



low **E**nergy **C**onsumption  
**NET**works



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Telecommunication Networks  
and Telematics Laboratory

**Enabling fixed network  
energy efficiency  
optimization through dynamic  
power management –  
The ECONET approach**

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*on behalf of the ECONET Consortium*

# Where did the idea of ECONET stem from?

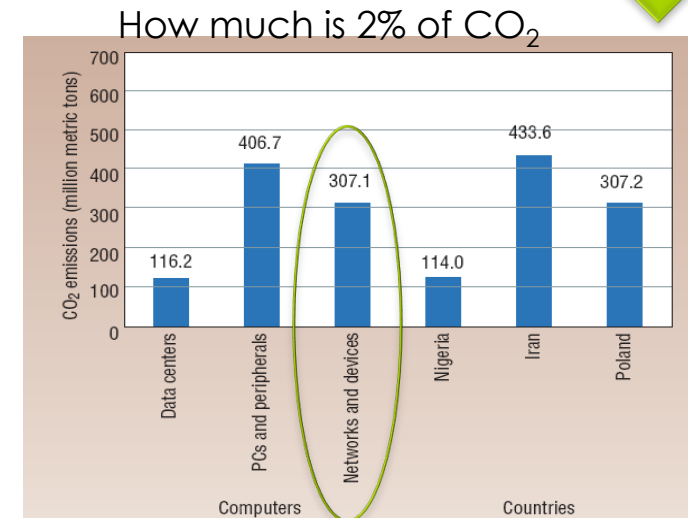
## ...Driving forces

- 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<sub>2</sub> emission;
  - the economical one, which stems from the reduction of operating costs (OPEX) of ICT services.

Gartner Group, Inc. (2007)

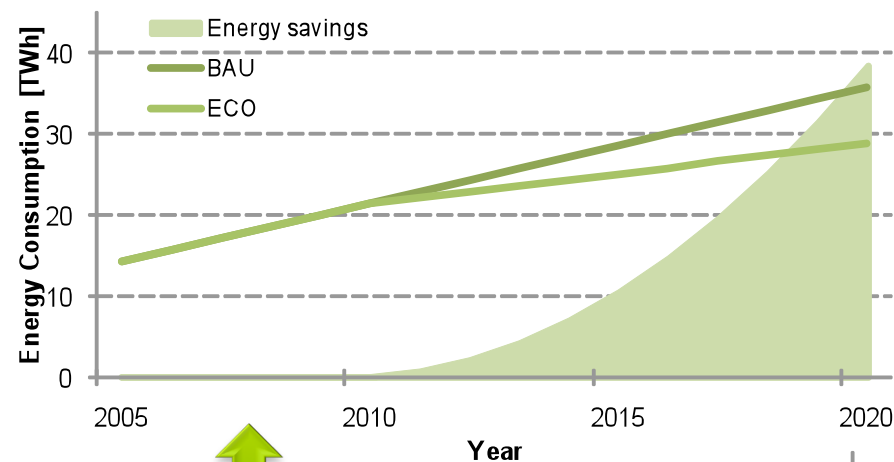
*“The global information and communications technology (ICT) industry accounts for approximately 2 percent of global carbon dioxide (CO<sub>2</sub>) emissions, a figure equivalent to aviation.”*

Note that the ICT sector raises much faster than aviation



# Where did the idea of ECONET stem from?

## ...Potential saving

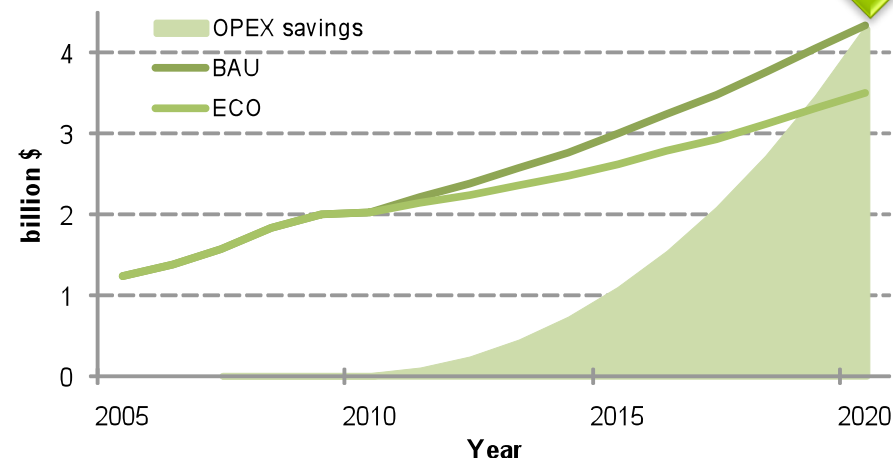


Energy consumption estimation for the European telcos' network infrastructures in the "Business-As-Usual" (BAU) and in the Eco sustainable (ECO) scenarios, and cumulative energy savings between the two scenarios.

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.

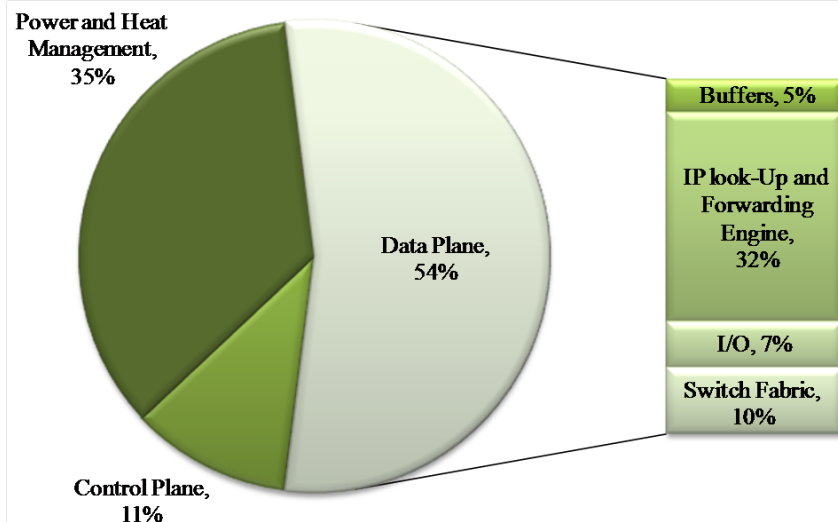
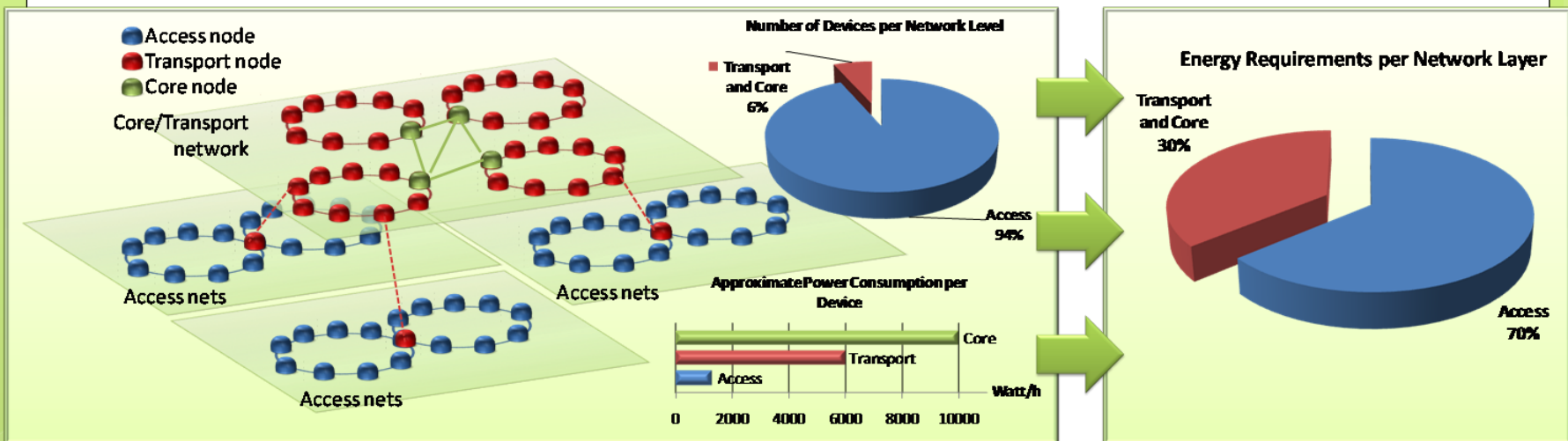
Source: R. Bolla, R. Bruschi, F. Davoli, F. Cucchietti, "Energy Efficiency in the Future Internet: A Survey of Existing Approaches and Trends in Energy-Aware Fixed Network Infrastructures," IEEE Communications Surveys & Tutorials, vol. 13, no. 2, pp. 223-244, 2<sup>nd</sup> Qr. 2011.



# Where did the idea of ECONET stem from?

...How to cope with 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 performance (large loads, very low delay, high availability, ....)
  - Services characterized by high variability of load and resource requests** along time (burstiness, rush hours, ...)
- The current feasible solution:
  - Smart power management**: energy consumption should follow the dynamics of the service requests.
  - Flexibility in resource usage**: virtualization to obtain an aggressive sharing of physical resources.

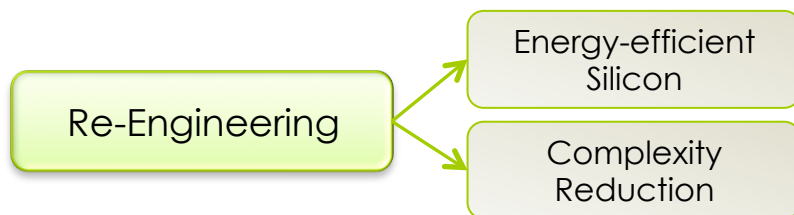


Examples of device density, relative power requirements and overall power consumption per network layer

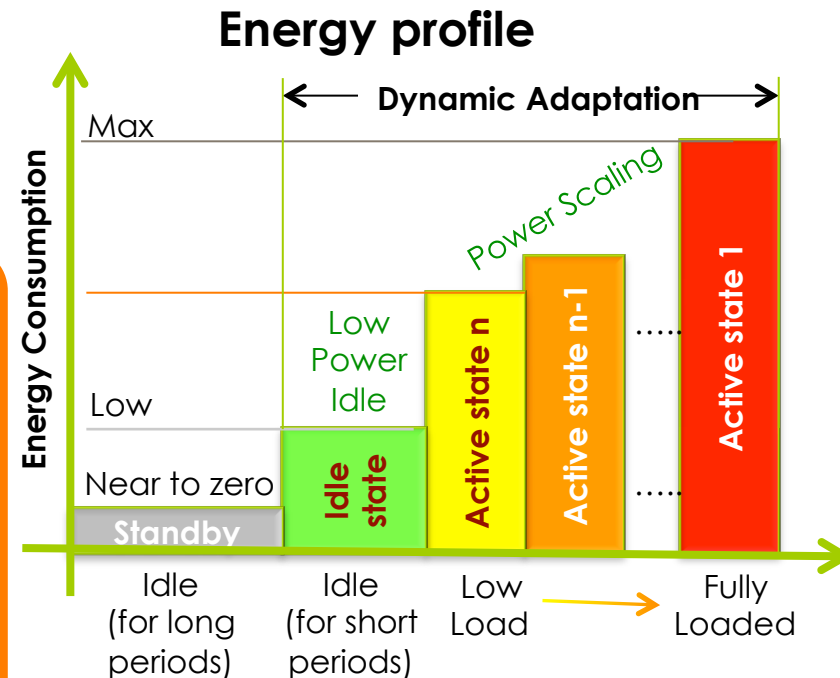
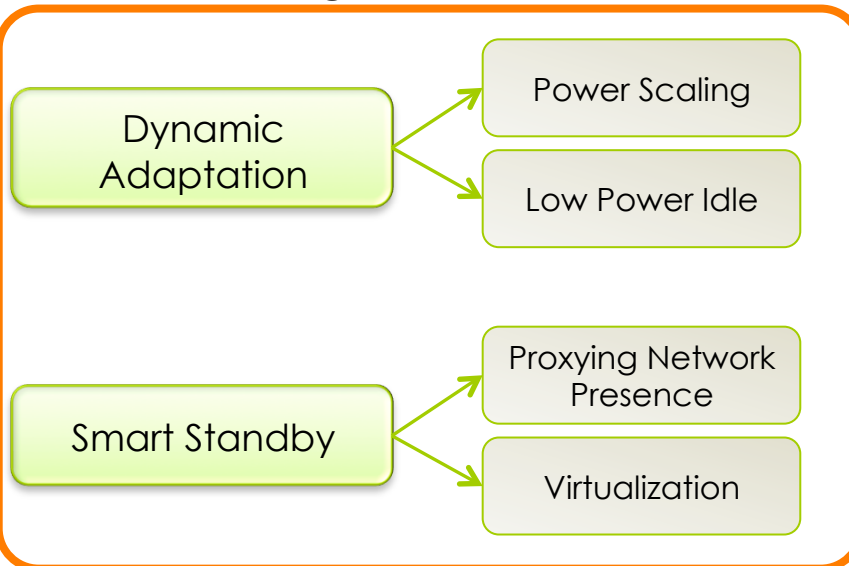
Example of energy requirements of components of multi-chassis routers

The main challenge is to design, develop and test novel technologies, integrated control criteria and mechanisms for network equipment enabling energy saving, by dynamically adapting network capacities and resources to current traffic loads and user requirements, while ensuring end-to-end Quality of Service.

# Possible Approaches



## Power management





## low Energy CONsumption NETworks

### Project data at a glance

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

| 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     |





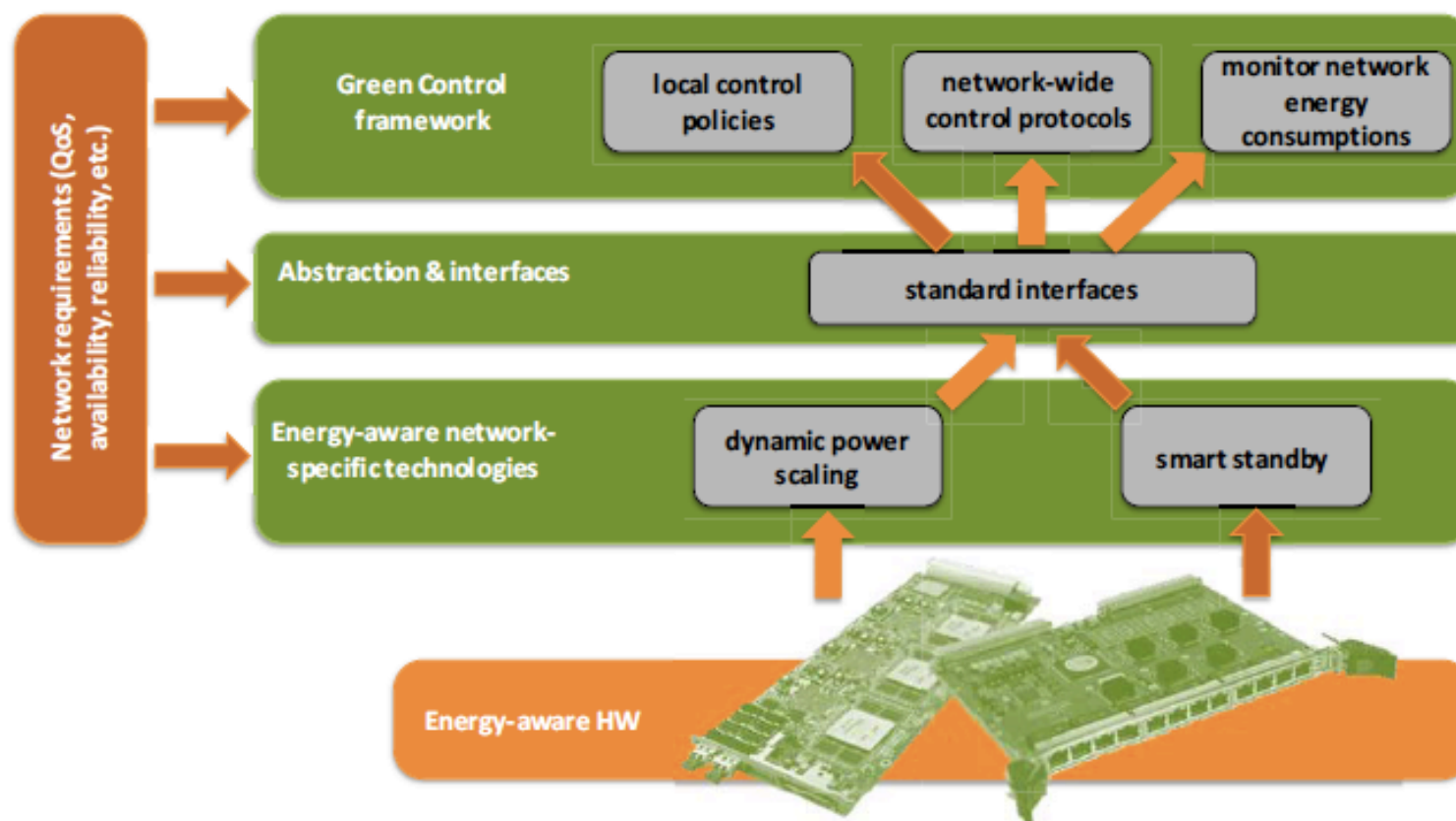
# Motivations

- 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.
- ECONET is dealing with the first aspect
  - Focused on short and medium term exploitation**

# Main objectives

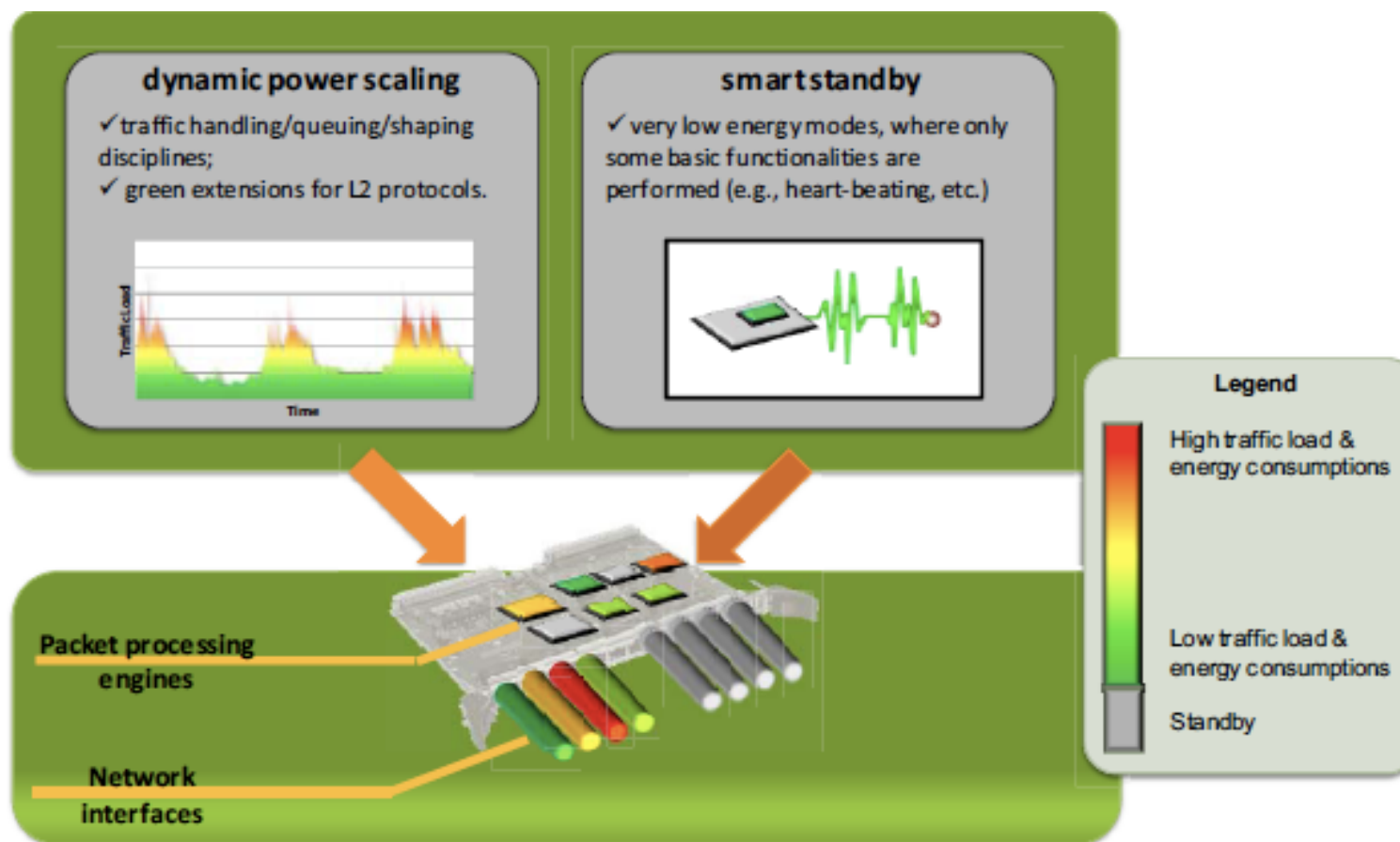
- The ECONET project aims at studying and introducing **adaptive technologies (standby and performance scaling)** that allow saving energy when a network device or part of it is not used in wire-line networks.
  - **Access/home** -> standby when users are not “connected”; idle/performance scaling when users are “connected”
  - **Core/metro** -> standby for redundant and unused HW; idle/performance scaling for active HW
- The **final objective is to obtain an average consumption reduction of 50-80%**
- **The ambition is to produce a feasible and concrete solution exploitable within very few years to improve the behaviour of the current equipment and architectures.**
- This goal is also pursued by
  - promoting bridging actions between the Research/Academia and the **Standardization arena** to guarantee early and effective adoption of the new energy efficient techniques.
  - exploiting clustering activities with other projects running on the same green subject

# The project approach



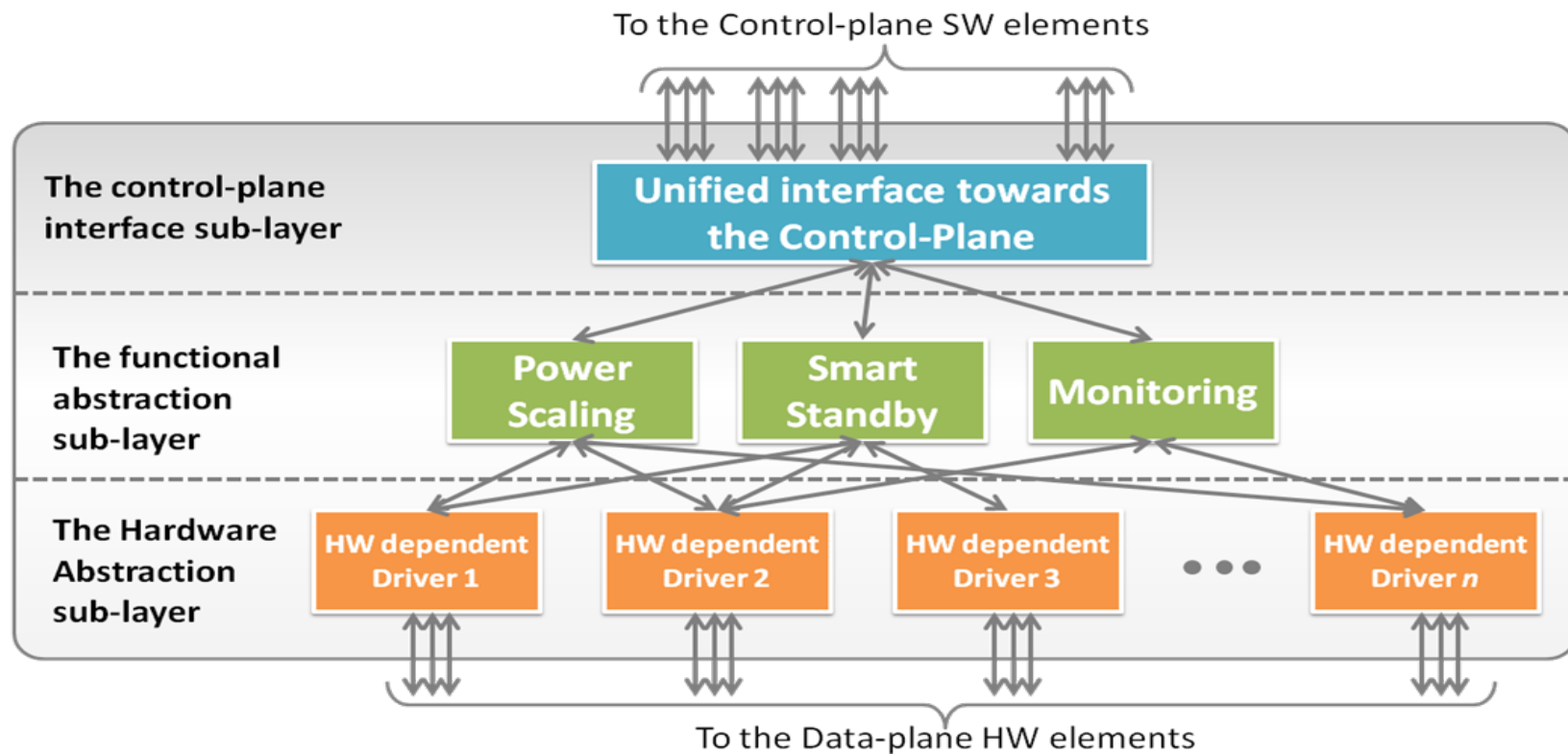
# The project approach

## Energy aware specific technologies



# The project approach

## Green Abstraction Layer





# The project approach

## Green Control Framework

Autonomic and short-term  
on-line optimizations

### Local Optimization Policies

Given:

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

dynamically find the best energy-aware configuration

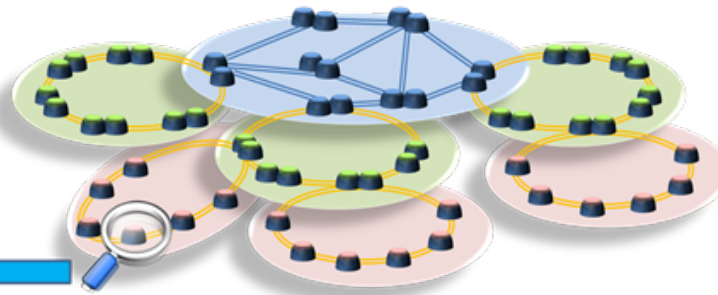


### Routing & Traffic Engineering

Given:

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

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



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)



## Exploiting Future energy-aware Optical Networks

Power consumption varies significantly across the different layers of the transport network with exponential increase in IP traffic.

It would be advantageous for operators to remain at lower layers to keep their energy bills under control.

The most eco-efficient architecture is a multilayer one that can automatically direct traffic to the lowest level of switching required according to service requirements (the proposed approach when implementing transport solutions).

Future energy-aware technologies to be deployed are:

1. ROADM and OTN
2. Intelligent Network Control Plane
3. Incorporating new technologies for devices (ECONET Device level)
4. Innovative photonic OAM features (e.g., Zero-Touch Photonics)
5. Power Scaling

## Exploiting Future energy-aware Optical Networks

### 1. T-ROADM (Tunable-Reconfigurable Add/Drop Multiplexing) and OTN

Multiple IP-traffic grooming options at the wavelength, port and sub-port-levels. Elastic network. GMPLS to the photonic layer, leveraging its resilience features and capacity for resource optimization.

### 2. Intelligent Network Control Plane

An ASON/GMPLS optical control plane simplifies network operations with the goal of creating a 'self-running' network in which 'the network is the database'. With ASON/GMPLS, the network has the intelligence to choose the most power-efficient layer for transport. With GMPLS provisioning and restoration capabilities at the photonic level, operators can improve their SLA (service level agreement) performance and the quality of their wavelength services.

### 3. Incorporating new component technologies (ECONET Device level)

Lower power cooling fan units, Power-efficient DC/DC converters and chips, Lower power optical components, Dynamic power and thermal management technologies

### 4. Innovative photonic OAM features (e.g. Zero-Touch Photonics)

The Zero Touch Photonics (ZTP) is a new concept. It consists of OAM features for complete networking capabilities at the photonic layer without requiring on-site intervention. New Green OSS features shall be introduced to cope with new green features of the optical network.



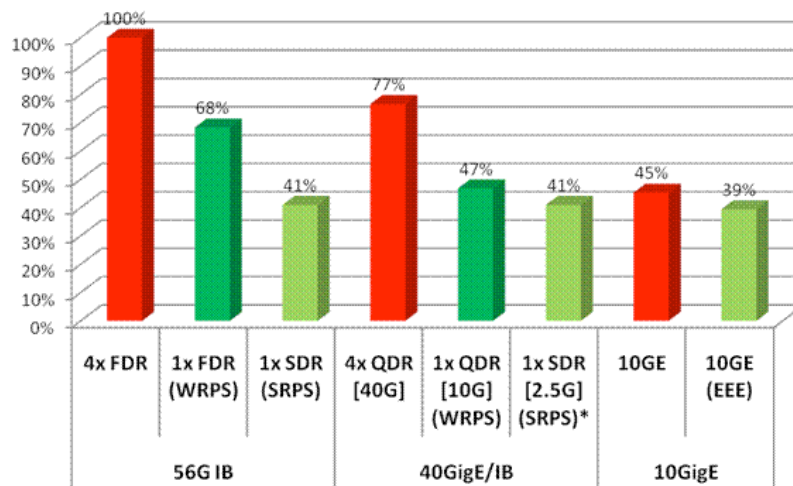
## Exploiting Future energy-aware Optical Networks

### 5. Power Scaling

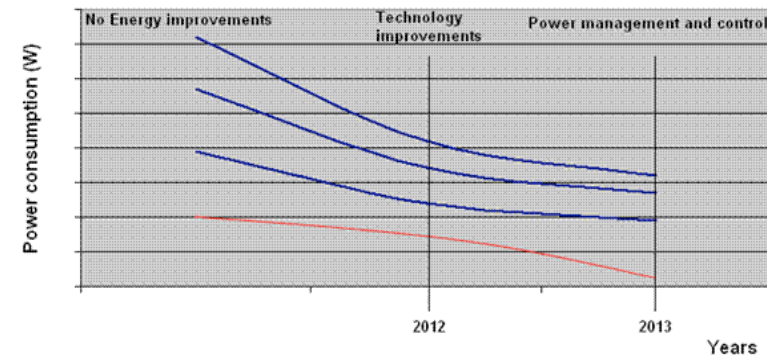
Current OTN is migrating from 2.5 to 10 Gb/s. 40 Gb/s to 100 Gb/s per-channel data rates have been accepted by standards bodies for the next-generation Ethernet. Further evolution to 400 and 1000 Gbit/s is also expected next.

By applying smart adaptation of power consumption of each port to the actual traffic it serves, we can accomplish power reduction up to 50% of the maximum power consumed by today switching systems. In the figure below we can assess the power benefit of applying width/speed reduction techniques.

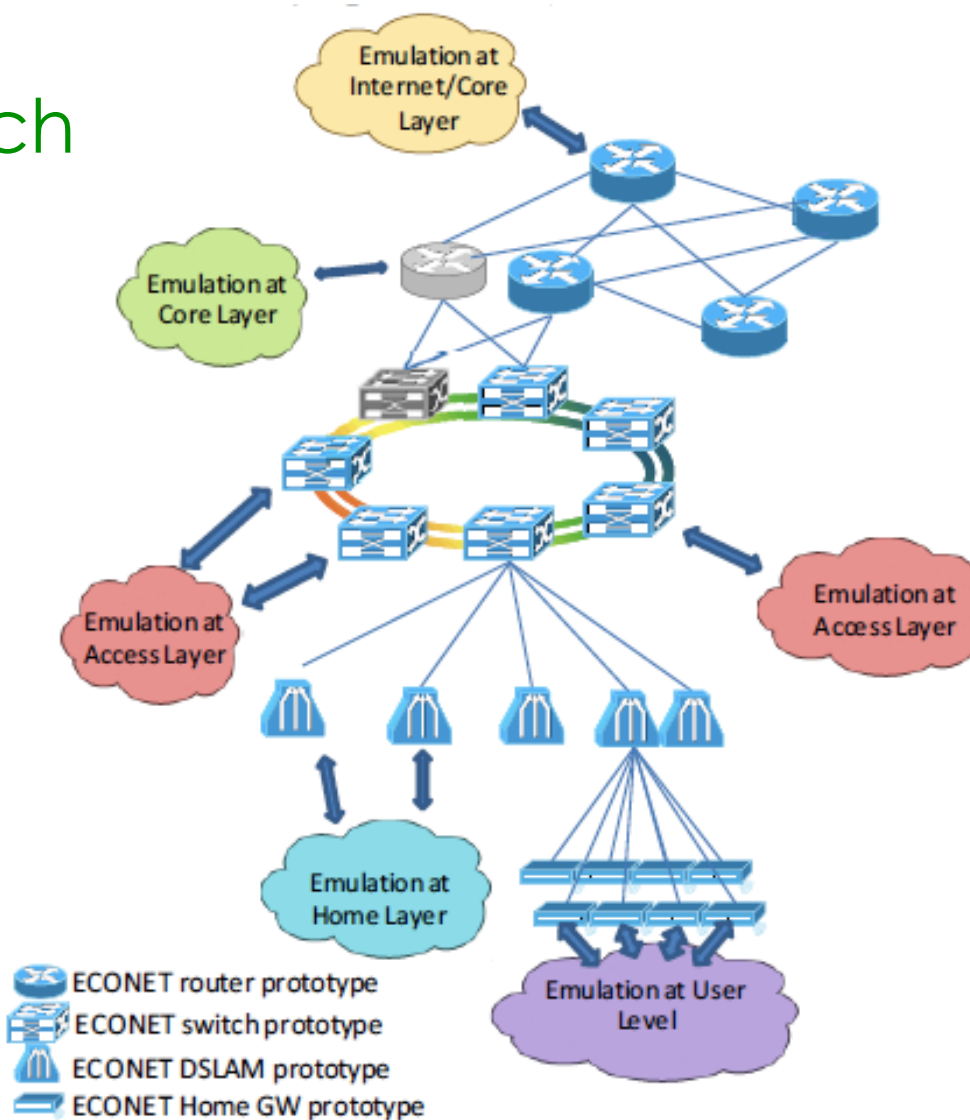
36 Ports Power Estimation ASIC Level(%)



PTN power consumption trends



## ECONET Test Bench @ TELIT Test Plant



Thanks for your attention