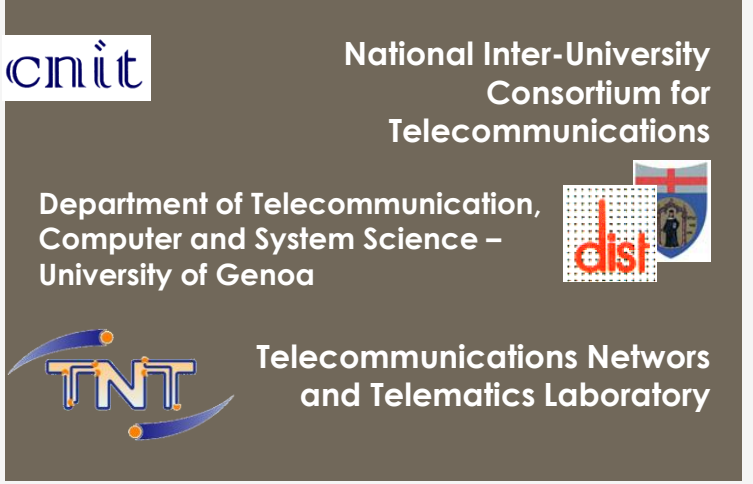

Efficienza energetica e Internet del futuro

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"Two faces of the same coin"

- Increasing the energy efficiency and the sustainable growth of our world is a global process where Telecommunications technologies (and the ICTs in general) play a key role.
- But to obtain optimum results the process should involve the "two faces of the same coin":
  - **Green ICT** – reducing the carbon footprint of ICT
  - **ICT for Green** – using ICT for reducing third party-wastes.

Why ICT should Go Green?

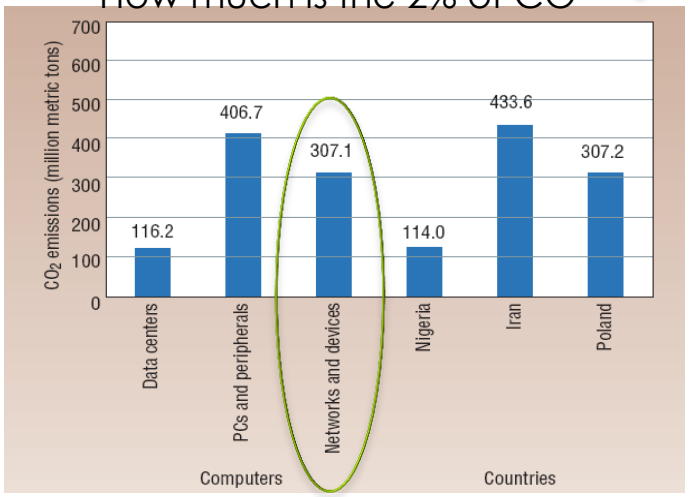
- There are two main motivations that drive the quest for "green" ICT:
  - the environmental one, which is related to the reduction of wastes, in order to impact on CO^2 emission;
  - the economical one, which stems from the reduction of operating costs (OPEX) of ICT services.

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

How much is the 2% of CO^2

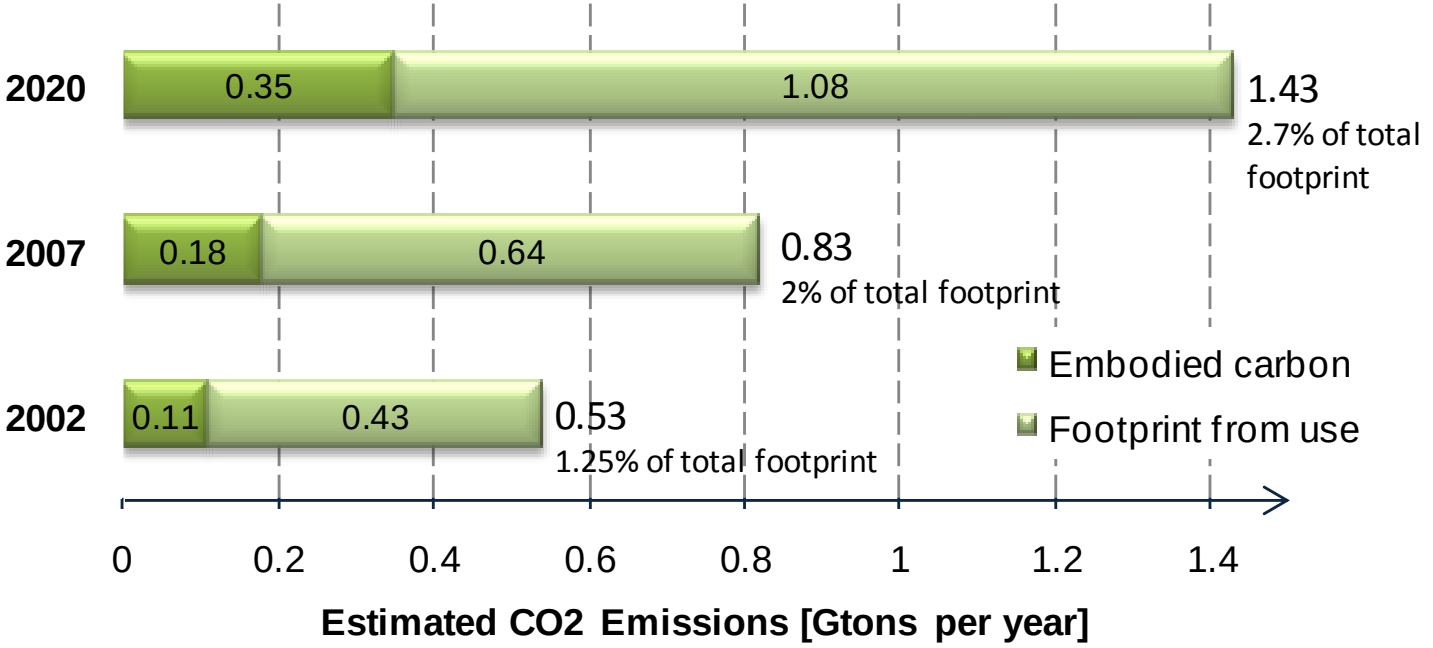


Telecoms

Energy Consumption (TWh per year)					
Telecom	2006	2007	2008	2009	2010
Deutsche Telekom (World)	7.10	7.22	7.84	7.91	-
France Telecom (World)	3.66	3.47	4.57	4.38	-
Telecom Italia	2.10	2.15	2.13	2.14	-
British Telecom (UK)	1.94	1.99	2.03	2.28	2.28
British Telecom (World)	-	-	2.6	2.71	3.12
AT&T (World)	-	-	-	11.07	11.14
Verizon	8.90	-	-	10.27	10.24
NTT	-	2.76	2.76	2.75	-
Telefonica	1.42	-	4.76	5.05	6.37
SwissCom	-	-	0.43	0.40	0.40
China Mobile	-	-	9.35	10.62	11.94
SK Telecom	-	-	0.94	1.09	1.09

Yearly energy consumption of some of the major world-wide Telecoms. These data were obtained by the Sustainability Report of each company.

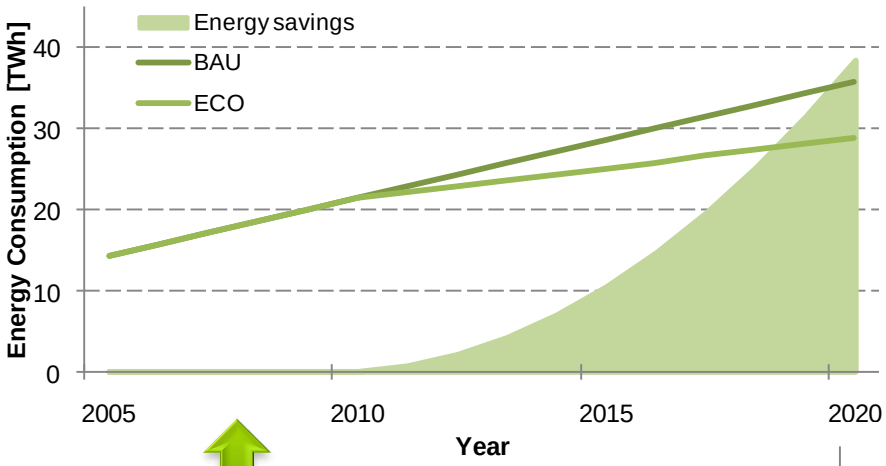
…and the Future?



Estimate of the global carbon footprint of ICTs (including PCs, telcos' networks and devices, printers and datacenters).

Source: Smart 2020 report by Global e-Sustainability Initiative (GeSI)

…and the Future?

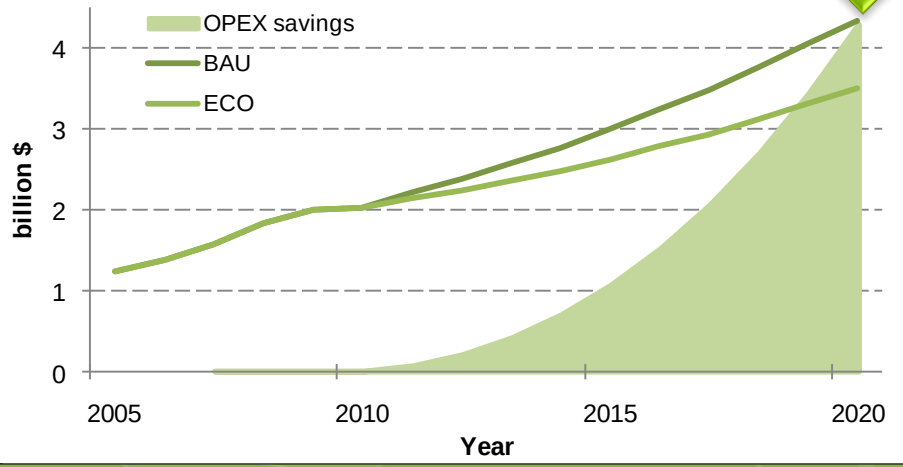


Energy consumption estimation for the European telcos' network infrastructures in the "Business-As-Usual" (BAU) and in the Eco sustainable (ECO) scenarios, and cumulative energy savings between the two scenarios.

Source: European Commission DG INFSO report

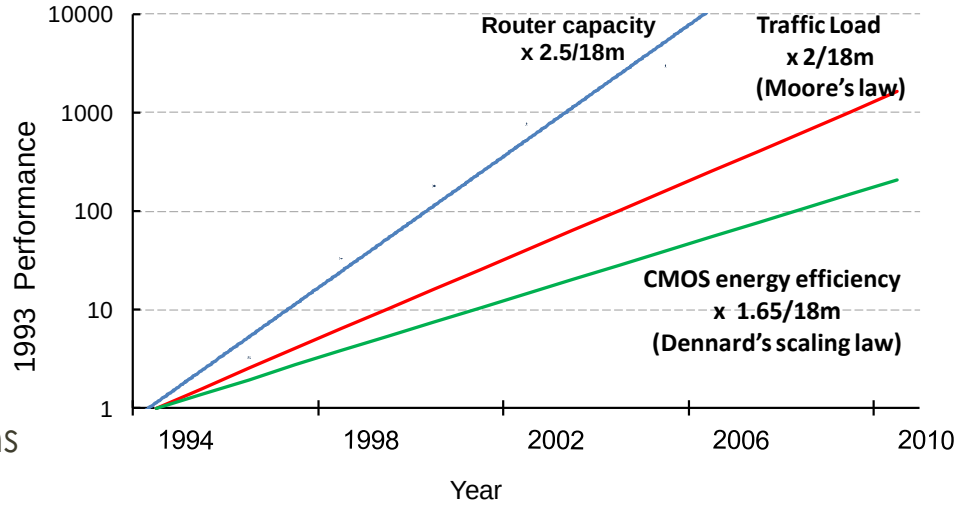
OPEX estimation related to energy costs for the European telcos' network infrastructures in the "Business-As-Usual" (BAU) and in the Eco sustainable (ECO) scenarios, and cumulative savings between the two scenarios.

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, in press.



And the Reasons?

- To support new generation network infrastructures and related services for a rapidly growing customer population, **telcos and ISPs need**:
  - an **ever larger number of devices**,
  - **devices with sophisticated architectures** able to perform increasingly complex operations in a scalable way.
- **The sole introduction of novel low consumption silicon technologies cannot clearly cope with such trends**, and be enough for drawing ahead current network equipment towards a greener Future Internet.



Evolution from 1993 to 2010 of high-end IP routers' capacity (per rack) vs. traffic volumes (Moore's law) and energy efficiency in silicon technologies.

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, 2011

Ongoing European Projects

- **ECONET** (low Energy COnsumption NETworks) – EU FP7 Integrated Project (IP).
- **TREND** (Towards Real Energy-efficient Network Design) – EU FP7 Network of Excellence (NoE).
- **Earth**(Energy Aware Radio and Network Technologies) – EU FP7 Integrated Project (IP).
- **C2Power** (Cognitive Radio and Cooperative Strategies for Power Saving in Multistandard Wireless Devices) EU FP7 STREP Project.

ECO net

low Energy COnsumption NETworks

Project data at a glance	
Project Type	FP7 Integrated project
Project coordinator	Prof. Raffaele Bolla (CNIT, c/o University of Genoa)
Project duration	October 2010 – September 2013 (36 months)
Consortium	15 partners from 8 countries and 2 American University associated
Project budget	10.5 M€ (6.2 M€ from EU)
Resources	1168 PM (33 full time persons for three years)
Website	http://www.econet-project.eu

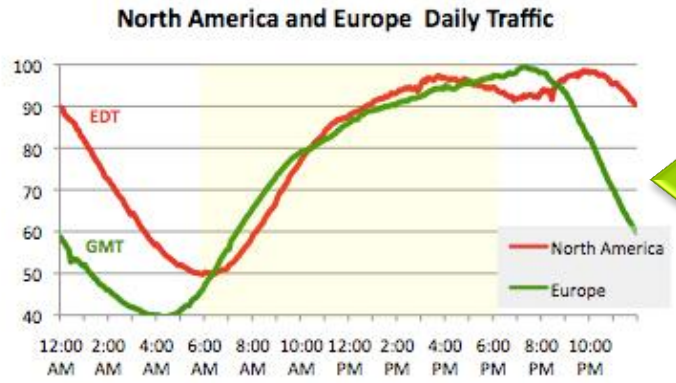
Participant organisation name	Short name	Country
Consorzio Nazionale Interuniversitario per le Telecomunicazioni – UdR at DIST University of Genoa (Coordinator)	CNIT	Italy
Mellanox Technologies	MLX	Israel
Alcatel Lucent	ALU	Italy
Lantiq	LQDE	Germany
Ericsson Telecomunicazioni S.p.A.	TEI	Italy
Telecom Italia	TELIT	Italy
Greek Research & Technology Network	GRNET	Greece
Research and Academic Computer Network	NASK	Poland
Dublin City University	DCU	Ireland
VTT Technical Research Centre	VTT	Finland
Warsaw University of Technology	WUT	Poland
NetVisor	NVR	Hungary
Ethernity	ETY	Israel
LightComm	LGT	Italy
InfoCom	INFO	Italy
Portland State University	PSU	USA
University of South Florida	USF	USA

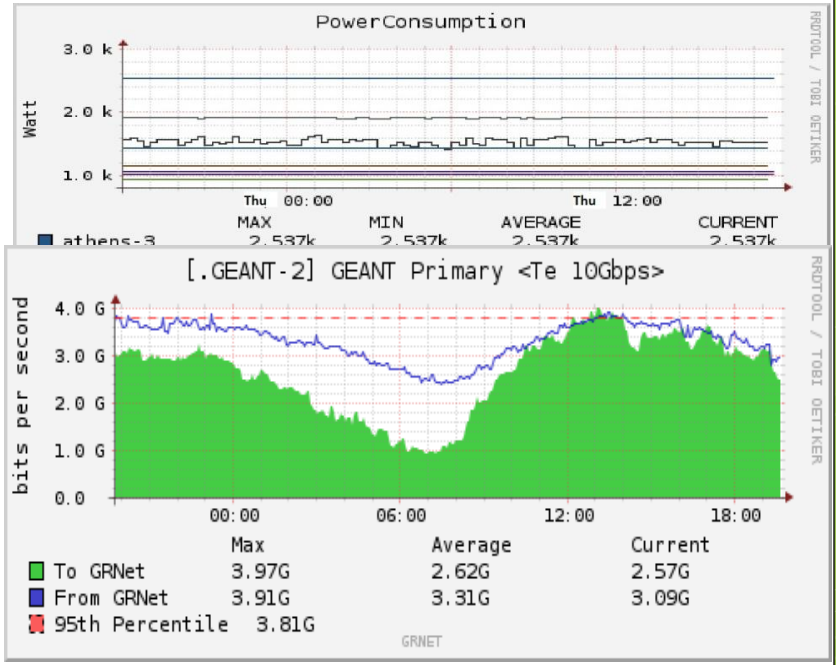
How to manage this

- Today's (and especially future) network infrastructures are characterized by:
  - **Design capable to deal with strong requests and constraints** in terms of resources and performances (large loads, very low delay, high availability, ….)
  - **Services characterized by high variability of load and resource requests** along time (burstness, rush hours, …)
- The current feasible solution:
  - **Smart power management**: energy consumption should follow the dynamic of the service requests.
  - **Flexibility in resource usage**: virtualization to obtain an aggressive sharing of physical resources

Is the energy consumption load-dependant?

Traffic load fluctuation at peering links for about 40 ISPs from USA and Europe

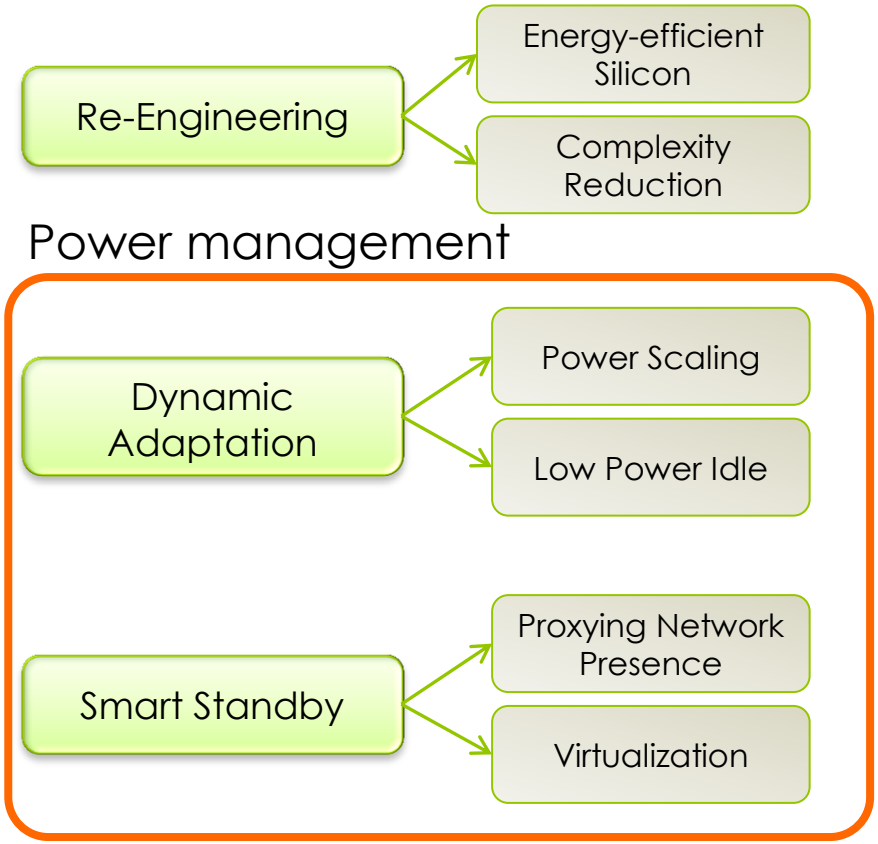


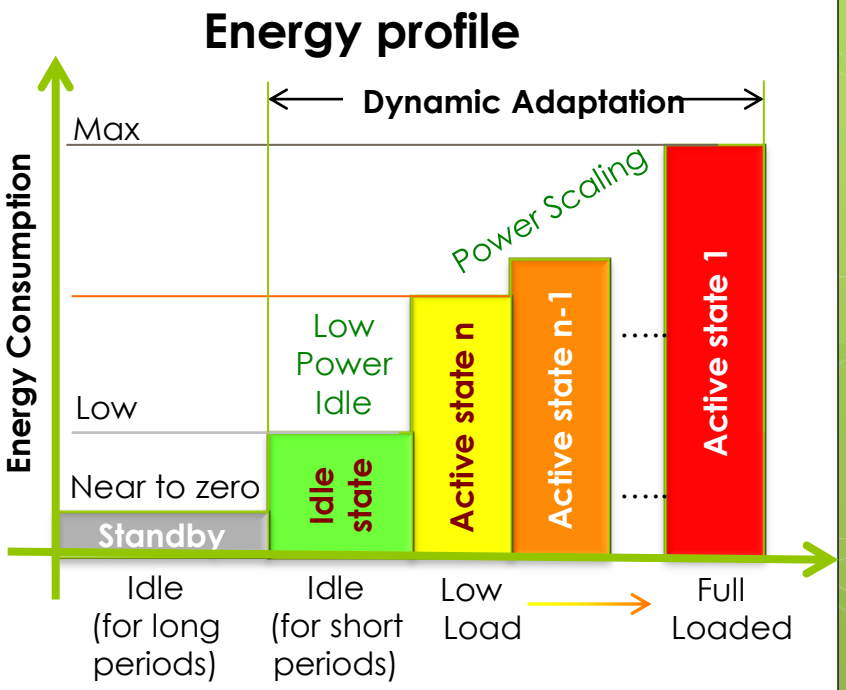


Network engineers only speak about the capacity of a device or of a link interface … in fact, device and link are specifically designed to work at the maximum speed…

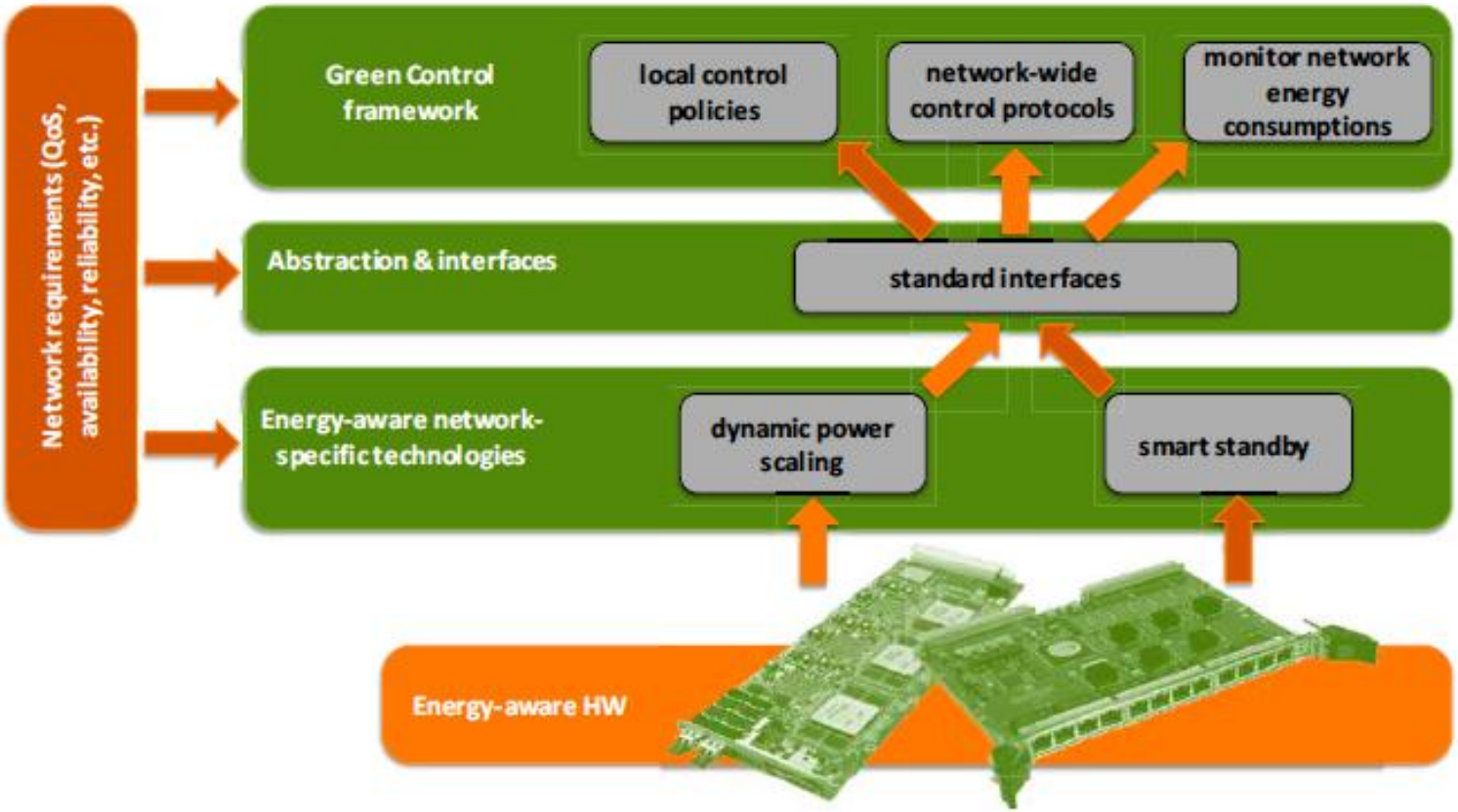
Source: The ECONET Consortium, "End-user requirements, technology specifications and benchmarking methodologies," Deliverable 2.1

A Taxonomy of Undertaken Approaches





The project approach



The Potential Impact

2015-2020 network forecast: device density and energy requirements

(example based on Italian network)

	power consumption (Wh)	number of devices	overall consumption (GWh/year)
Home	10	17,500,000	1,533
Access	1,280	27,344	307
Metro/transport	6,000	1,750	92
Core	10,000	175	15

Overall Energy Gains

	full load power consumption (Wh)	number of devices	Overall full consumption (GWh/year)	Gains	Energy gains with ECONET technologies (GWh /year)
Home	10	17,500,000	1533	70%	1060
Access	1,280	27,344	307	70%	213
Metro/transport	6,000	1,750	92	54%	49
Core	10,000	175	15	58%	9
			Overall gain	**68%**	
	Total BAU [GWh / year]		1947	**Total ECONET gains [GWh / year]**	**1331**

Customers' savings 1060 GWh/year

Networks' savings 270 GWh/year

Per-customer money savings

	Direct (Home)	Indirect (Telco)	Total
At today's energy cost	12€	2€	14€
At 2020 energy cost*	30€	6€	36€

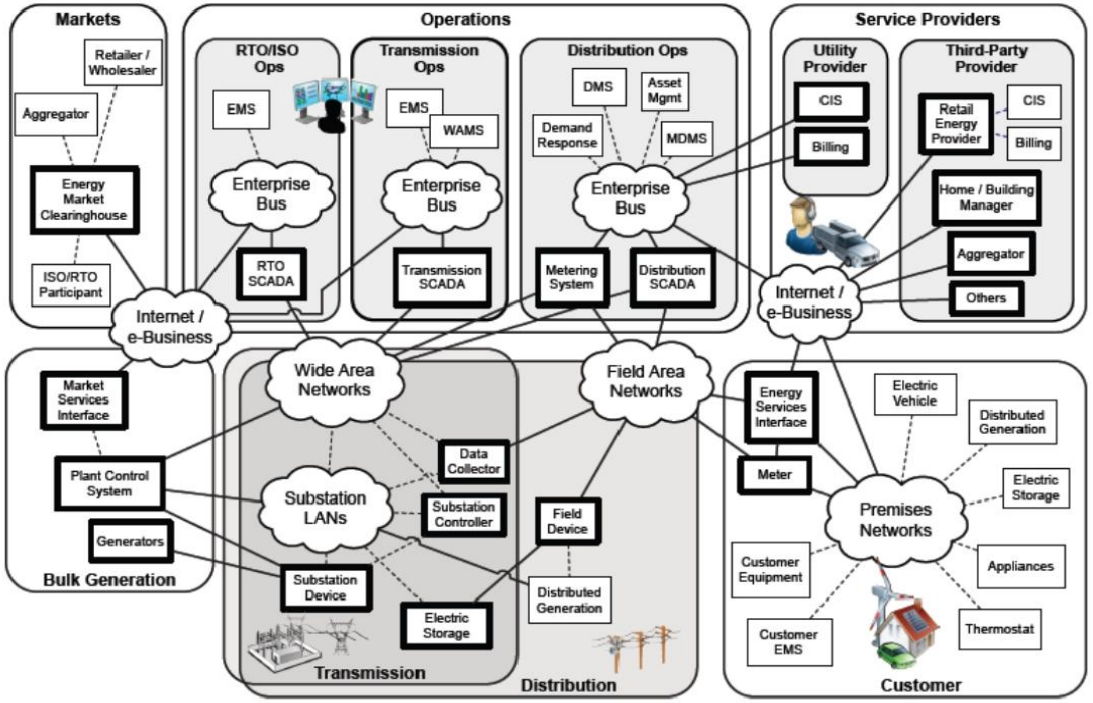
* Based on past 5-year trends in energy costs after inflation

Source: R. Bolla, R. Bruschi, K. Christensen, F. Cucchietti, F. Davoli, and S. Singh, "The Potential Impact of Green Technologies in Next-Generation Wireline Networks – Is There Room for Energy Saving Optimization?," *IEEE Communication Magazine (COMMAG)*, Special Topic in "Green Communications," Nov. 2010, in press.

Why ICT for green

The role of ICT for Smart Grids

- ***Actors***
  - make decisions and exchange information;
  - perform applications;
  - *devices, systems, programs*.
- ***Applications***
  - various kinds of tasks;
  - *home automation, energy generation, energy storage, energy management*.
- ***Domains***
  - group of actors,
  - similar objectives, same applications.



The NIST conceptual model for Smart Grids

Why ICT for green

ICT issues in Smart Grids

- **Distributed services and applications**
  - Service-Oriented Architectures: REST, Web Services , CORBA , DCOM;
  - EU projects: SmartHouse/SmartGrid, Hydra.
- **Data models and information exchange**
  - many IEC standards available
    - powerline communication, WAN operations, distribution and substation automation, distributed energy resources, head-end and cross-domain interaction;
  - lack of standards for home automation, generation resources, etc.;
  - description languages: SCL, CIM;
  - communication protocols: MMS, GOOSE, GSSE, Web Services (soon).
- **Networking**
  - Enterprise Buses, Wide Area networks, Field Area Networks and Premises Networks;
  - the TCP/IP stack is currently used for enterprise data and business networks, while specific protocols are used for SCADA systems.
- **Communication media and technologies**
  - wired and wireless infrastructures
    - IEEE 802.3/Ethernet, IEEE 802.11 (WiFi), IEEE 802.16 (WiMax), IEEE 802.15.4 and ZigBee (sensor networks), IEEE 1901 (HomePlug), ITU G-series (HomePNA and HomeGrid), ITU G.992/993 (xDSL), GSM/GPRS, UMTS and most of IEC standards for electricity grids.

Why ICT for green

Challenges for ICT

- *The use of Internet technologies and infrastructures*
  - worldwide consensus, mature technology, lots of applications available;
  - Smart Grids have strict requirements on resilience, robustness, security, performance.
- *Security*
  - safety, secure data exchange.
- *Management of large amounts of data*
  - measure, report and control of electricity production and consumption.
- *ICT impact on overall consumption!*

Why ICT for green

Current initiatives

- Many standardization bodies involved
  - NIST, IEEE, **ETSI**, **Joint Working Group of CEN/CENELEC/ETSI**, IEC, **ITU (Focus Group on Smart Grids)**, ISO/IEC JTC 1, IETF, TIA, ATIS.
  - **ITU - Guidelines for Environmental Sustainability Standard for the ICT Sector**
- Several roadmaps and frameworks already published
  - vision and strategy for deployment;
  - inventory of current technologies and applicability to smart grids;
  - identification of missing technologies.

Thanks for your attention

Any question?