GRNET Cloud Center economics and Green IT case studies

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Greek Research & Technology Network

Outline

- Driving forces for Green IT
- GRNET Data Centers Deployment and Cost
  - Cloud Computing Infrastructure
  - High Performance Computing Infrastructure
  - Design of a Green Data Center
- GRNET Green IT activities
  - ECONET project
  - Green GÉANT Team
  - GEN6 – Smart energy meters in public schools
- GRNET environmental policy

Driving forces for Green IT

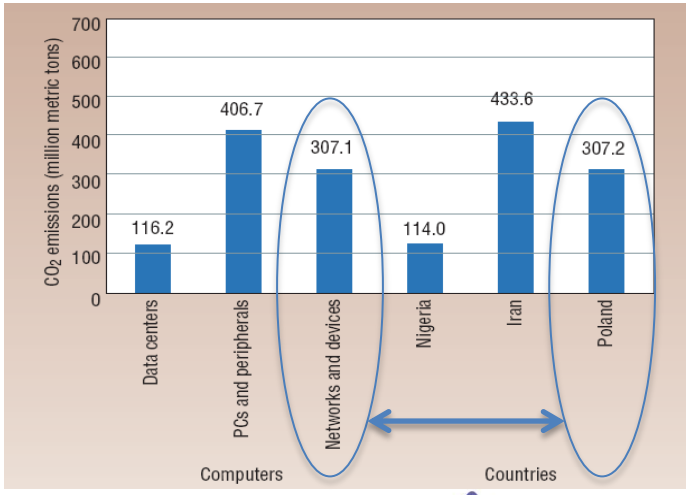
- There are two main motivations that drive the quest for "green" ICT:
  - the environmental one, which is related to the reduction of wastes, in order to impact on CO_2 emission;
  - the economical one, which stems from the reduction of operating costs (OPEX) of ICT services.

How much is 2% of CO_2?

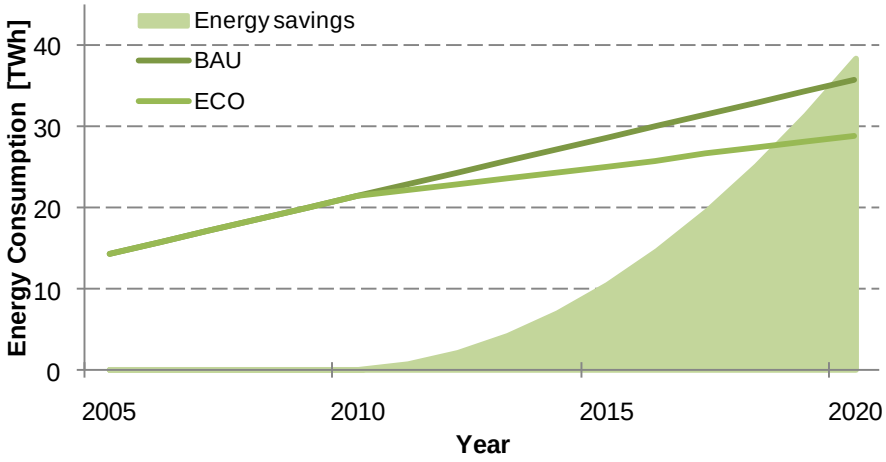
Gartner Group, Inc. (2007)

"The global information and communications technology (ICT) industry accounts for approximately 2 percent of global carbon dioxide (CO_2) emissions, a figure equivalent to aviation."

Note that the ICT sector raises much faster than aviation



Potential saving in energy consumption and costs

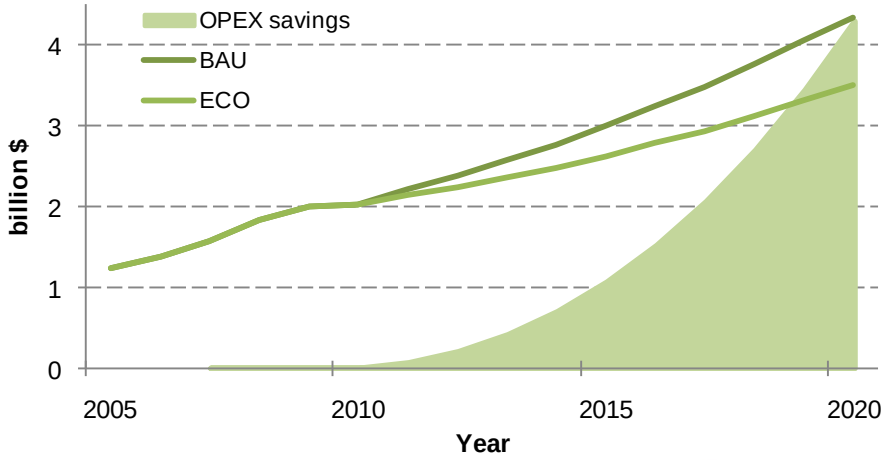


Energy consumption estimation for the European telcos' network infrastructures in the "Business-As-Usual" (BAU) and in the Eco sustainable (ECO) scenarios, and cumulative energy savings between the two scenarios.

Source: European Commission DG INFSO report

OPEX estimation related to energy costs for the European telcos' network infrastructures in the "Business-As-Usual" (BAU) and in the Eco sustainable (ECO) scenarios, and cumulative savings between the two scenarios.

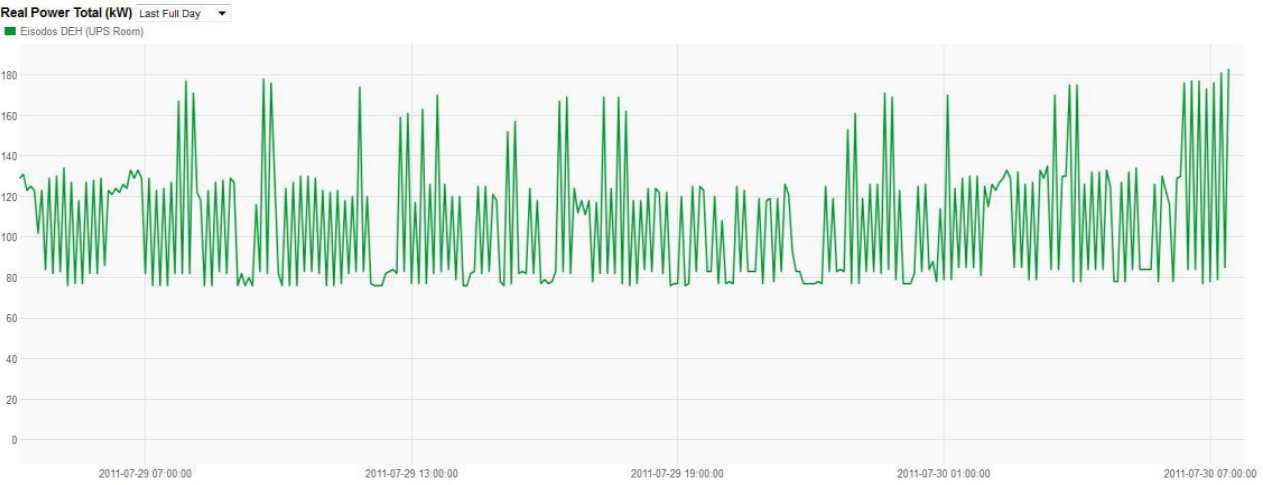
Source: R. Bolla, R. Bruschi, F. Davoli, F. Cucchietti, "Energy Efficiency in the Future Internet: A Survey of Existing Approaches and Trends in Energy-Aware Fixed Network Infrastructures," IEEE Communications Surveys & Tutorials, vol. 13, no. 2, pp. 223-244, 2nd Qr. 2011.



GRNET Cloud Computing Infrastructure: DC in Ministry of Education and Religious Affairs

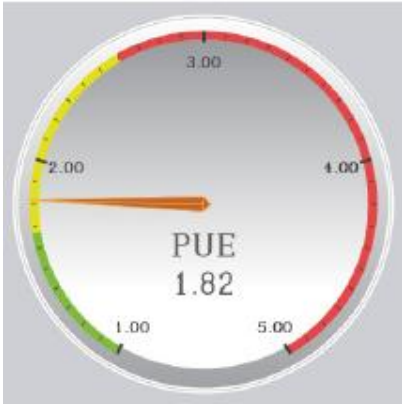
- Green High-Density Data Center - 16 kW/rack
- Hot and cold aisle zones
- Free cooling
- European Union Code of Conduct for Green Data Centers

GRNET Cloud Computing Infrastructure: DC in Ministry of Education and Religious Affairs



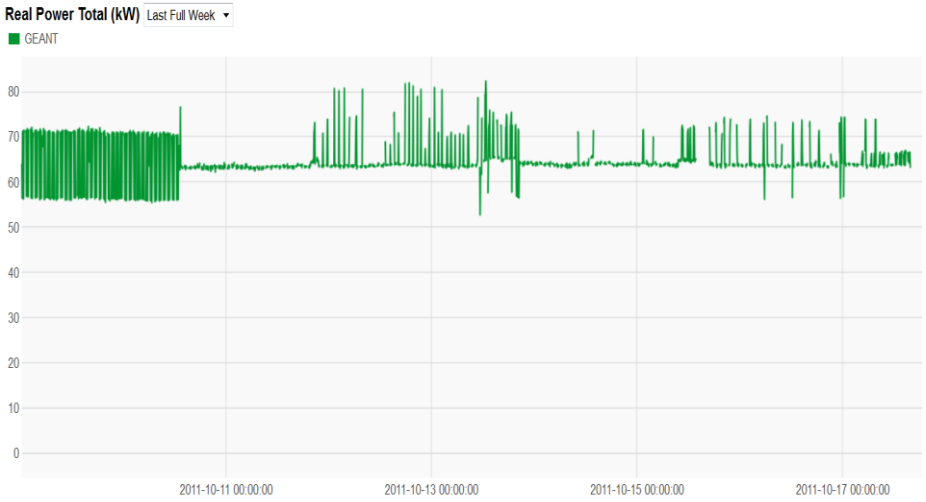
GRNET Cloud Computing Infrastructure: DC in Ministry of Education and Religious Affairs

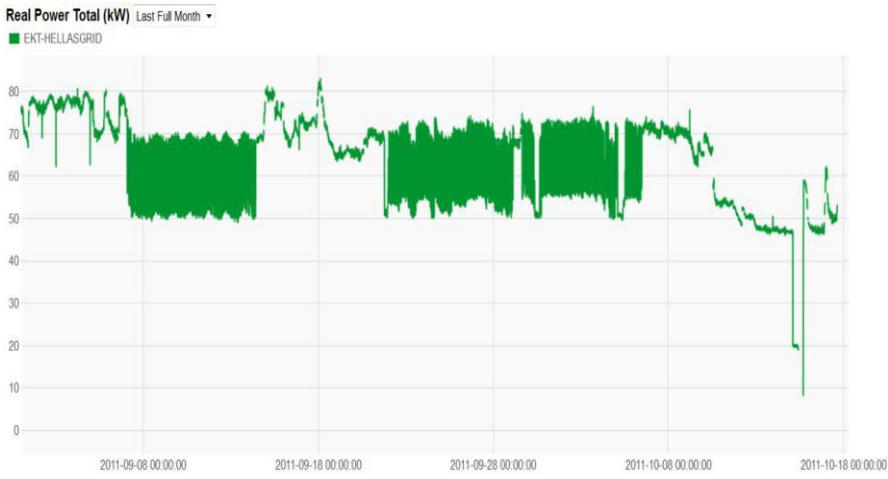
- Deployment cost ~ 1.5 M euro
- 28 racks hosting servers and storage equipment
  - 7132 logical CPUs in 2011 - 1024 logical CPUs in 2010
  - 1800 TB storage in 2011 – 440 TB storage in 2010
  - Cost per core: 160 euro
  - Cost per TB/disks: 19k for SSD, ~1.5k for SAS
  - Networking costs: ~ 25% of total costs
  - Support contract costs: ~10% of total costs
  - Network connectivity costs: ~ 5000 euro/year (2x10 Gbps)
- 200 KW average energy consumption (not fully loaded)
- PUE at 2.2 in 2011 but currently estimated at 1,82
- 850 MWh in 2011



GRNET Cloud Computing Infrastructure: DC in National Hellenic Research Foundation Research Centre

- GÉANT PoP (63 KW) and NHRF HellasGrid node (67 KW)
- GÉANT PoP: 4 racks with servers and 14 racks with telecom equipment
- NHRF HellasGrid node: 6 racks hosting servers and storage equipment





GRNET plans for a HPC Infrastructure

- Three logical zones:
  - Zone A (HPC Compute): high density servers with high cooling requirements, but low availability requirements
  - Zone B (HPC Storage): metadata/disk servers with low cooling requirements and also low availability requirements.
  - Zone C (HPC Service nodes): user interfaces and other services with low cooling requirements, but high availability requirements
- Consider separating the Zone A infrastructure from Zone B and C
  - achieve increased ambient temperature by several degrees (i.e. up to 35^{o}C).
- Performance close to 150 Tflops
- Storage is estimated to be between 300 and 500 Terabytes

GRNET plans for a HPC Infrastructure

- Deployment cost ~ 2.5M euro
- Liquid cooling solutions (inlet temp ~15-20 ^{0}C and outlet temp 6-8 ^{0}C higher)
- Zone A: max power with cooling ~350KW
- Zone B and C: ~20KW/rack
- Planned PUE close to 1.2

GRNET Green data center

GRNET Green data center

- Planned to be installed close to close to a power production hydroelectric plant facility
- Cooling based on water from a nearby river
- Water-cooled racks and circuits with heat exchangers
- Container with at least 14 racks for IT equipment
- Disaster recovery - ensure business continuity of the services supported by the existing data centers
- Plans for PUE < 1,2! – Average power: 200 KW
- 40% energy saving in comparison with existing data centers in Greece (PUE close to 2) → 1,17 GWh energy saving per year

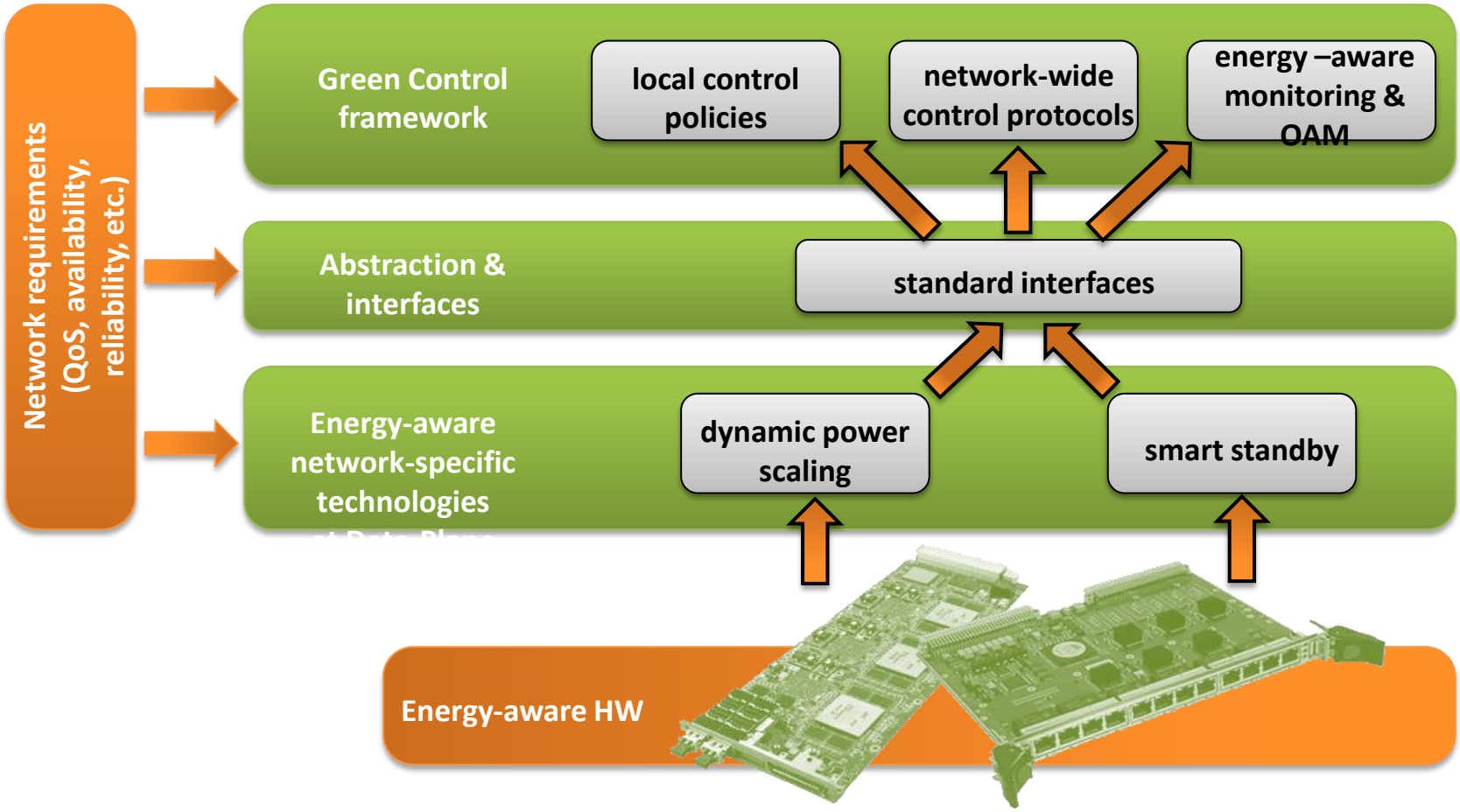
GRNET Green IT activities

- ECONET – low Energy COnsumption NETworks
- Green GÉANT Team
- GRNET-4: GHG audit
- GEN6 – Governments enabled with IPv6
  - Greek pilot: Energy Efficiency in School Networks with IPv6
- GRNET Environmental Policy
- More at: http://green.grnet.gr

GRNET Green IT: The ECONET project

- The ECONET project aims at studying and introducing **adaptive technologies (dynamic adaptation and smart standby) that allow saving energy when a wire-line network device or part of it is under-utilized**.
  - **Access/home** -> standby when users are not “connected”; idle/performance scaling when users are “connected”
  - **Core/metro** -> standby for unused and/or redundant HW; idle/performance scaling for active HW
- The **final objective is to obtain an average reduction of 50-80% in energy consumption of operating networks**

ECONET: The project approach
Energy aware specific technologies



ECONET: The project approach
Green Control Framework

Autonomic and short-term on-line optimizations →

Routing & Traffic Engineering

Given:
- The traffic matrix
- Service requirements
- The energy-aware capabilities of network nodes and links

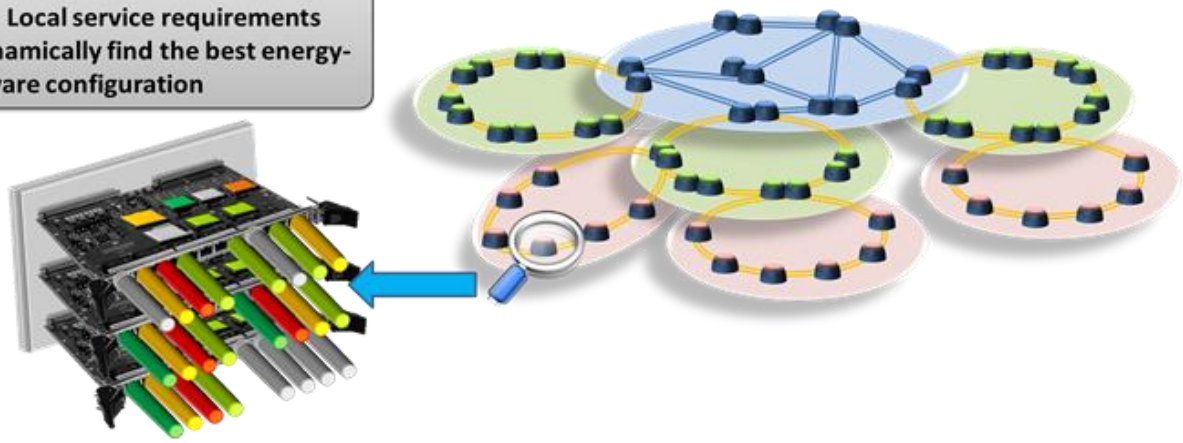
Dinamically move the traffic flows among network nodes in order to minimize the overall network consumption

↓

Local Optimization Policies

Given:
- the actual traffic workload from input links
- Local service requirements

dinamically find the best energy-aware configuration



Operator-driven long-term off-line optimizations

↓

Network-wide Monitoring

Given the history of measurements regarding:
- network performance
- energy consumption

The operator can explicitly plan and/or reconfigure the settings of:
- single device
-Traffic engineering and routing.

The Network Operations Center (NOC)

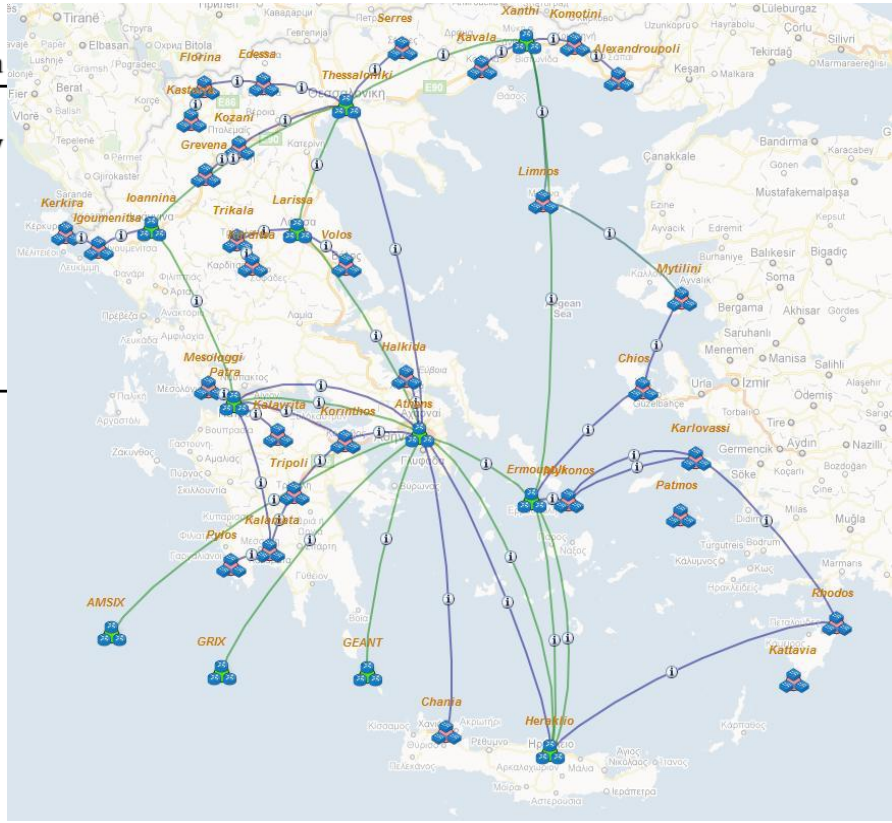
Energy savings in GRNET network

Maximum power consumption for the access and core network devices in the GRNET network.

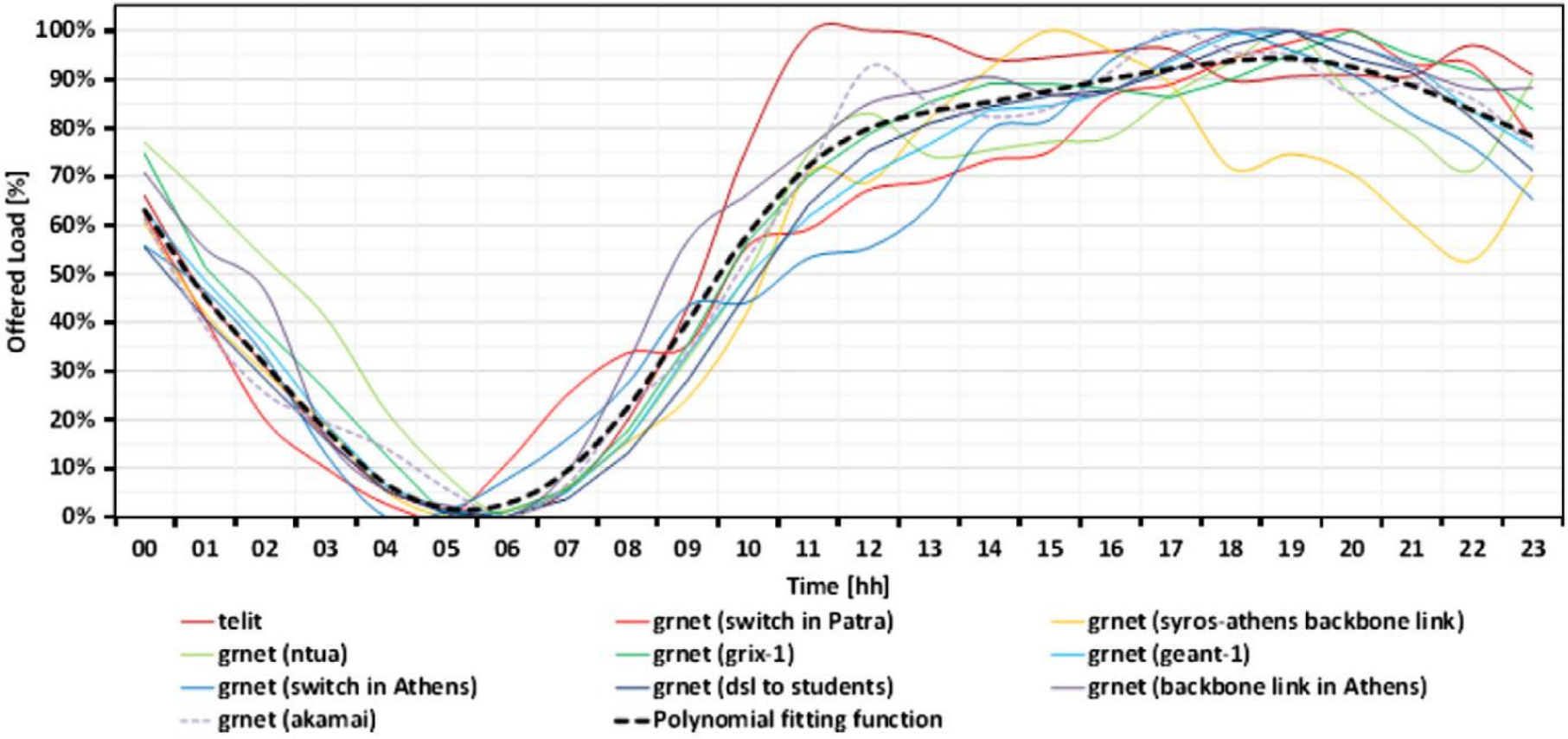
Network part	Number of devices	Type of equipment	Vendor/model	Maximum power consumption
Access	42	Switch	Cisco Catalyst 2970, Extreme X350, Extreme X450a	190 W, 75 W, 659 W
Core	11	Router	Juniper T1600, Juniper MX960, Cisco 12406, 12410, 12416	~8000 W, ~3000 W, 5450 W

Topological data (average figures) for the GRNET network. *Source*: Greek Research and Technology Network.

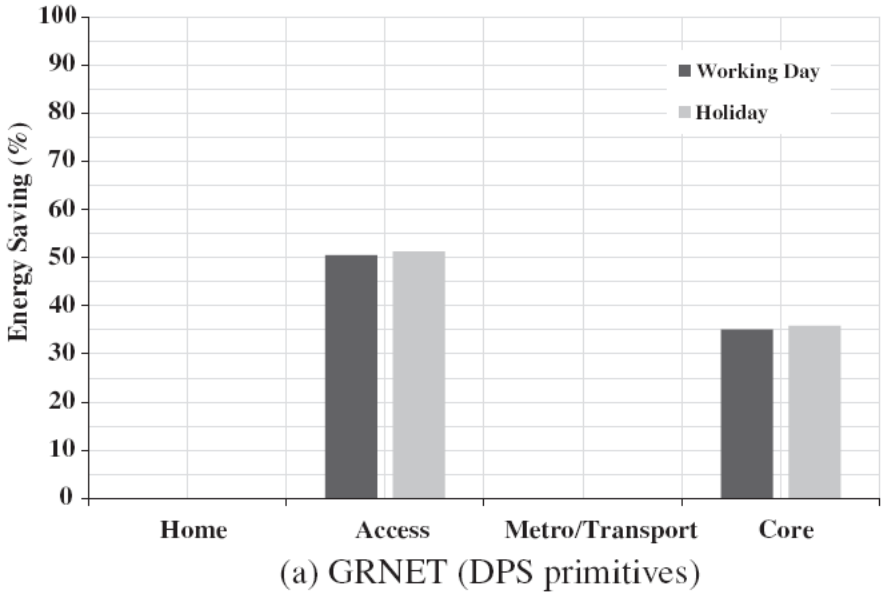
Network part	Redundancy degree type	Redundancy degree value (%)
Access	Redundancy degree for access devices	13
	Redundancy degree of access links	88
Core	Redundancy degree for core devices	72
	Redundancy degree of core links	71



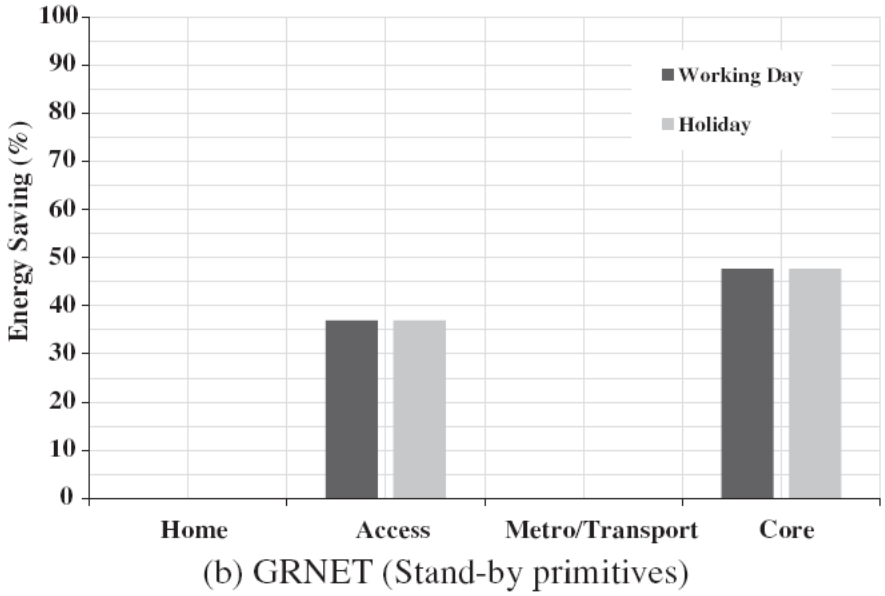
Normalized traffic loads



Potential saving in GRNET network



(a) GRNET (DPS primitives)



(b) GRNET (Stand-by primitives)

Estimated energy savings for GRNET's access and core networks during the working days and holidays profiles with only DPS or Stand-by primitives and the BAU scenarios.

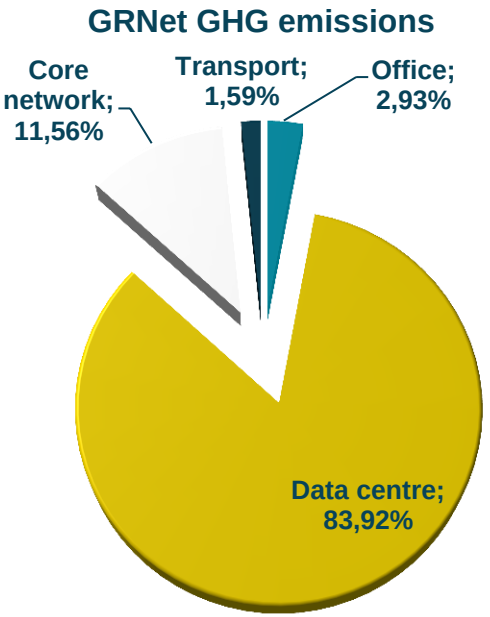
Source: Raffaele Bolla, Roberto Bruschi, Alessandro Carrega, Franco Davoli, Diego Suino, Constantinos Vassilakis, Anastasios Zafeiropoulos: Cutting the energy bills of Internet Service Providers and telecoms through power management: An impact analysis. Computer Networks 56(10): 2320-2342 (2012)

GÉANT Green Team – GHG audits

- Measuring and monitoring GHG emissions are essential features of a strategy to reduce such emissions.
- The GÉANT Green Team has been carrying out audits of the greenhouse gas (GHG) emissions of NRENs and the GÉANT pan-European network.
- The Green Team has adopted the ISO 14064 standard for its carbon audits.
- A common scheme or template for their networks has been adopted, to enable the audits to be carried out in a methodical and consistent manner.

GRNET GHG audit

- This is the first GHG inventory for GRNET, covering the year January 2010 to December 2010.
- This period will serve as historical base year as well as base year for this inventory.
- Data Sources
  - Real time measurements
  - Manufacturers datasheets and technical documentation
  - Online database for network equipment
  - Emission factors from Public Power Corporation S.A reports
  - GHG emission of heating with a gasoil boiler - http://www.nef.org.uk/greencompany/co2calculator.htm
  - Transportation – input from questionnaire and emission factors from http://www.greenpeace.org/greece/el/getinvolved/137368/137462/ and http://www.carbonfootprint.com/calculator.aspx
  - Totally for GRNET: **7865 tons CO_2-eq** (3.9 GWh)



GEN6: IPv6 Pilot in Greece

- **Energy Efficiency in School Networks with IPv6**
- Vision
  - **Mobilise** school communities for **environmental protection**
  - Raise **energy awareness** by **interconnecting energy smart** meters in selected schools intranets
  - Raise awareness in **new technologies**, especially **IPv6**
- The pilot aims **to interconnect intelligent smart meters over IPv6** in 50 schools and **influence the behaviour** of the school communities so as to reduce energy consumption.
- Energy related information from participating schools will be recorded using smart meters, stored and processed using scalable cloud computing.
- ***Target to reduce energy consumption in public schools at least 10% (going up to 30%)***

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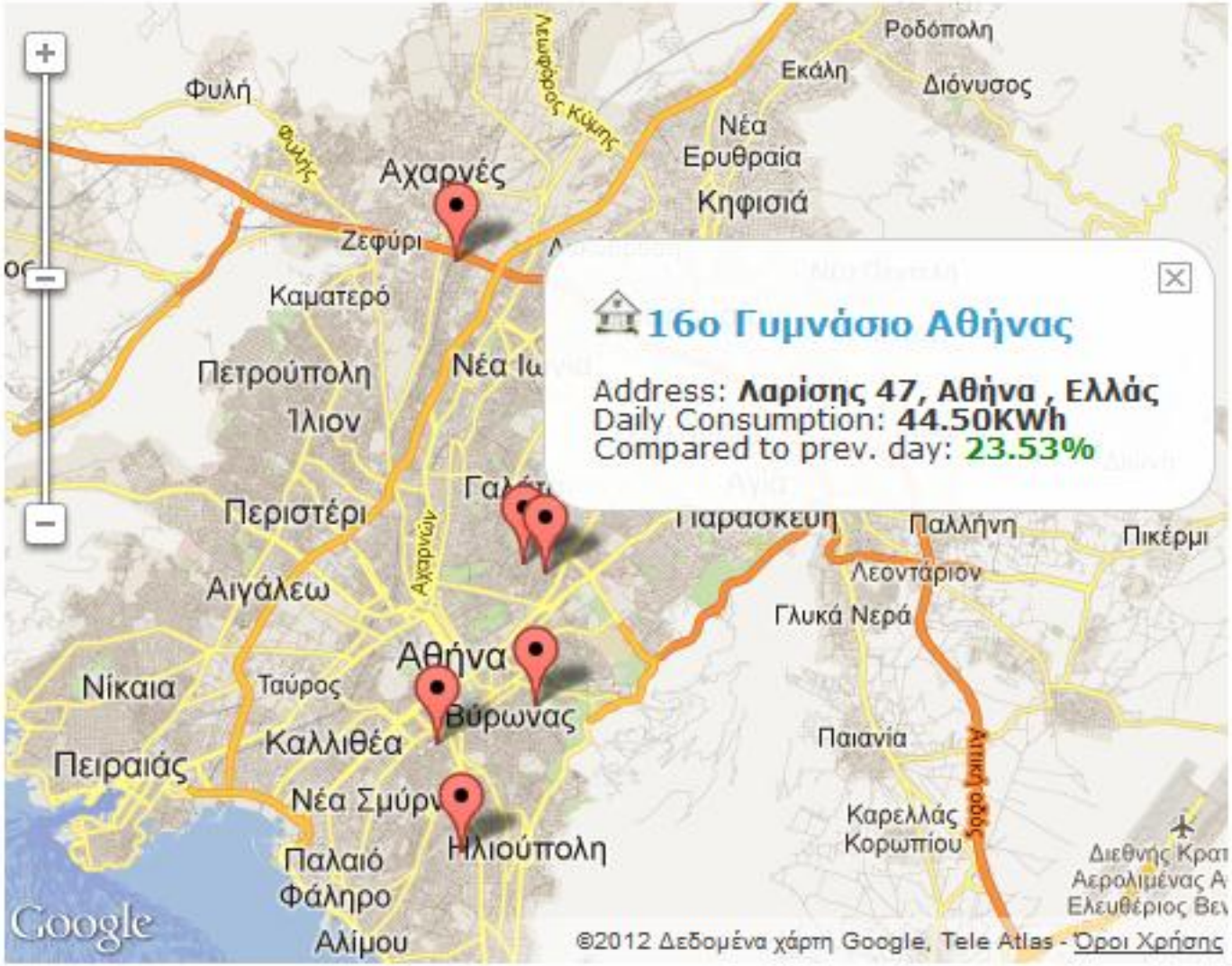
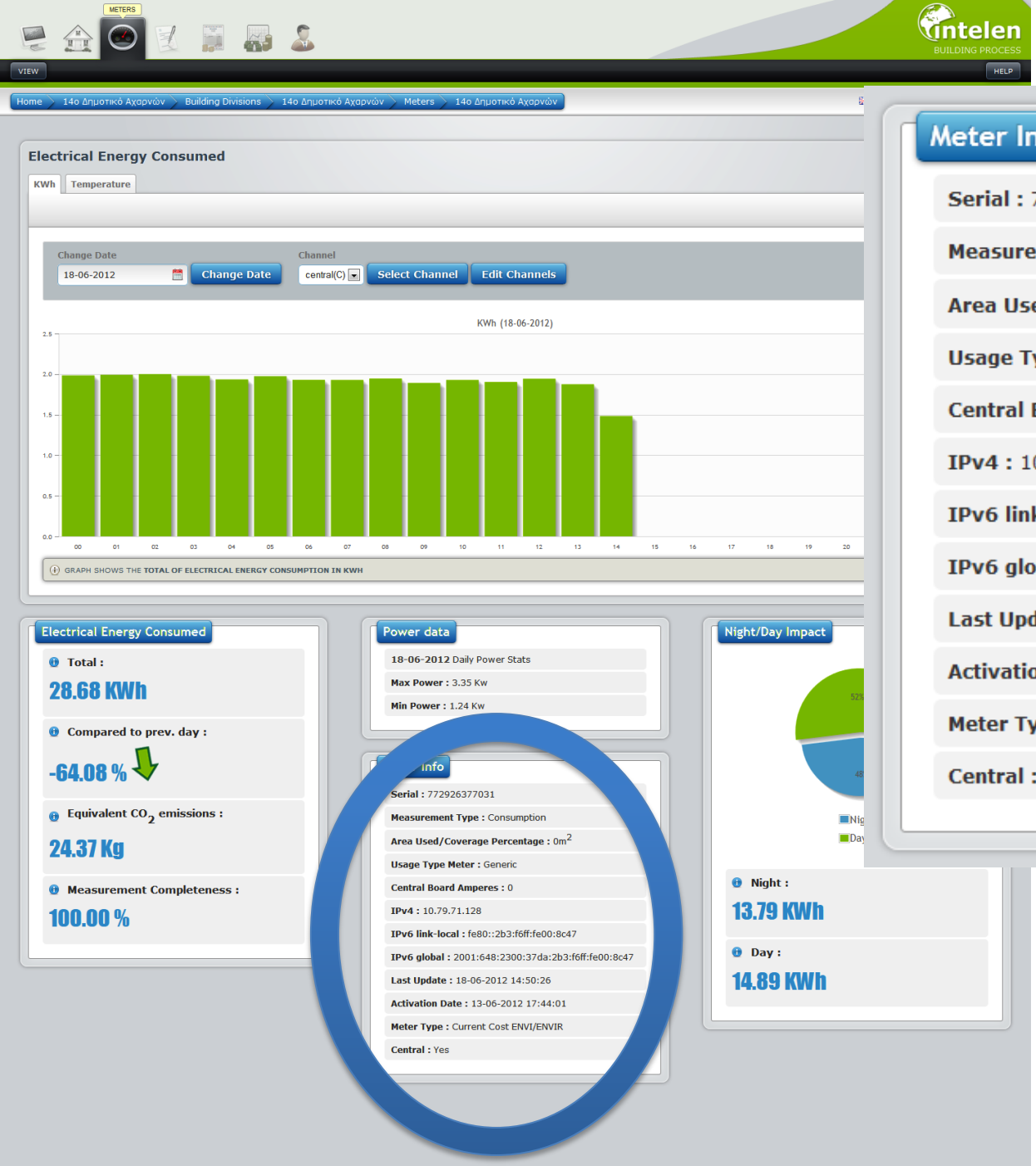
Map


Fyli
65
Petrou
Peri
Egale
E75
Nikaia
Piraeus
Pal
Google

Map


Ροδόπολη
Εκάλη
Διόνυσος
Φυλή
Λεωφόρος Κύπρου
Φυλής
Αχαρνές
Νέα Ερυθραία
Κηφισιά
Ζεφύρι
Καματερό
Πετρούπολη
Ίλιον
Περιστέρι
Αγίου Δημητρίου
Αιγάλεω
Παλλήνη
Πικέρμι
Λεοντάριον
Γλυκά Νερά
Αθήνα
Νίκαια
Ταύρος
Βύρωνας
Καλλιθέα
Παιανία
Πειραιάς
Νέα Σμύρνη
Ηλιούπολη
Καρελλάς
Κορωπίου
Παλαιό Φάληρο
Αλίμου
Google
16ο Γυμνάσιο Αθήνας
Address: Λαρίσης 47, Αθήνα , Ελλάς
Daily Consumption: 44.50KWh
Compared to prev. day: 23.53%
©2012 Δεδομένα χάρτη Google, Tele Atlas - Όροι Χρήσης



Meter Info

Serial : 772926377031

Measurement Type : Consumption

Area Used/Coverage Percentage : 0m^2

Usage Type Meter : Generic

Central Board Amperes : 0

IPv4 : 10.79.71.128

IPv6 link-local : fe80::2b3:f6ff:fe00:8c47

IPv6 global : 2001:648:2300:37da:2b3:f6ff:fe00:8c47

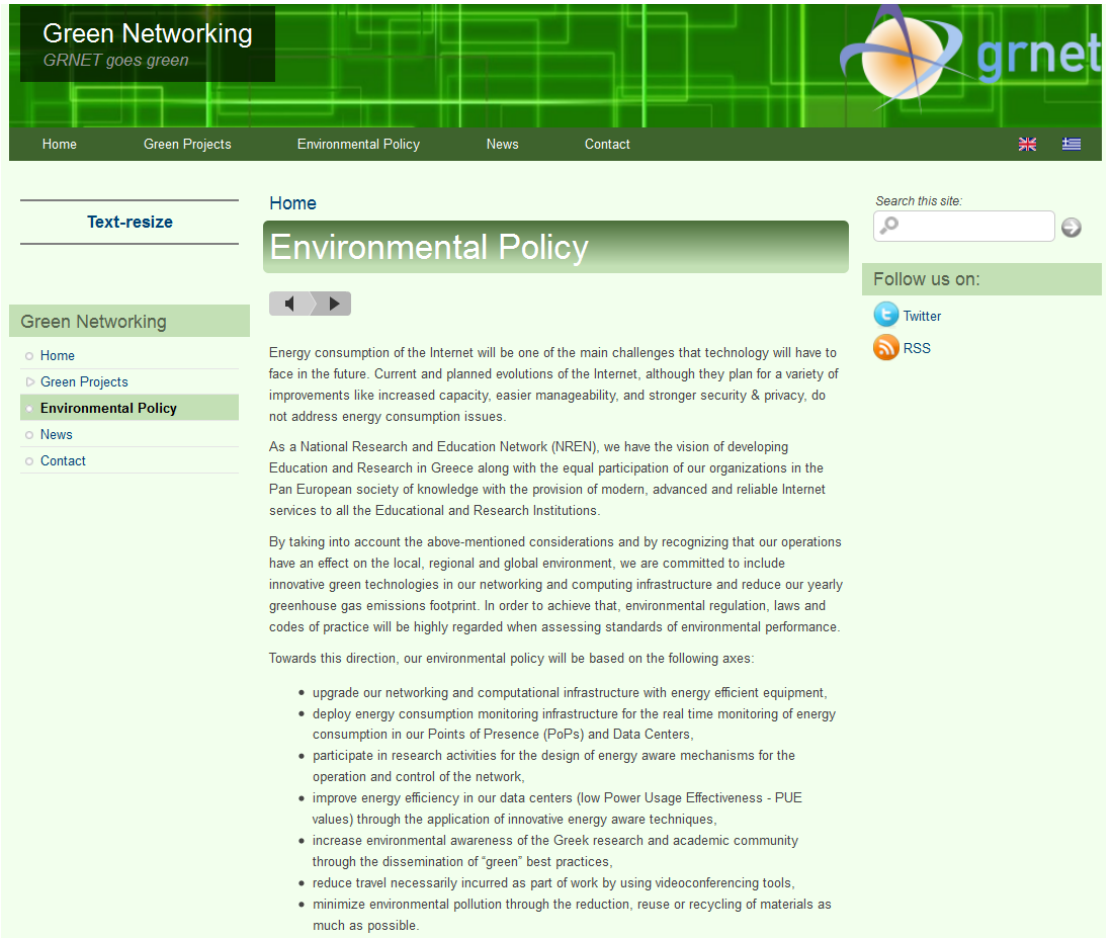
Last Update : 18-06-2012 14:50:26

Activation Date : 13-06-2012 17:44:01

Meter Type : Current Cost ENVI/ENVIR

Central : Yes

GRNET goes green!



Thank you for your attention
Questions?

http://green.grnet.gr
https://twitter.com/#!/GreenGRnet