electricity needed to power the required number of individual student workstations.

Purpose and Contribution Towards Team Goals

This example shows another innovative approach to using small form factor computing to reduce energy costs and utilise virtualisation platforms to provide cloud access and virtualisation technologies while also providing centralised archive facilities for student work.

Results

The new workstation platform, based on virtualisation and low-power dummy terminals, consisting of Raspberry Pis, offers significant advantages over the previous solutions. The most important advantage points are:

- Much cheaper solution, providing a workstation for only a fraction of the price of a full-blown workstation.

- Very power-efficient solution, dropping the power requirements from 350 W for a regular workstation to a 20 W for a dummy terminal (plus the share of the costs per workstation of the data centre virtualisation platform).
- Significantly easier deployment, since there is no need to clone the master workstation image to each end every other workstation, but only to have a template image at the virtualisation platform.
- Easier management, since every change has to be done at the central location (on the image or the template of the VM at the data centre).
- Simplified maintenance with higher availability. In the case of hardware malfunction, only the dumb client is replaced, while the image at the data centre stays intact.

The main downside of this solution is that the data centre virtualisation server is a single point of failure. This is usually mitigated by having redundant servers and storage, all of these already available in the data centre.

Recommendations

The next step is to deploy the solution on a wider scale, to investigate how to tackle the network management problems and the QoS issues that will arise from a larger-scale implementation and to consider various virtualisation platforms, along with increased reliability and availability.

New developments of other small computer platforms similar to the Raspberry Pi (and also newer versions of the Raspberry Pi 2 and 3) require additional analysis to see how they compare to the more powerful thin clients, which will be even more power efficient, and can use better virtualisation technology to further increase the end user experience [RASPBERRY_PI].

3.2.4.2 *How a Network Technology Refresh can make an NREN's Network Greener*

Short Task Description

One of the best opportunities to reduce energy usage in an NREN's network arises when the technology that is used in the network has to be refreshed to increase network capacity, to support new services and to overcome the operational obsolescence of the existing equipment.

Purpose and Contribution Towards Team Goals

This example shows details that can be included in briefing materials, tender request documents and utilisation of specific answers to the tender queries. Items which contribute to making these new solutions more environmental more sustainable can include use of low-energy consumption technology, reduced box count through more integration, utilisation of energy saving techniques when interface functions are not in use. Other functional capabilities of interest include provision of facilities to monitor energy usage and access to network management software, which can dynamically segment functionality into different usage segments to provide new services, such as Network as a Service (NaaS). Querying suppliers about how they pack their technologies, how they participate in the WEEE scheme and insistence that they responsibly dispose of the products being replaced also contribute to the sustainability value of assessing these major technology updates.

Results

Evaluating the new solution was considered under a number of aspects, and these are shown as the range of values from low too high for all the technical solutions proposed as answers to the tender. Consideration of the total cost of ownership included the amount of energy consumed by the products offered over a five-year period and suppliers were requested to supply both average and maximum energy usage figures. Cooling requirement and size of equipment in number of rack units are some other factors that were compared. Calculations for energy consumed per Gigabit of bandwidth and an estimate of energy to setup a particular type of circuits and services are also provided in the test case study.

Recommendations

This study has been undertaken to illustrate a particular solution for deployment. It only compares the responses provided in a number of areas that can contribute towards environmental sustainability [NETWORK_GREEN].

3.2.4.3 *How to Achieve Energy Savings by Functionality Aggregation on Customer Premise Equipment*

Short Task Description

Currently NREN customers need more bandwidth and broader functionalities on Customer Premise Equipment (CPE).

In some cases, at a customer's site, the so called "router on the stick" (a router and switch connected using one Ethernet link configured as an 802.1q trunk link) is still present. Common practice is to change old equipment with routers. Another issue facing NRENs is that older CPE equipment does not support needed functionalities.

In both cases two actions can be taken. First, old CPE equipment can be replaced with new. Second, functionalities from core equipment can be migrated and aggregated to the CPE. Described actions result in unloading resources of core equipment, as well as energy savings on the core and CPE side.

Purpose and Contribution Towards Team Goals

This work may serve as a good example of how to optimise network architecture in order to achieve better functionality and energy savings without a large investment in replacing core equipment.

The energy saving achieved per single CPE device may not be large, but the large number of deployed devices will result in significant savings.

Results

Typical values of power consumption of old CPEs, depending on the vendor, are 31 W, 45 W and 100 W. The typical value of power consumption of new CPEs deployed in 2015 is 15 W.

From the above values it is evident that in the best case for old CPE (31 W) there is a 16 W difference in power consumption.

In the worst case for old CPE (100 W) we have significant savings of 85 W per CPE after it has been changed by a new one.

Recommendations

Power consumption should be considered with every purchase of equipment. It is also good to consider network architecture in which some functionalities (e.g. NAT, DHCP) are migrated from the network core and aggregated at the access layer. This results in energy savings on core side of the network because less CPU time and RAM are consumed by the core device. In the future work, such activities may consider the trend for virtualisation of end user devices and provision of most of their functionalities by virtual machines in the cloud. Energy efficiency may be achieved through reduction of energy consumption at homes and in parallel application of advanced virtualisation techniques in the cloud [AGGREGATE_CPE].

3.2.4.4 *Using ICT Design Guidelines to Improve Classroom Energy Efficiency*

Short Task Description

The practical contribution of this test case is an analysis of power consumption in one of the computer classrooms at the Faculty of Electrical Engineering in Podgorica in Montenegro. The classroom had 48 networked desktop computers and standard accessories. The first exercise was to measure the electricity consumption during a work week, and then to prove that the calculated energy savings could be achieved by applying a series of measures, as set out in the study. Behavioural aspects and changing work practices of students are also considered in the full report.

Purpose and Contribution Towards Team Goals

This study demonstrates how good design practices and usage of automated scripts can achieve valuable energy saving in a classroom environment. Examples of these design practices include:

1. Consider the size of the monitor and select it according to the needs of the students.
2. Use LCD/LED monitors, which have greater energy savings and twice the shelf life compared to older CRT monitors.
3. Use Energy Star (energy efficient) devices that are characterised by up to 25% energy savings.
4. Adjust the appropriate computer settings to activate the automatic 'sleep mode' function after a period of inactivity.
5. Avoid using a screen saver, which unnecessarily consumes energy.
6. Adjust the brightness of the monitor.
7. Turn off the computer whenever possible (manually or using automated procedures).

Results from Trial/Implementation

After the analysis of the measurements revealed that in periods when the classroom is not in use, there is a significant power consumption (network devices, computers that are not excluded, etc.). This consumption has varied from 140 to 400 W. Using very simple solutions (manual or automated) this consumption can be reduced to zero (expelling the main switch, automatic fire fighting devices, using automated scripts for driver alarm, lock or video surveillance, setting group policy, etc.). A 28% savings of energy usage was achieved from normal daily usage.

Recommendations

The power consumption in a computer classroom was analysed and a contribution to the implementation of green solutions (green classroom) projected, which helps to save energy consumption and reduce CO_2 emissions into the atmosphere. Identified work practices should be implemented, which will result in considerable savings [CLASSROOM].

3.2.4.5 *Moving Libraries to the Cloud in Serbia*

Short Task Description

The concept of cloud computing has two goals: centralisation and minimisation of resource requirements. Centralisation provides easier maintenance of whole system and less human effort due to management of the system from a single physical location. Minimisation of resource requirements returns savings in capital and operational expenses.

This paper considers the potential power savings that could be achieved in case of the realisation of a cloud for libraries in Republic of Serbia. Four services are identified as the main services for all libraries in Serbia: email, website, Co-operative Online Bibliographic Systems and Services (COBISS) and digitisation. Implementation of two of the application cases are discussed when all activities are migrated to the cloud.

Purpose and Contribution Towards Team Goals

This paper shows the motivation, planning and realisation to migrate to cloud services for libraries in an energy efficient manner at national, regional and international level. The article also describes the process of dimensioning the required resources and the calculation of potential power savings.

Results

In this analysis, there are around 170 libraries in Serbia, holding over 3 million titles in total that can be setup to use all 4 previously mentioned services. This requires considerable planning is to estimate, procure and install all cloud requirements for CPUs, RAM memory and hard disks. Finally, an estimation is provided for potential power savings that could be realised through the digitisation and cloud migration exercise. This is expected to average approximately 200.00 kW/h a year for each library.

Recommendations

It is clear that power savings could grow larger as the number of libraries and books migrate into a cloud-supported library infrastructure.

Libraries are unique knowledge bases that have an important role in human evolution. By introducing digitisation, people will be able to more easily access books with a few clicks online. Location will not be a factor and return and damage to this valuable commodity is also safeguarded when offering a digitised library service. The concept of sustainability helps focus a goal to realise virtual libraries with minimal power consumption. This test paper describes the processes and constraints that are considered towards achievement of this goal [CLOUD_LIBRARY].

3.2.4.6 *Designing and Building an Environmental-Aware Data Centre*

Short Description

The goal of NIIF was to design and construct a new data centre that is able to accommodate several components of the renewed IT infrastructure used for providing the NREN services, including storage, cloud and supercomputing services. During the whole process of the design and construction, energy efficiency and general environmental issues of the data centre were taken into account within the limits of the related regulations and financial possibilities, obviously. The target was to reach a PUE value that is at least 1.2 or less.

Purpose and Contribution Towards Team Goals

This test case shares the experience of how another NREN approached the task of building a green Data Centre. It highlights which parts of the specification were required and which technical areas needed focused so that all components are able to contribute to the efficiency of the data centre.

Results from Trail/Implementation

The construction of the data centre was completed in 2015, and it was put into operation from Q3. The installation of the IT equipment and moving the services to the new platforms are still ongoing as well as some further developments in monitoring and supervising the operation of the infrastructure. For this reason, there is still not enough data to fully evaluate the performance of the whole object from an energy efficiency point of view, but the initial measures are promising.

Some efforts to make the investment as green as possible included:

- The architectural plans of the building were optimised by orientation, shape and colour in order to gain the most energy efficiency.
- There were design considerations to enable use of waste heat for heating the nearby pool and dormitory of the campus where it is located.
- A solar power field will be installed next to the data centre to provide renewable energy.
- The transformer, generators and UPS units were sized to operate with the best possible efficiency.
- The cooling system was designed to use free cooling as much as possible.
- Energy efficiency was a key aspect for the evaluation and selection of the IT equipment e.g. usage of hot water cooling wherever possible.
- Usage of closed, water-cooled racks.
- Usage of intelligent PDUs in order to allow precise measurement and control of energy usage of each equipment.
- Deployment of several temperature sensors and power meters to provide full supervision and control of the operation of the whole environment.
- Several low consumption devices such as RI, Damocles, Poseidon, etc. were used for gathering and pre-processing data from the several sensors and monitoring of the environment.

Figure 3.3: External View of the NIFF Data Centre [DATACENTRE]

3.2.4.7 *Power Cycling CPE at Small Clients to Save Energy*

Short Task Description

Once an NREN provides connectivity to small clients it usually is more convenient to leave the small CPE equipment continuously powered on at those clients. If these clients only use their equipment for a portion of the day, does it make sense to turn off the equipment during non-core hours? This would result in energy savings. This test case considers if this is a viable exercise to give a positive return for investing in extra technology and site and considers extra operational considerations when monitoring small sites.

Purpose and Contribution Towards Team Goals

The exercise looks at the practicality of switching off equipment remotely using internal timers built into small Power Distribution Units (PDUs) and then powering back on the CPE router before normal daily work operations. Several clients requested that this capability was studied as part of their engagement with HEAnet as their NREN, in trying to achieve energy savings. As the equipment is actively monitored, power cycling introduces extra overheads in having to filter system logs to exclude controlled power cycling. Small PDUs, such as the four outlets units considered for this exercise, are relatively more expensive per outlet that their large counterparts. The study also considers the length of time required to show a positive return of investment. It also makes a judgement and justification whether this is a practical exercise and supplies the rational to clients about the viability of the exercise.

Results

In summary, there are potential savings from switching off equipment of 1Kw/H of electricity per night, per site. This approach may not be ideal for all, but could be implemented in up to c. 50 sites, with the option for additional logging to show power on/off events for users that cannot completely power-off.

Recommendations

This study compares the responses provided in a number of areas that can contribute towards environmental sustainability [POWERCYCLE]. The magnitude of savings and its impact on the generation of extra reporting, along with the greater possibility of the CPE unit not returning to service will be discussed with each client, and together the client and the responsible NREN will agree to proceed (or not) with this activity.

3.2.4.8 *Power Consumption Measurements of a Photonic Testbed*

Short Task Description

Testbeds provide fertile ground for disruptive experiments for researchers and students. The basic idea for constructing the remote-accessible Photonic Testbed, now deployed at CESNET´s laboratories in Prague, was to provide services for the testing of various aspects in the field of photonic services. The testbed consists of *CzechLight* lighting technology, which is a fully open solution and therefore is suitable for experiments, at a reasonable cost.

One possibility for green goals is testing the real power consumption of the testbed with the real traffic provided by Fibre Channel and Ethernet Test Set. Uni-directional traffic was tested with various utilisations of the link (1–99%). The measuring instrument was set with two sensors to both power plugs, as the testbed has a redundant power supply.

The testbed is unique for its fully photonic functionality without Optical-Electrical-Optical conversion of the signal. It follows the latest trends in photonic networking. The transmission paths consist of a total of 600km of fibre spools with G.652 fibre and Erbium-doped optical fibre amplifiers (for either uni-directional or bi-directional transmission), and switches, wavelength selective devices, etc. as shown in the topology. The testbed allows channel capacity of 10Gbps transmission.

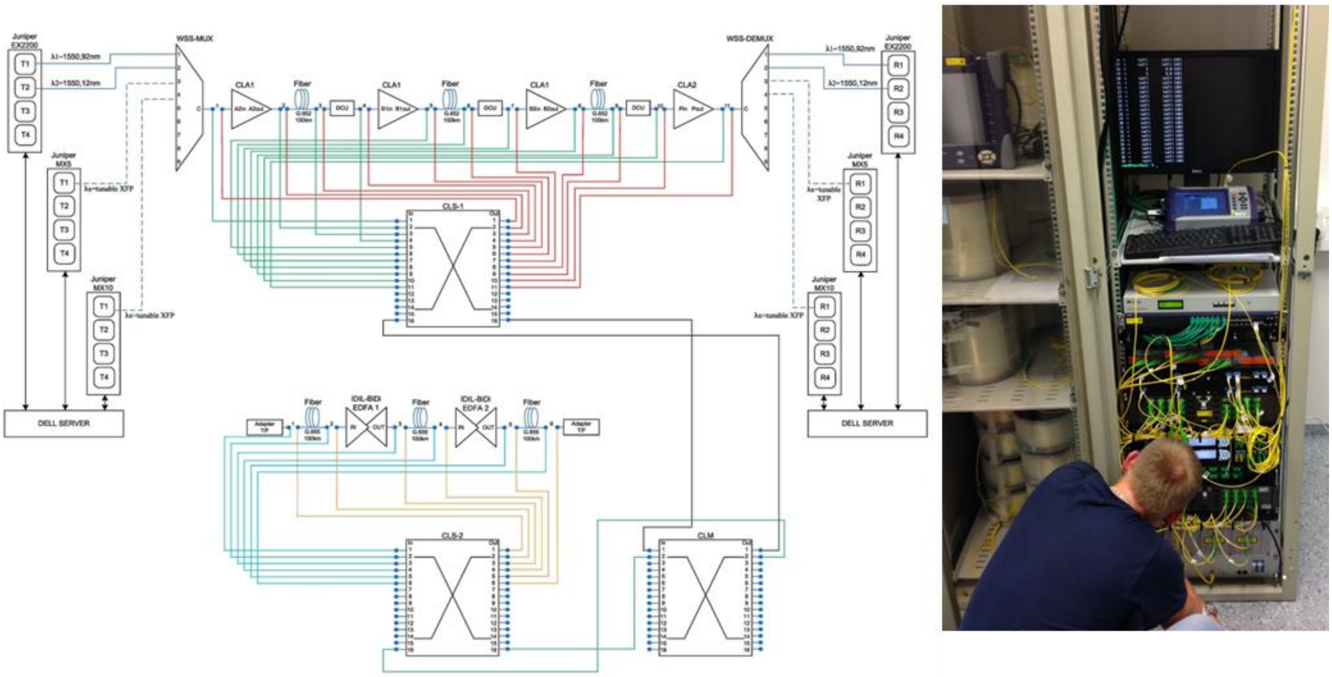

Figure 3.4: Topology of the Photonic Testbed

Measuring the real energy consumption not only provided verified results for this testbed, but also tested the predicted small or none differences amongst the very various capacity utilisations of the 10G transmission system (1–99%). Both power plugs were tested simultaneously and according to measurements, when available, both plugs of the testbed are utilised at any time of operation with a scale of 60:40. The aspects of the climate (heating x cooling of the testbed environment) were not considered, as these are estimated to be negligible.

Purpose and Contribution Towards Team Goals

Real energy consumptions of the testbed were needed for accurate analysis. Such energy consumption investigations might have further influenced future development of photonic devices. The basic "consumption of the Internet" is often based on much estimation, therefore, it was important to get the real figures for a small artificial segment of the Internet; a realistic model showing the basic W per Bit consumption.

Another issue was the possible difference amongst energy consumptions of various traffic utilisations of the testbed infrastructure (network). According to the technical design of the infrastructure, it was estimated to have nearly the same energy consumption at any rate of traffic utilisation. To prove such a statement was another test task. It was also important to test if e-transportation of "3 Bibles per second" needed the same energy as "333 Bibles per second" via the same device.

Results

The measurements were realised within 30 days of non-stop traffic on the testbed. The traffic utilisation was changed four times in the whole period (0–100%) as the Fibre Channel and Ethernet Test Set allows that without breaking the traffic. There were four segments when the average power consumption was counted according to the measurements shown in Figure 3.5.

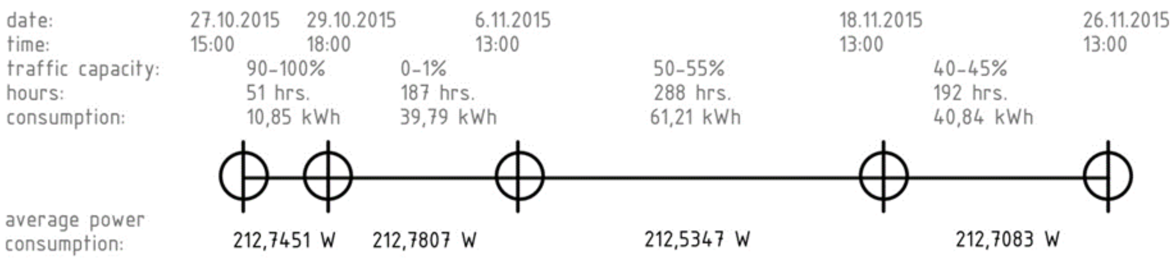

Figure 3.5: Energy utilisation on a time-based display

The results clearly show there is no difference between the power consumption of a testbed which is fully utilised with the traffic (10Gbps) or not utilised, and the testbed is operating with 0–1% of its capacity. The average consumption of the testbed was 212.7 W. In total, the testbed transmitted 989 280 Gigabytes (times 8 = bits) with the total consumption of 152.69 kWh (in the total period of 718 hours). It shows an interesting fact: 1Gigabyte transported over 300km via CESNET´s Photonic Testbed consumes 0.154345 Wh with the realistic average of 35% utilisation of 10G network. To gain a better idea of such figures, please imagine transporting an electronic version of the Bible (3.8 MB) in such an infrastructure over 300km needs 0.00058651 Wh. Such a figure changes rapidly, when the utilisation of the network capacity grows, power consumption per Byte decreases – but the overall consumption only increases marginally for the actual increased data being transported.

Figure 3.6: Actual power reading on a power meter

It is important to note that this test was made to verify the pure consumption of the transmission system without other aspects – e.g. the energy needed for the appropriate environment where the infrastructure is placed.

Figure 3.7: Example testbed energy utilisation

Recommendations

The test case shows the energy consumptions of the testbed (realistic model of a real network) and proves the fact there are no differences between the consumptions with high or low capacity utilisation of the photonic infrastructure. The figures are to be compared with other manufacturers, and with other technologies.

If the general consumption of any dataflow (Byte/km) should be considered, then utilisation of the capacity of the networks is crucial [PHOTONICS-TB].

4 GHG Energy Audits in 2015

4.1 Using eCO_2meter – GHG Emissions Online Reporting Tool

The requirements for the realisation of annual GHG emission reports from the NRENs based on the ISO 14064 standard have been taken into account in the design of the online tool eCO_2meter [ISO14064]. As shown in Figure 4.1, for NRENs, GHG emissions can be consolidated into four categories: office, data centres, network and transportation. Each one of them is measured in a controlled and documented manner.

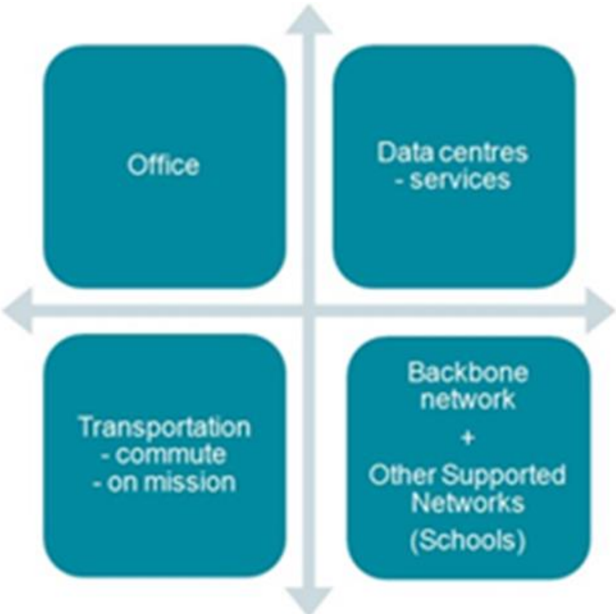

Figure 4.1: Categories of NRENs' GHG emissions

Having developed a structured framework to record the GHG emissions that result from the daily activities of NRENs, the next practical step was to develop the eCO_2meter to partially automate the production of GHG-emission reports of the GÉANT Green Team NRENs [eCO_2meter]. The design of the eCO_2meter was based on the process followed up to now for the preparation of the reports, however, some modifications and adjustments were made, to reduce the complexity and the administration overhead.

Access to the online tool is based on the support of authentication/authorisation schemes, according to the eduGAIN service [eduGAIN]. Authenticated and authorised users from each NREN are able to access the eCO_2meter, view the existing reports, and edit and finalise new reports. Unauthorised users are able to view the finalised reports. Specific guidelines, suggested texts and URLs to existing emission calculators (e.g. calculator for flight emissions) are provided throughout the process of completing the report online. Text areas for describing methodologies, samples, exclusions etc. per form/section and predefined texts are also provided, as well as capacity to upload images and add references to the text in each section.

One page per NREN entitled “NREN Specific Data” is also provided as a web form for inserting/updating/validating NREN specific data, such as NREN’s name, website, environmental policy, country, logo, the base-year report and the names of the responsible person for generating the report and contributors to the report.

In addition to the introductory forms, a series of web forms are available for providing input data to each category of GHG emissions of each NREN (indirect and direct emissions). For the indirect emissions, specific sub-pages are available for the office area, the networking infrastructure, the data centres and the transportation sector. Indirect emissions in the office area originate from electricity usage for the office itself (electricity is used for lighting, air conditioning and ventilation, desktop/laptop computers, coffee machines, displays, beamers, etc.) and electricity for building services.

Specific forms are also provided for declaring energy consumption of the networking infrastructure that, as previously stated, includes energy consumption in all the PoPs, where network equipment, owned by the NREN, is located. In case the total energy consumption in the PoP, including the networking and the supportive infrastructure, is available (through an energy consumption monitoring infrastructure or the energy bills from the utility operator), the corresponding value may be declared and no further calculations need to be done. Otherwise, the NREN must state all of its PoPs and list the network equipment in each PoP, accompanied with the corresponding energy consumption. In the latter case, energy consumption values may result either from real-time monitoring of energy consumption of the device (e.g. in case of existence of a smart power outlet or in case of collection of such data via SNMP) or from the device specifications in the manufacturer’s datasheets.

Following this, the web forms direct the user to provide information regarding energy consumption and GHG emissions in data centres. Energy consumption data for each data centre (IT and supportive infrastructure) may be based on real-time measurements (in case that monitoring infrastructure is available) or on typical energy consumption of the hosted equipment, as detailed in the manufacturer’s datasheets.

It should be noted that in both the network PoPs and the data centres, it is important to provide information for the Power Usage Efficiency (PUE) metric in order to be able to estimate the total energy consumption, given the value of the estimated IT equipment consumption. Furthermore, some extra values are requested for the extraction of meaningful statistics, such as: total network traffic (incoming and outgoing) served by the NREN’s network, minimum and maximum values of the real-time energy consumption, number of racks in a DC, etc.

In the latter category, GHG emissions result from personnel’s daily transportation and from travels on mission as part of their duties to the NREN. Given the online completion of the data in the four specified sections, a summary of the overall consumption and emissions is automatically provided in the form of a table in a specific web page.

4.2 eCO_2meter Architecture

The design of eCO_2meter follows a Model–View–Controller (MVC) architecture at the client and the server side. Communication among the client and the server is standardised via a RESTful API in order to provide an easy integration workflow for the future needs of the tool [RESTFUL]. Python and the Django Framework was chosen as the platform for backend development [DJANGO], since it contains a robust object relational mapper and provides all the necessary automation for creating a web-browseable RESTful API through Django REST Framework. On the front end, backbone.js, a library that facilitates the design of MVC applications and provides communication interfaces via REST, provides basic model representation in JavaScript [BACKBONEJS] Bootstrap and JQuery take care of the presentation layer and XHTML2PDF was used for PDF creation. The design of the eCO_2meter architecture ensures flexibility within the platform, especially the proper assignment of tasks in multiple end users. Documentation of the used API is automatically generated and may be provided to developers for the design of specific extensions or interconnection of eCO_2meter with other tools/services.

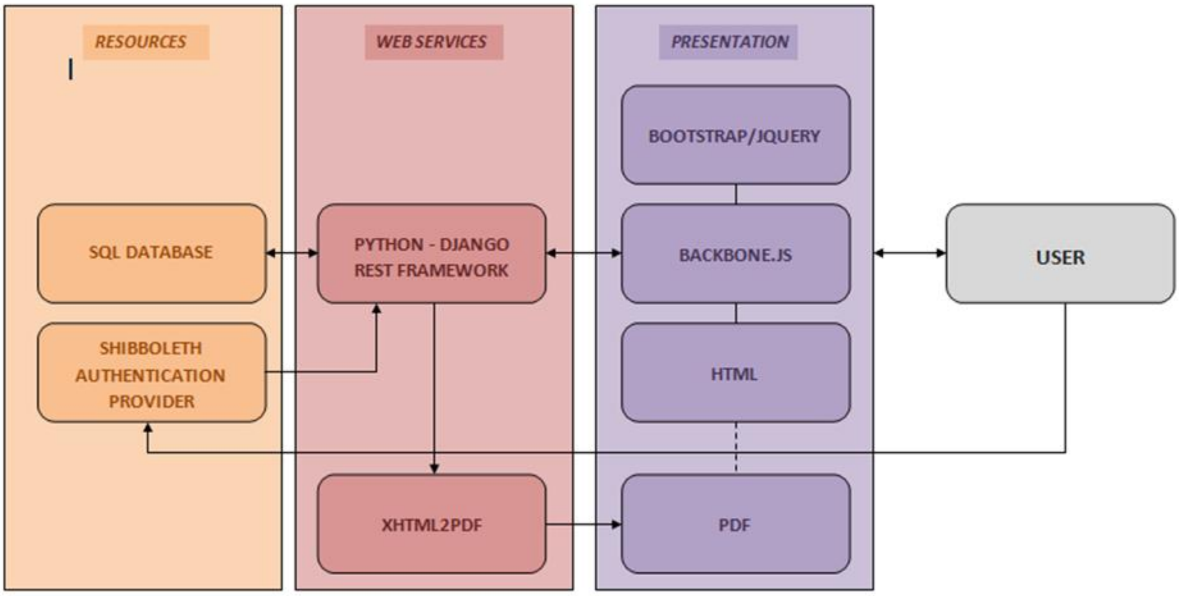

Figure 4.2: eCO_2meter Architecture

4.3 Functionalities

The main functionalities provided through the eCO_2meter include accounting and authorisation services (for instance, the eduGAIN service is supported, for the trustworthy exchange of information related to identity and authentication [eduGAIN]. The tool offers advanced editing functionalities (integration of user-friendly editors, ability to add figures and references), provision of storage space per report for uploading the required documentation. It, provides indicator and guidelines/tips to end users per type of the required information. Also included is access to previous reports for automatic cloning of text (e.g. in case of creating a new report with minor differences from the previous ones).

Further functionalities are provided, such as the automatic creation of the final emission reports based on the input provided through the eCO_2meter (these reports have now be used for verification by an audit external body, which is a requirement for an official ISO 14064-compliant report), the automatic estimation of data based on predefined values (e.g. CO_2 emission factors per country, tonnes of emissions per passenger-mile in international flights), the provision of advanced statistics with useful (longitudinal) comparisons based on a diverse set of criteria (e.g. geographical area, energy consumption per sector of an NREN's infrastructure, GHG emissions per number of PoPs) and the comparisons of results and rankings among NRENs.

4.4 Energy Consumption Data Management

As stated in the previous sections, a wide set of energy consumption data is envisaged to be collected within eCO_2meter based on existing, in progress as well as future GHG emission reports from NRENs. This data will constitute the basis for the design and application of a set of environmental friendly actions, given the potential for increasing energy efficiency in diverse parts of the NRENs' infrastructure (Figure 4.3).

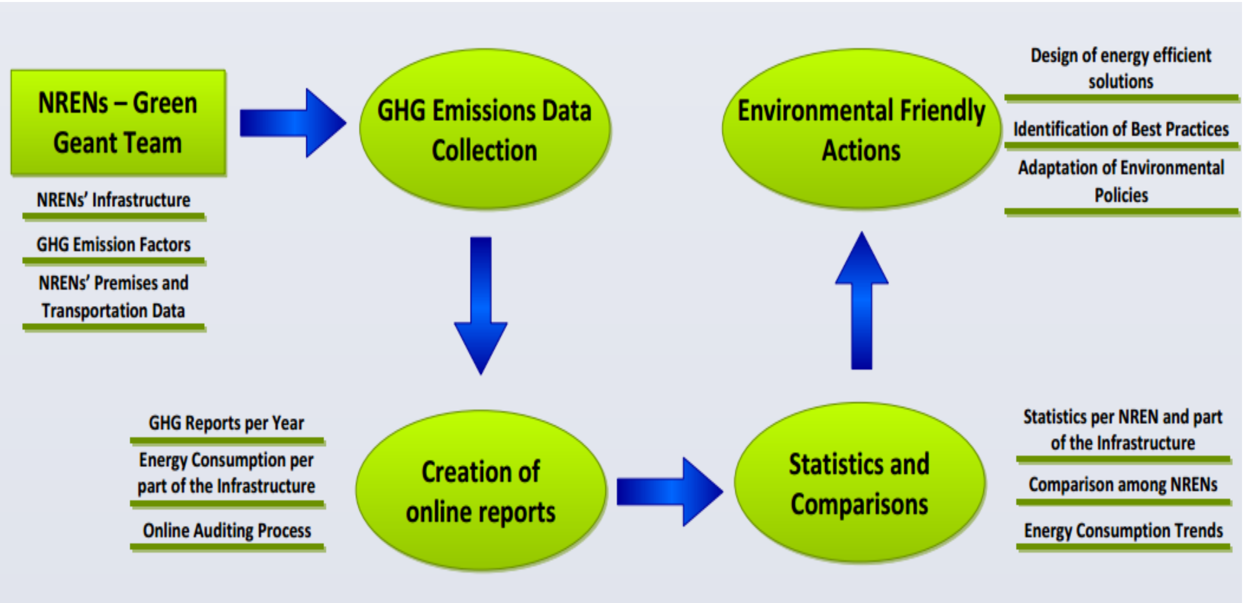

Figure 4.3: Design of environmentally friendly actions through eCO_2meter

Initially, collected data was to be used in order to acquire an overall picture of the energy consumption levels in the various parts of an NREN's infrastructure, identify the most energy-hungry parts, and then evaluate the energy efficiency achieved upon the application of energy-aware techniques and proceed to a series of comparative analyses among the reporting periods as well as among NRENs in different geographical areas. Statistics extraction and trends analysis regarding the annual evolution of the energy consumption of NRENs and monitoring of specific performance metrics (e.g. energy consumed per bit of the overall traffic served, tons of emissions per number of clients) will be periodically produced. Furthermore, forecasting analysis may be realised, where appropriate, for estimating the impact of the application of specific techniques or energy-aware policies and, thus, facilitate decision makers to proceed or not to their adoption. It could be also claimed that the results extracted from the available data should facilitate the GÉANT community to determine the benefits of any initiative taken towards the reduction of its energy consumption footprint.

In addition to the preparation of statistics and the realisation of comparisons, it is envisaged that data available in eCO_2meter, an international database with energy consumption data, will be used for liaison with international organisations and relevant projects targeting the exchange of knowledge, dissemination of best practices as well as organisation of common activities. For instance, comparison of energy consumption trends of NRENs with relevant trends in commercial ISPs and telecoms operators may provide helpful insights on further actions that could be undertaken to move towards greater environmental awareness and best practice for NRENs.

4.5 Comparison of Results from GHG Audits

For the first time, the GÉANT Green Team has chosen to present its approach to GHG emissions auditing in a forum based on industry and academic researchers working with *the energy challenges and roles of mechanics as a means for seeking solutions, involving multiple disciplines in technology, science and management* [ISECM]. Next, the output of one of these GHG Emissions report is presented, and then, for the sake of brevity, summaries for all the other teams' results are shown in a table.

4.5.1 Comparison of Audit Results: GRNET

The CO_2 footprint of the GRNET network is fluctuating quite a bit, which is mostly due to a CO_2-factor of 1.021 kg/kWh used in the 2010 report, a factor of 1.14 kg/kWh in 2011, a factor of 1.19 kg/kWh in 2012, a factor of 1.12 kg/kWh used in the 2014, a factor of 1.02 kg/kWh used in the 2015. The difference in the office section is attributed to the fact that extra flats were rented at the multi-tenant building. This means that in some cases with the same amount of energy consumption, the footprint changes 'automatically'. Commentary on the analysis will take into account such variations to attempt to normalise the data being presented. While these figures are fine for reporting on the carbon footprint, the ultimate goal is to use the actual energy consumption and compare those figures to determine whether any measures taken had any impact.

Emissions in Tonnes CO_2-eq	2010 Emissions	2011 Emissions	2012 Emissions	2014 Emissions	2015 Emissions
Office	230.41	209.96	235.30	275.90	245.21
Transportation	127.47	110.84	143.87	95.91	90.53
Data centre	6600.66	3766.11	4132.83	2847.54	2483.02
Backbone Network	483.11	525.21	566.23	886.21	807.08
Totals	**7864**	**4612.12**	**5078.24**	**4105.56**	**3625.84**

Table 4.1: GRNET GHG Audit result comparison

Energy consumption in the GRNET data centres follows an increasing trend, which is mainly due to the expansion of the computational and storage equipment hosted within the data centres. In 2012, GRNET extended its computational infrastructure with processing, storage and networking equipment, aiming to permit the provision of advanced cloud computing services and to enhance the scalability and reliability of such services.

The network (or backbone) includes all the PoPs where network equipment, owned by the NREN, is located. The new generation of GRNET's network (GRNET-4) was installed in 2014. GRNET-4 is supporting three distinct levels: I) optical services provided by the optical network (optical equipment and fibre optic network), ii) carrier level services provided by the Carrier network and the GRNET Access network that provides Ethernet type of interconnection services and iii) IP level services provided by GRNET's IP network (IP interconnection between operators of GRNET, data centres and Greek Internet Exchange node).

Furthermore, it should be noted that the energy consumption due to the six Grid nodes that are owned by GRNET are not going to be included from 2014 on in the report, since they are hosted within the GRNET client's infrastructure.

In 2013–14, the existing cloud computing infrastructure was extended, while an HPC infrastructure and an energy efficient (green) data centre is going to be installed, aiming at a low PUE through the exploitation of green technologies and renewable energy sources. Therefore, changes in the energy consumption of the various parts of the networking and computational infrastructure are expected.

GRNET’s emissions for 2014 were verified by an external body on 21 of December 2015.

4.5.2 Comparison of other NREN GHG Emissions Results

The table below shows results of GHG Emissions reports generate by NRENs who were members of the NA3 T3 team in 2014 and 2015, and shows the percentage change between both reporting periods. It takes at least one calendar quarter before interim results can be ready for each NREN. Other difficulties that arise are that the Carbon Efficiency factor estimated from the fuel mix of that country is not usually published until the middle of the following year. There the results shown are usually preliminary and could be adjusted again because the CEF figure is a multiplier of the Power used to calculate the GHG emissions for each category.

NREN	Country	2014	2015	% Change
AMRES	Serbia	652	769	17.9%
CyNet	Cyprus	309	292	-5.5%
GRNET	Greece	4106	3626	-11.7%
HEANET	Ireland	1986	1888	-4.9%
NIIF	Hungary	2006	2559	27.6%
SURFNET	Netherlands	1469	1314	-10.6%
UNINETT	Norway	105	120	14.3%

Table 4.2: NREN GHG Emissions report results

eCO_2meter has now been expanded to produce a series of graphical reports to allow NRENS compare performance in each of the four categories. These graphics can be modified 'on the fly' to exclude categories and a mouse rollover of each category shows the actual amount of CO_2 emissions per category. An example is shown in Figure 4.4, below.

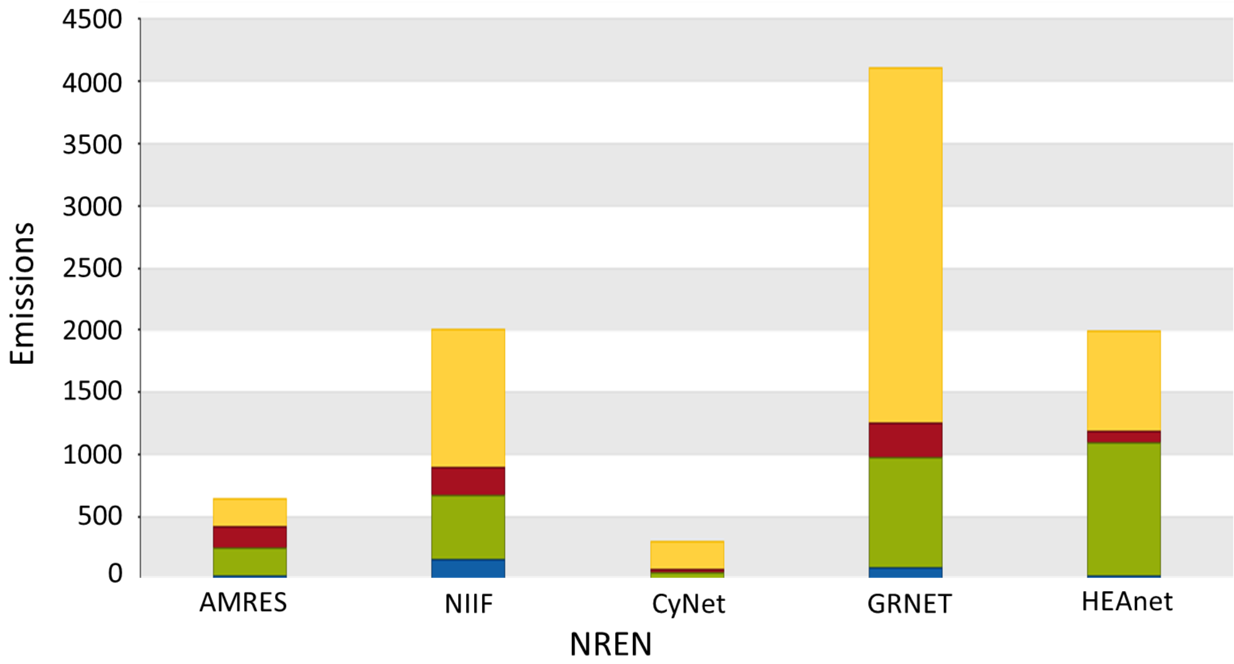

Figure 4.4: Graphical report generated by eCO_2meter showing NRENs GHG emission by category
Source: eCO2meter.grnet.gr

Energy usage at the larger NRENs has increased over the past few years but this is not apparent in a report of GHG emission because the CEF multiplier has decreased more than the rise in energy usage. This is due to several factors such as milder, wetter winters, and also, the amount of renewable energy has increased in the national aggregates to derive this figure. eCO_2meter can be modified to show output graphics also showing energy usage. The team has taken this requirement on board as soon as the 2015 GHG Emissions figures have become available.

NRENs can achieve energy reductions if they refresh the technology that is used in their BACKBONE NETWORKS. However, demands for more centralised, shared services require higher port counts so switches and routers must have interfaces that can be used to provide this connectivity. Transceiver power usage now is about 1-2 watts for a 1Gb or 10Gb connection and about 10-20 watts for a 100Gb connection. Router or switch power consumption has stayed about the same for the equipment hosted in these data centres. It is the actual server platforms that cause the largest part of the increase in power consumption. Resilience and introduction of new services require, at least, duplication of hardware platforms and change control, and development of enhanced features also require a separate platform. All of these contribute to increasing the energy load.

In Figure 4.5 below, a graphical output for a selected number of years, which shows each of the four location's categories. Again, this is the graphical report for GRNET, and it is visible to see that data centres are the largest contributor to this GHG emission. There has been a rapid improvement in these figures since 2011. Unfortunately, no report was generated for 2012. GRNET designed its own data centre, which has very low CEF figures. This is the major reason for the dramatic improvement in the emissions from GRNET data centres.

Further analysis into the background of the GRNET figures show how hospitals that are connected with GRNET use cloud computing services for the support of their research activities and medical exams.

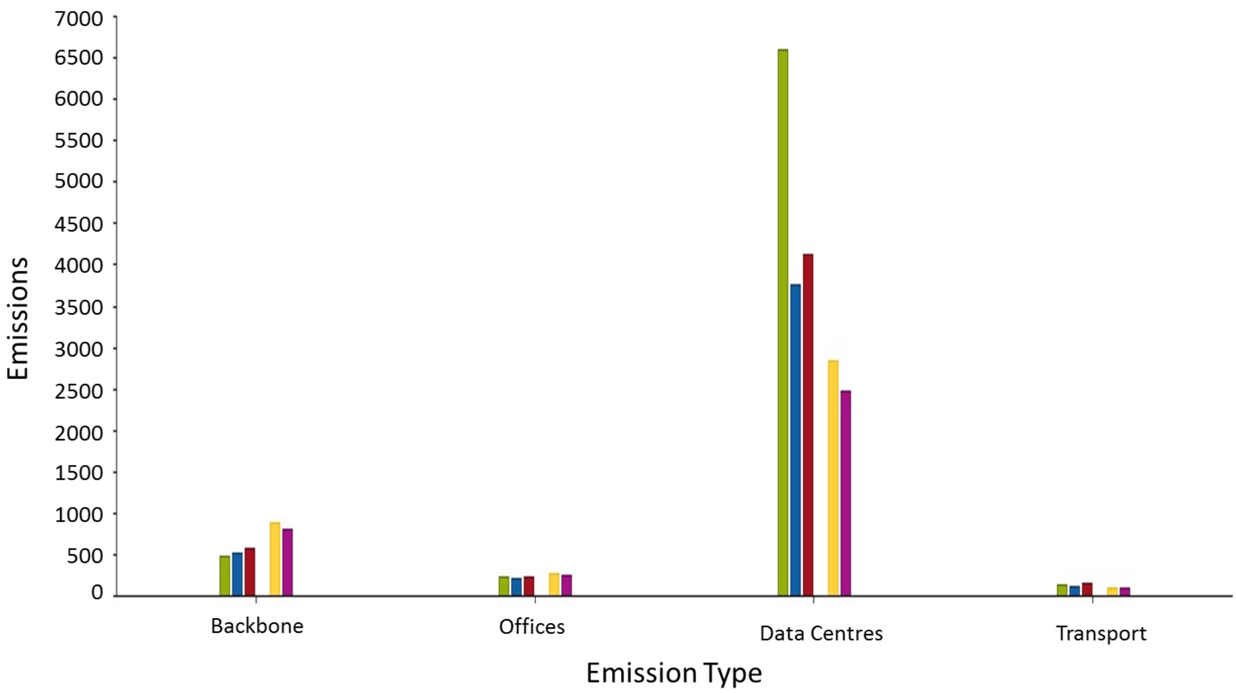

Figure 4.5: Graphical report generated by eCO$_2$meter showing NRENs GHG emission by category
Source: eCO2meter.grnet.gr

Some of the emerging NRENS are very small, and at present, do not have much autonomy from their parent institutions, which make the meaning of some of the trends more difficult to identify.

We have requested that NRENs fill in as much information as they can. As the reporting starts to build up a more complete record, and as the NRENs get bigger, they (and the data sets) may become more autonomous. The results and knowledge will be useful for future comparison and analysis.

NREN	Country	2015
ASNET	Armenia	17.13
MREN	Montenegro	81.36
MARNET	Macedonia	In Progress
CESNET	Czech Republic	In Progress
GÉANT	Netherlands and UK	In Progress

Table 4.3: New Green Team Member GHG Emissions report results/ status

As shown in Table 4.3, values of GHG emissions from some of these NRENS are small, as they may share office and data centre accommodation with some of their larger clients. GÉANT's measurements for PoP and network deployment has to be measured from all of the 36 PoPs throughout Europe, and are being carried out when it is necessary for an engineer to visit a PoP location for equipment upgrade or maintenance activity. Initially, the intention was to install deterministic metering at these locations, but there are too many variations of PoP designs to be able to do this economically to achieve a feasible return on investment.

5 Training and Awareness-Raising Activities

5.1 Introduction

One of the major tasks for GN4-1 was to develop a structured training module, which is the result of work and experience gained done in several GÉANT programmes (GN3, GN3+, GN4-1) by the GÉANT Green Team. Several key elements that had to be included in this module are the environmental policy template and the GHG Audit template eCO_2meter, which been developed by the team. The aim of the Green Team is to create a sustainable awareness methodology in the approach used the in training and any associated training materials. The intention is to raise the awareness of the possibilities of Green ICT and the readiness for NRENs to act for themselves on an organisational level, as well as motivating the higher education user community, through the efforts of NRENs.

The goal of the Green ICT Training module for NRENs and the education community is threefold:

- To introduce participants to Green ICT and to let these interested participants get started with developing sustainability policies and reporting processes. To inspire participants using examples, tools and best practices from the NREN community and to illustrate that small implementation steps can be the foundation of future savings.
- To move towards larger and more structured sustainability implementation strategies.

All this training material is now available through the GÉANT website as downloadable content [TRAINING]. NRENs can use this material by themselves or ask someone from the GÉANT Green Team to facilitate a training session.

Drawing on previous work experiences, the GÉANT Green Team always focused on dissemination of its work to increase environmental awareness in the NREN and Higher Education communities and stimulate sustainable use of ICT.

This is illustrated in the organisation of workshops, for example:

- The Green ICT Workshop [WORKSHOP].
- Presentations at several venues such as TNC, GÉANT Symposium, national and regional NREN meetings and higher education conferences.
- Several multimedia showcases have also been produced, for example [SHOWCASE].
- Publications in magazines, websites and journals for educational, scientific and NREN communities.

The Green ICT for NRENs training makes use and complements this previous work.

5.2 Training Design and Material

Training typically consists of three blocks of half-day material that can be given in any order:

- Environmental Policy
- Greenhouse Gases (GHG) Audit
- Learning from Best Practices

To complement the knowledge of the instructor, some general training materials have been prepared which include:

- Instructors Guide
- Slides for General Introduction

A quick overview of the contents of each training block and how it is presented to the audience to promote engagement with the activity is presented in the following sections.

5.2.1 Block 1: Environmental Policy

The focus of this block is on strategic and organisational aspects of Green ICT and sustainability. The goal is for every participant to have drafted an environmental policy for its own organisation and to set some targets.

Available training material includes:

- Slides for an introduction to environmental policy.
- Exercise to create an environmental policy.
- Exercise to generate targets and actions from statements in the policy.
- Template for an environmental policy.

5.2.2 Block 2: GHG Audit

The focus of this block is on the environmental footprint of an NREN. The GÉANT Green Team has designed a method for GHG audits based on the ISO14064 standard and made this method available through an online tool, the eCO_2meter. The goal is for every participant to get started on their own GHG audit such that they have the ability to complete their first audit on their own.

Available training material includes:

- Slides for GHG Audit Introduction.
- Slides for eCO_2meter demonstration.
- How to access the eCO_2meter tool.
- Exercise to complete a GHG audit for an imaginary NREN.

5.2.3 Block 3: Learn from Best Practices

The focus of this training block is on generating ideas for what an NREN can do, given their strategy, context and maturity in this field. Participants can learn from best practices and examples gathered over the years by the GÉANT Green Team. The goal is for every participant to conduct a maturity scan on their own organisation and make a list of actions that can be carried out. Available training material includes:

- Slides for an introduction to a maturity model.
- Green ICT Maturity Model form.
- Form to analyse results from maturity scores.
- Slides to discuss maturity model results.
- Best practices from the GÉANT Green Team as a source of inspiration.

5.3 Training Delivered

Training has been facilitated twice in 2015/16, for ASNET-AM in Armenia and for multiple organisations in a training workshop hosted by MARnet/FINKI in Macedonia. Both approaches (single and multi-organisations) are effective for training and information sharing, and given the results and feedback below, can be considered as very successful.

5.3.1 Single NREN Training: ASNET-AM

This section presents a summary of the training covered at ASNET-AM. The training highlighted a number policy statements, which included how to:

- Monitor energy and material use and create an energy-aware infrastructure.
- Promote the use of appropriate ICT services as an environmental friendly alternative.
- Develop green ICT services and make current service offerings more green.
- Support staff in the use of sustainable practices.
- Save energy through proper procurement (total cost of ownership, green guidelines).
- Participate in research activities to discover new Green ICT innovations.
- Share experiences with others in different communities (HE, NRENs, industry, etc.).

Some ideas for generating an action/implementation plan included how to:

- Formulate a deterministic policy and reporting mechanism.
- Finish an initial GHG audit for at least the backbone, then data centres, then office and staff.
- Develop requirements/standards for what makes a service green (including the right balance between performance and energy efficiency).
- Develop policy/guidelines for procurement.

Actions to determine which areas that could benefit from Greening of ICT discussions involved:

- Introduce monitoring infrastructure to identify areas for improvement.
- Minimise energy consumption of HPC.
- Add dynamic features to virtual machine environment to automatically turn on/off hardware.

Some potential projects that the trainees could assess for their future business activities include:

- Demonstrate when SDN can be a green alternative.
- Develop videoconference service.

Suggestions that were made on how to engage other NREN staff include:

- Increase awareness of staff through communication on green activities (like GHG audit) and workshops.
- Look into the possibility to use PC power management software to automatically put workstations to sleep when not used.

Suggestions about how to work with the Higher Education and Research Community included:

- Organise workshops/meetings on Green ICT to share knowledge and increase awareness in the community.
- Collaborate with researchers on:
  - Energy efficient algorithms.
  - Scientific gateways.

5.3.2 Insight Gained from Offering the Training Module to Multiple Organisations at the Same Time

This event was attended by both local and international participants. Feedback from local participants on the training was quickly incorporated as the workshop progressed, which highlights the need for customisation of the training that could only happen with local participation. Note that an additional benefit of training multiple organisations is that new opportunities for collaborations between participants are found.

Comments from the training host FINKI:

"The Green ICT training held at the Faculty of Computer Science and Engineering [FINKI] was a great opportunity to broaden the scope of green IT-related topics we pay attention to in the courses held on our undergraduate and graduate studies. As a result of the covered training topics, we extended our energy efficiency coverage with additional information on evaluating IT energy efficiency, in particular, estimating the PUE coefficient for data centres and using the eCO_2meter."

Dissemination of the event to students and staff:

"The additional lecture held by the official trainer of the event and offered to our students on the undergraduate level (also attended by undergraduate students from Montenegro via VC) has become a great success, offering our students insight into the importance of green ICT and how it relates to other green- efforts. After this effort for raising the awareness for green ICT, the students exhibited increased consideration of the energy efficiency of systems and components when facing with tasks that include choice of equipment and other related design solutions. The lecture was attended by some of our other staff members that are also interested in different aspects of energy efficiency: energy efficient VM provisioning, energy efficient wireless networking, or simply energy efficiency in everyday faculty life."

Some comments received from the FINKI Faculty Computing Centre are:

"The training event was attended by representatives from the Faculty Computing Centre as well. Their focus on the training was discerning new ways of measurement and control of the energy consumption of the data centre and the great number of computing labs open for the faculty students. Special interest was put on the ways to improve the energy efficiency of the hosted HPC computer that is also part of the Faculty Computing Centre. Also, the people present at the event acknowledged that the training event has grown into an excellent place for exchanging information, best practices and innovative solutions to tackle with the problems concerning energy efficiency, especially among the attendants that belong to different computing centres on the same or different universities in Macedonia. There were spontaneous exchanges of ideas and experiences, especially on the topic of some binding rules defined with particular Macedonian laws on procurement of IT equipment and archiving student activities. The international participants were happy to exchange their experience on the various topics and thus promote different views and different solutions for common problems."

Some additional Comments from the representatives from MARnet who were not members of the Green Team are:

"Being a very young institution as a separate entity, MARnet's technical staff consists of mostly newly employed engineers that are tasked to gradually take over the NREN computer networking tasks from the previously responsible university computer centre. The Green ICT training event was an excellent addition to their skills especially since MARnet in its transformational period is focused on building infrastructure, establishing data centres and providing new services for the E&R community. With the help of the training event, the MARnet staff has included the energy efficient parameters during their procurement phases and design and setup processes. The attending representatives have managed to successfully transfer their obtained knowledge on the rest of the technical team in the NREN. As a result of the training, MARnet has also pledged in the task to use eCO_2meter for getting information on the energy efficiency of its equipment. In this way, they are more skilled in trying to implement their published environmental policy."

5.4 Other User Dissemination Activities

Since 2013, HEAnet has investigated outreach activity with its university and higher education institute users, and quickly found that many of them (35%) were actively involved in the "Green Campus" programme, run by An Taisce, the National Trust for Ireland [GREENCAMPUS]. The relationship between HEAnet and the Green Campus programme has grown stronger over the past year, and HEAnet will seek Green Campus recognition status in Autumn 2015. HEAnet is also planning a number of joint workshops for both groups' mutual clients. This program is the pilot program for the eco-University campus program [ECOUNIVERSITY].

The Green Campus initiative is based on the success of the Green Schools and International Eco-Schools programmes. It has been piloted and amended for implementation in post-secondary and tertiary-level educational institutions. The Green Campus programme encourages a partnership approach to environmental management in third-level institutions, and aims to ensure that members of a campus community can engage in a meaningful way to enhance sustainability on their campus. This is an enhancement of traditional environmental management systems, which tend to be management driven. The Green Campus programme identifies the campus as a community, and places significant importance on the inclusion of all sectors of the campus community in its environmental management and enhancement.

The Environmental Education Unit within the An Taisce organisation is the national operator in Ireland for all international environmental education programmes of the Foundation for Environmental Education (FEE), (see [FEE]). An Taisce as a group has welcomed HEAnet's involvement, as it views IT as one of the most important enablers for success. The group now has access to a source of technical knowledge that is independent of local campuses and can provide visibility and advice that will be readily accepted by all parties.

It must be noted that the Green Campus programme does not reward specific environmental projects or implementation of a new technology. Instead, it rewards long-term commitment to continuous improvement from the campus community in question.

In order to refine its focus on environmental sustainability, HEAnet has chosen the following three topics that align with its business to support NRENs.

- Energy conservation/reduction.
- Reduction/management of materials.
- Procurement and environmental risk.

An Taisce has now awarded Green Campus Partner certification and the award was presented at the HEAnet national conference in November 2015. This certification is reviewed every two years, and HEAnet must furnish a brief report summarising its Environmental Sustainability activity during each year. Both parties are trying to setup joint workshops to share their expertise with their mutual client sets.

Some other NRENs in the group are also exploring options to work with their local branch of FEE to see what mutual opportunities exist for these groups to work together.

The Green Team wants to promote good practices and actions that can be performed with minimum cost and work effort in order to minimise the energy usage of offices and data centres across Europe. Sharing eco-friendly Ideas with the community, through action such as using a poster, is an easy and pleasant way to remember and share information and thoughts about the environment.

A poster has been created, featuring the top-50 eco-friendly ideas for business/organisations, in conjunction with a report that briefly describes those ideas [TOP50]. Furthermore, the Green Team also had an idea to create a roadmap or flowchart illustrating how everyone can be more environmentally friendly. CyNet coordinated this action as part of its communications and dissemination work, and created a second poster, which was circulated to the Green Team to support its activities (as shown in Appendix B).

6 Conclusion and Summary of Accomplishments

All 13 NRENs who are GÉANT Green Team member NRENs (see Section 2) have published environmental policies and have followed up with implementation activities, such as completing GHG Emission Reports. Several of these policies have been drafted using the template produced by the team to make it easier to create this documentation. Using other knowledge and experience from earlier experiences of other NREN team members has made it easier for some of the newer NRENs to develop and get management commitment on implementation strategies, as shown earlier in the report with the GÉANT's experience.

Each of the team-member NRENs have produced GHG Audits and are now using the eCO_2meter tool that has been developed by GRNET. This tool is currently being revised to enable NRENs to compare their reports and energy consumption performance. Training has been provided to a wider forum of users at events, such as at the initial team workshop. Another more intensive workshop was a help later in the year in Macedonia and this was also attended by other groups from the local university. This training compliments the training support videos have also been made and are available on YouTube [VIDEOS]. Other resources to support the training are listed in Appendix A.

Fourteen test cases/best practice documents have been produced by the team, some of which look at NRENs' work practices and identify potential energy saving solutions. Several, such as PowMon and Green Dashboard, are software applications that will offer energy savings. Other test cases/Best Campus Practice-style documents may be added to this list, based on feedback from workshops, webinars, conferences and training events.

The Green Team had hoped to cooperate with a research group studying 'Climate Change' to produce a specific report about the possible impact of disruptive climatic events on NREN Networks in Europe. The intention was to identify considerations and actions that should be taken to help minimise disruption should these events occur. Two such groups were approached, and agreement was reached about the content of the report but then both groups indicated they had manpower resourcing difficulties.

Dematerialisation activities, such as virtualisation of computing storage and networking were evaluated and demonstrated opportunities for energy saving identified to all NRENs and their user base. Two studies showed different opportunities to save energy in a classroom-based environment. Another area of great interest to the NREN UNINETT's continuing program of digital assessment process development and implementation will also be reported in a number of Campus Best Practice documents.

The Green Team has presented its findings at several NRENs' annual conferences and is continuously sharing its experience.

As data centres are one of the large consumers of energy in an NREN-supported network, experiences of building or procuring these facilities will be analysed, and findings shared among the NREN community. NIIF has shared its experience designing and building its new data centre in Hungary. CyNet has produced reports on the planning, deployment and use of Renewable Energy Sources by NRENs, and in response to user interest, produced another report on Eco Friendly Office Design (detailed in Section 3.2.4.6), which also gives some guidelines for building fabric design.

6.1 Future Activities

The new GÉANT SIG, Sustainable Community Practices Exchange (SCOPE) is the successor of former Campus Best Practice and Green Team activities within since the GN3 and GN4 projects. The main topics covered by the new SIG would include, but would not be limited to:

1. To facilitate knowledge exchange and collaboration between IT staff, with a focus on Campus issues and Green IT technologies.
2. To enable the continued production of documentation regarding best practices.
3. To foster face-to-face and online meetings, providing a breeding ground to discuss, elaborate and disseminate early thoughts, brought in by members of the research and education community that can evolve into best practice documents.

The initial preparation for this SIG was very successful, working out a charter for the groups, creating a manifesto to focus on specific ideas and contributions from the SIG, such as training and development activities. With a new steering group planning the transition and centralisation or all previous deliverables, the group expects active engagement from many of the NREN member contributors to previous tasks.

The work realised by the Green Team is of high quality and it is very important to include a detailed plan on how this work should be continued in future. Starting from eCO_2meter, collecting data and making it available in a unified manner is a valuable way to gain insight on energy consumption and efficiency. The NRENs that supported the development of tools such as eCO_2meter and PowMon are considering how to maintain such tools for future use. While these NRENs can help support the operational activities, they also wish to share access to information and tools with other NRENs and clients, therefore, maintenance of the tools are high on the agenda to see if there are joint opportunities for sharing overheads. Responsibility for test case documents will be transferred to the new Special Interest Group Sustainable Community Practices in Europe (SCOPE), and Current Best Practice documents will be reviewed for relevance and to introduce or discuss if the practice encourages environmental sustainability. Some of the test cases are now focusing on the huge potential for energy saving through 'softwarisation' of network technologies (following SDN/NFV principles) and this work will continue as a topic for SCOPE [SCOPE-SIG].

Appendix A Support Material for eCO_2meter

Support material for eCO_2meter includes:

- Author Manual for the eCO_2meter
- eCO_2meter Video Manual short edition on YouTube
- eCO_2meter Video Manual on YouTube
- Showcase on @How to use the eCO_2meter GHG emissions tool
- Connect magazine issue 17 (page 25) – eCO_2meter Helping NRENs green their IT
- NRENs and GHG reporting: creating a collaborative environment – 1st International Symposium on Energy Challenges and Mechanics
- Improving NRENs' environmental impact through eCO_2meter – TNC 2014 (https://tnc2014.terena.org/getfile/1371)

Appendix B Posters Designed in GN4-1

The following examples are posters created by CyNet during the course of GN4-1 to help support the impact of the Green Team initiatives:

- “Let’s think something GREEN”
- “Let’s think GREEN”
- “Go GREEN”

Figure B.1: "Let's think something GREEN" poster

Figure B.2: "Let's think GREEN" poster

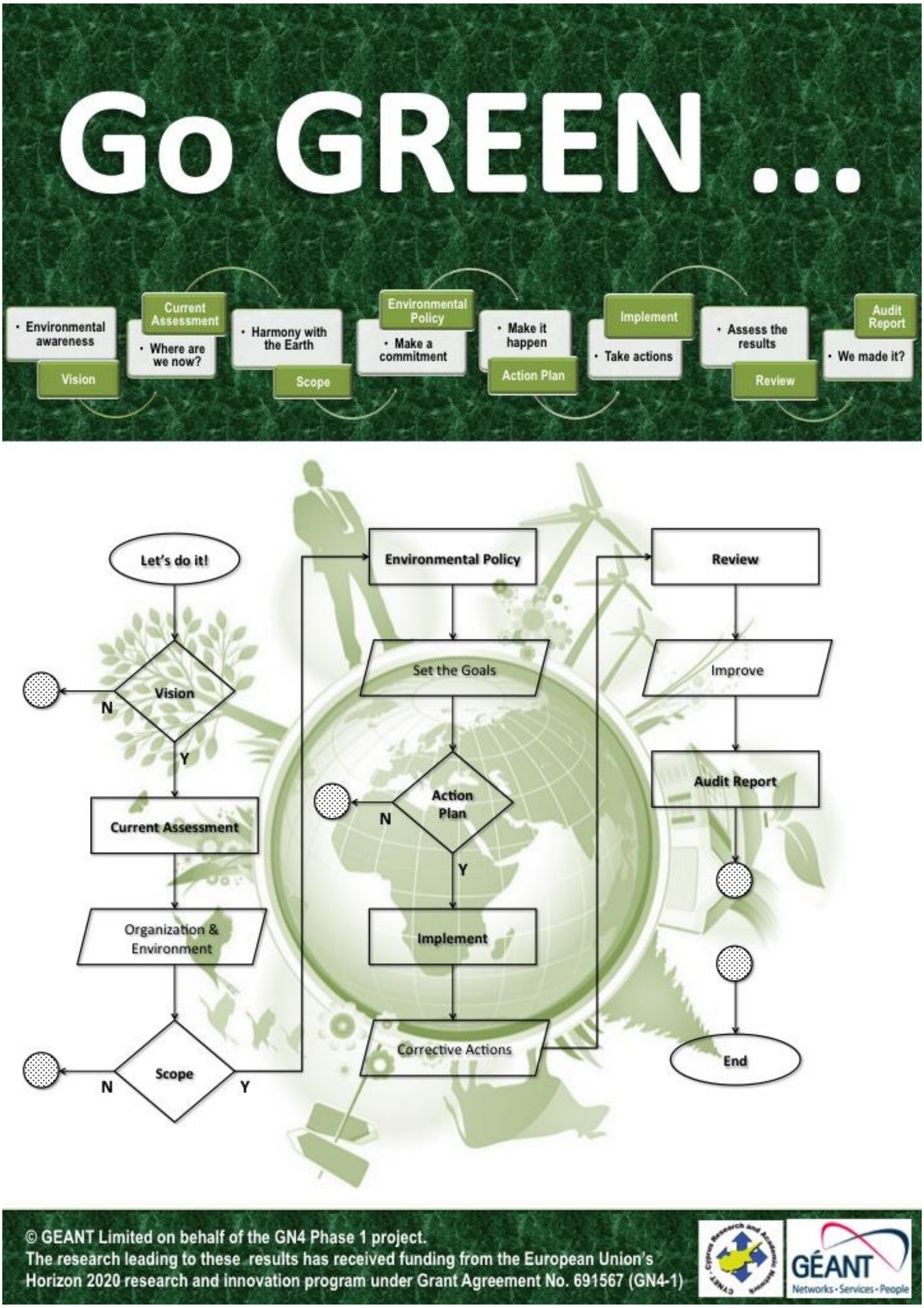

Figure B.3: "Go GREEN" poster

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Glossary

APC	Schneider Electric (formerly American Power Conversion corporation)
BoF	Birds of a Feather (discussion group based on shared interests, usually conference based)
BEMP	Best Environmental Management Practices
BYOD	Bring Your Own Device
COBISS	Co-operative Online Bibliographic Systems and Services
CO_2	Carbon Dioxide
CA	Certificate Authority
CBP	Current Best Practice
CER	Commission for Energy Regulation
CIP	Competitiveness and Innovation framework Programme
CPE	Customer Premises Equipment
DC	Direct Current
DWDM	Dense Wavelength Division Multiplexing
EMAS	Eco-Management and Audit Scheme
e-waste	Electronic waste (discarded electronic equipment)
FEE	Foundation for Environmental Education
GeSI	Global e-Sustainability Initiative
GHG	Greenhouse Gas
GN3	(GÉANT Network 3), a project part-funded from the EC's Seventh Framework Programme under Grant Agreement No.238875
GN3plus	(GÉANT Network 3 plus), a project part-funded from the EC's Seventh Framework Programme under Grant Agreement No.605243
GN4-1	(GÉANT Network 4 Phase 1), a project part-funded from the EC's Horizon 2020 research and innovation programme under Grant Agreement No.691567
GPIO	General Purpose I/O
GUI	Graphical User Interface
HE	Higher Education
HPC	High Performance Computing
HW	Hardware
I2GS	Internet2 Global Summit
ICT	Information and Communications Technology
IOS	Internetwork Operating System
IP	Internet Protocol
IPCC	Intergovernmental Panel on Climate Change
IPV6	Version 6 of the Internet Protocol (StB IETF)
ISECM	International Symposium on Energy Challenges and Mechanics

ISP	Internet Service Provider
ITU	International Telecommunication Union
kg	Kilogramme
kWh	Kilowatt hour
LTS	Long-Term Support
MDM	Meter Data Management
MVC	Model View Controller
NA	Networking Activity
NA3	GN4-1 Networking Activity 3 Status and Trends
NIF	New Ideas Form
NIIFI	National Information Infrastructure Development Institute
NMS	Network Monitoring System
NREN	National Research and Education Network
PDU	Power Distribution Units
PoE	Power over Ethernet
PoP	Point of Presence
PSP	Policy Support Programme
PSU	Power Supply Unit
PUE	Power Usage Efficiency
PV	Photovoltaic
QoS	Quality of Service
RA	Registration Authority
RCUB	University of Belgrade Computer Centre
RES	Renewable Energy Sources
SCOPE	Sustainable Community Practices in Europe Special Interest Group
SIG	Special Interest Group
SNMP	Simple Network Management Protocol
T	Task
T3	NA3 Task 3 The GÉANT Green Team
TF	Task Force
TNC	The Networking Conference
TNE	TransNational Education
TF-MSP	Task Force on Management of Service Portfolios
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UPS	Uninterruptible Power Supply
WEEE	Waste Electrical and Electronic Equipment Directive