Smart Consumption: the Energy@home approach

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A INITIATIVE OF

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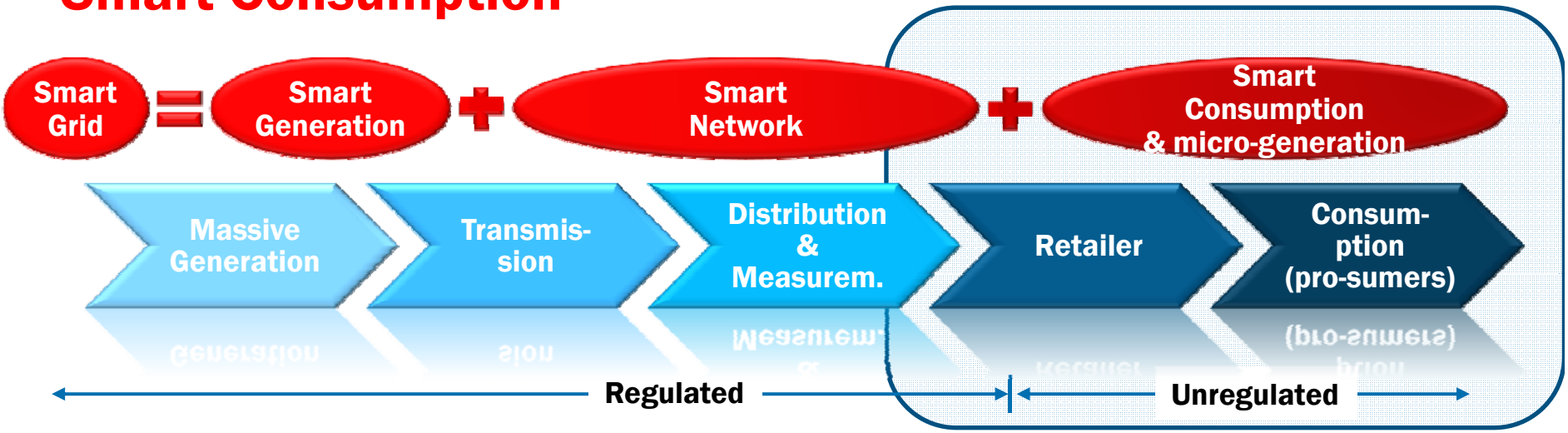
Outline

- The context: Smart Grid & Smart Consumption
- The Energy@home Association
- The Energy@home Approach
- First achievements
- Future directions

Smart Consumption

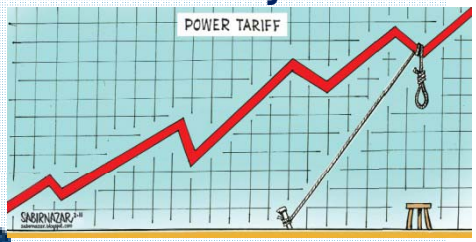


Some trends in Smart Consumption

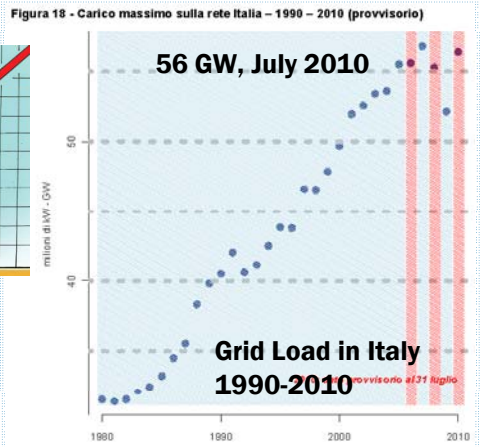
Electric Cars

Distributed Renewables

Time of day Tariffs



Peak reduction



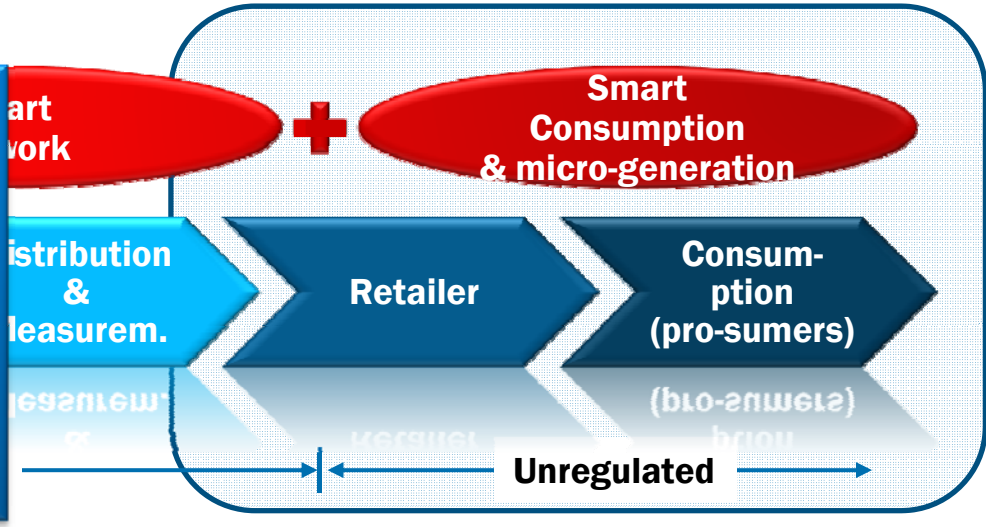
Efficiency

Tools to empower consumers

Smart Consumption

Goals for Smart Consumption:

- flexible & controllable demand
- flexible & controllable generation
- user awareness (beyond the bill)
- user empowerment



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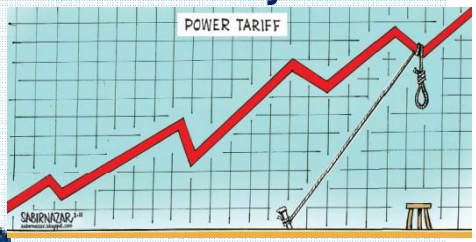

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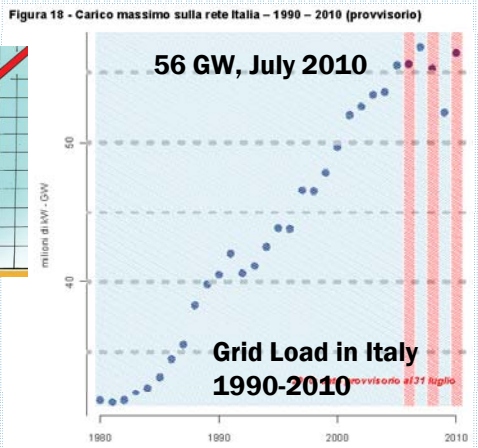
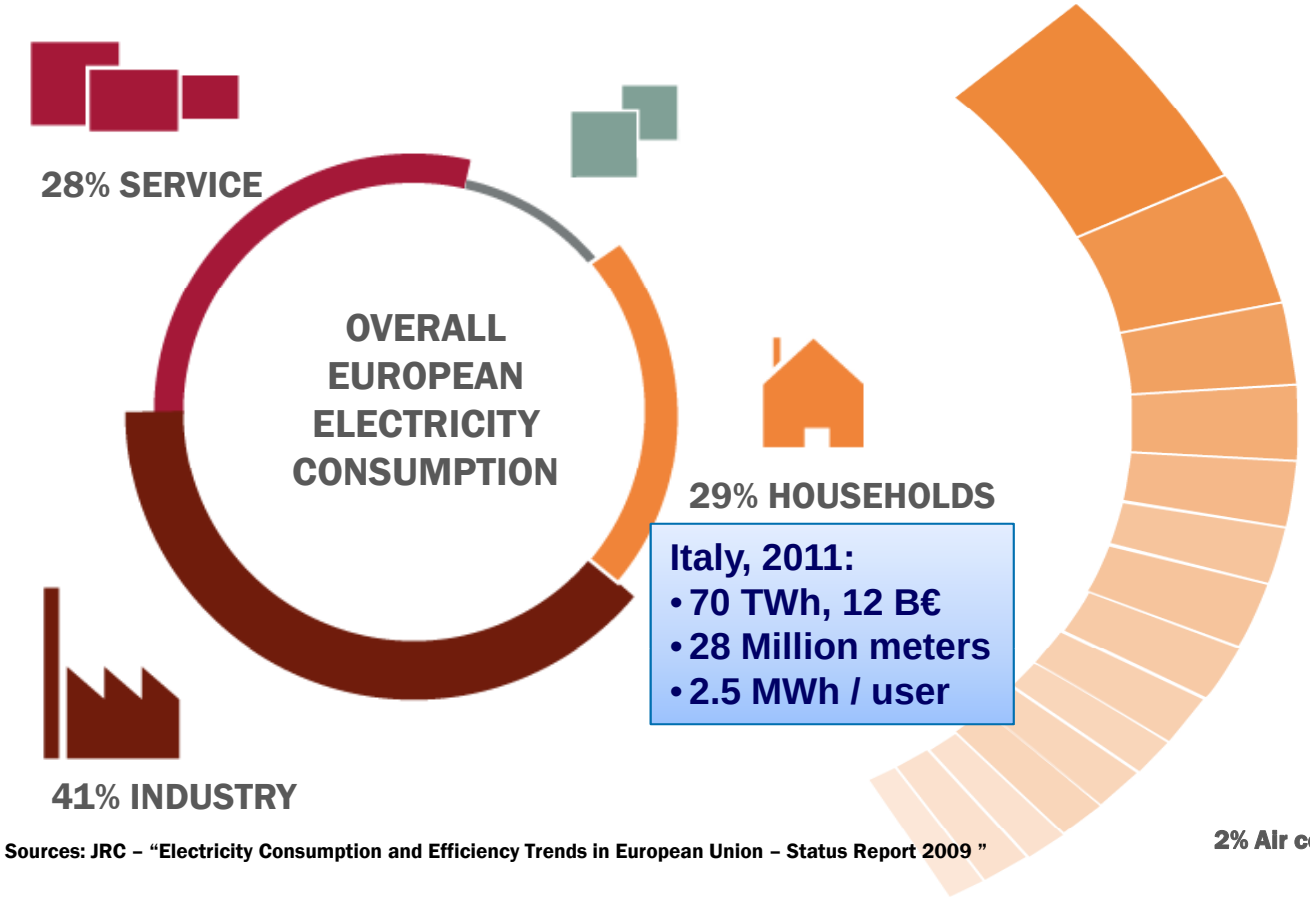


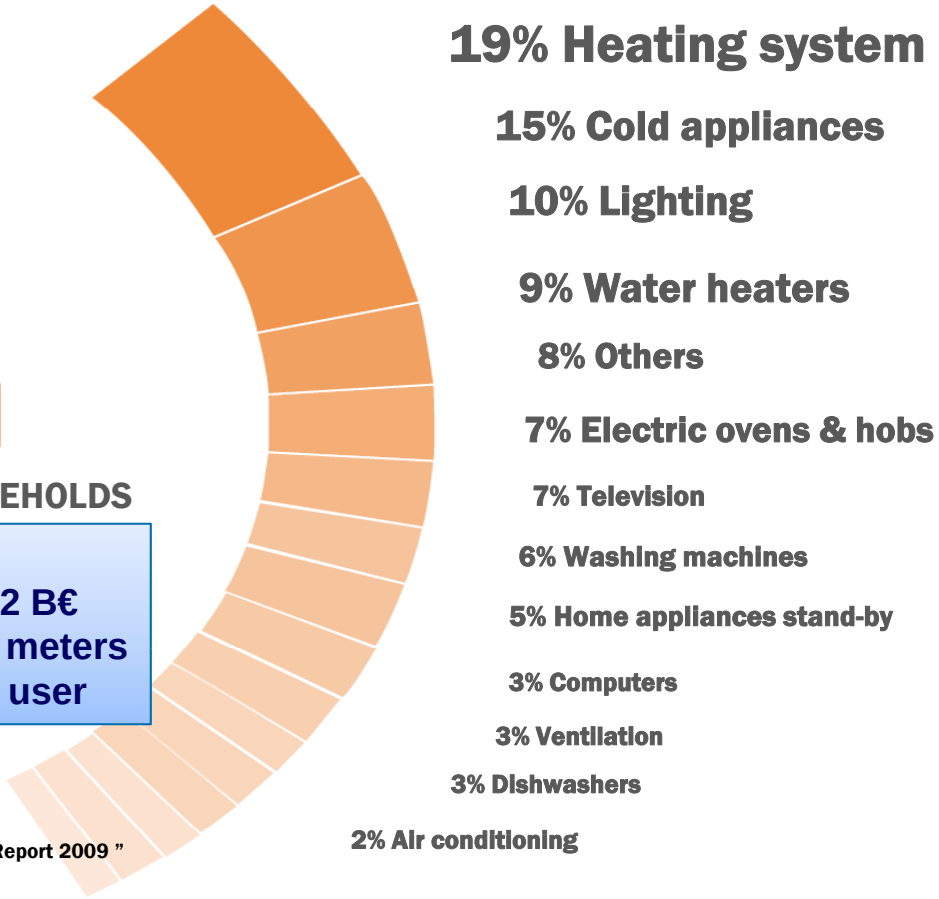
Efficiency

Tools to empower consumers

Energy Consumption in EU



Italy, 2011:
- 70 TWh, 12 B€
- 28 Million meters
- 2.5 MWh / user

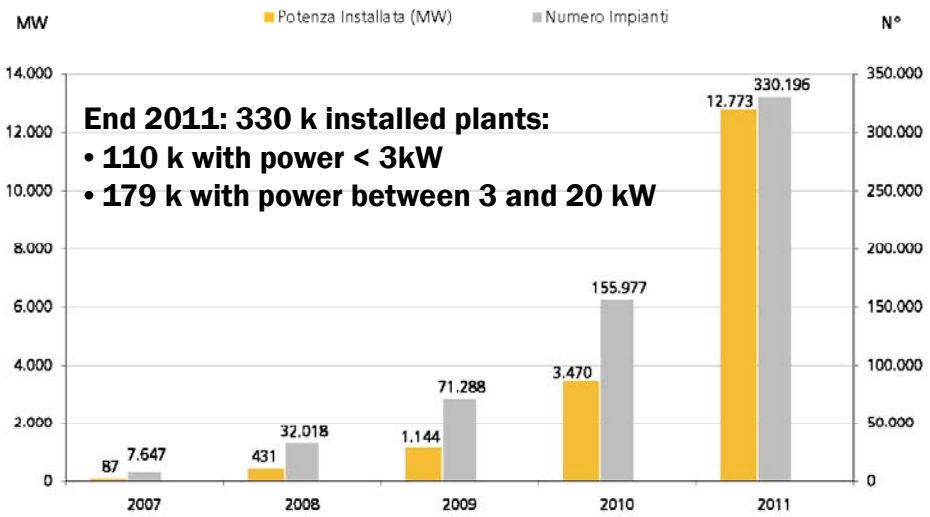


Sources: JRC – "Electricity Consumption and Efficiency Trends in European Union – Status Report 2009 "

- Devices should be turned into "smart" products that are **connected** to a network, **aware** of how they are being used, able to **inform** the user about their status, and able to be **controlled** by smartphones or also by utilities signals

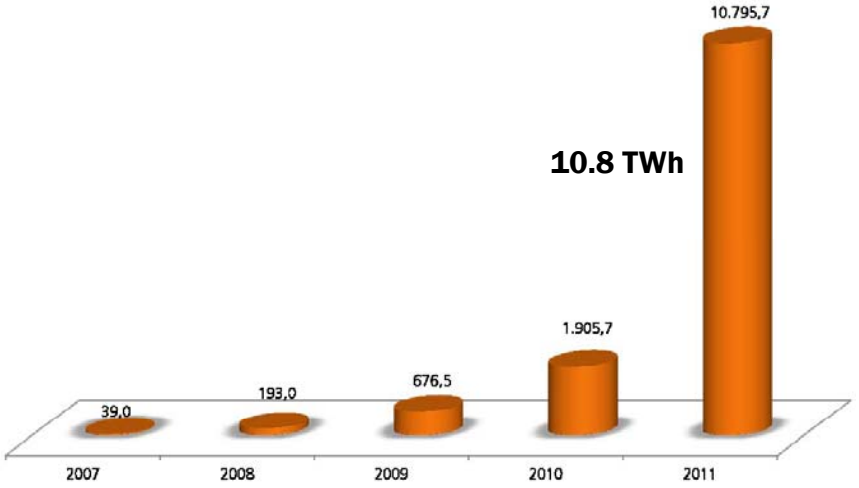
Micro-generation in Italy

Installed power & Numerosity



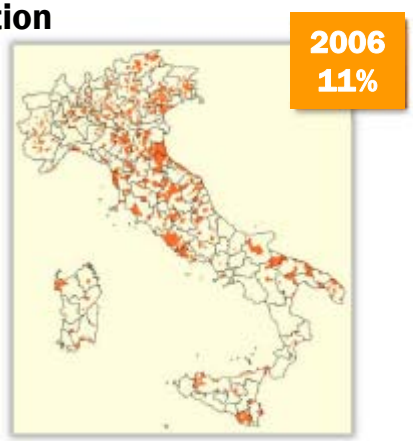
End 2011: 330 k installed plants:
- **110 k with power < 3kW**
- **179 k with power between 3 and 20 kW**

Gross generation

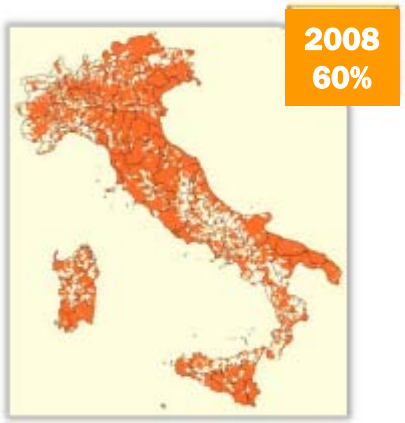


10.8 TWh

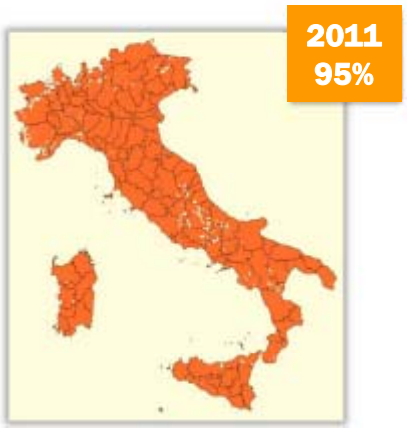
Penetration



2006 11%



2008 60%



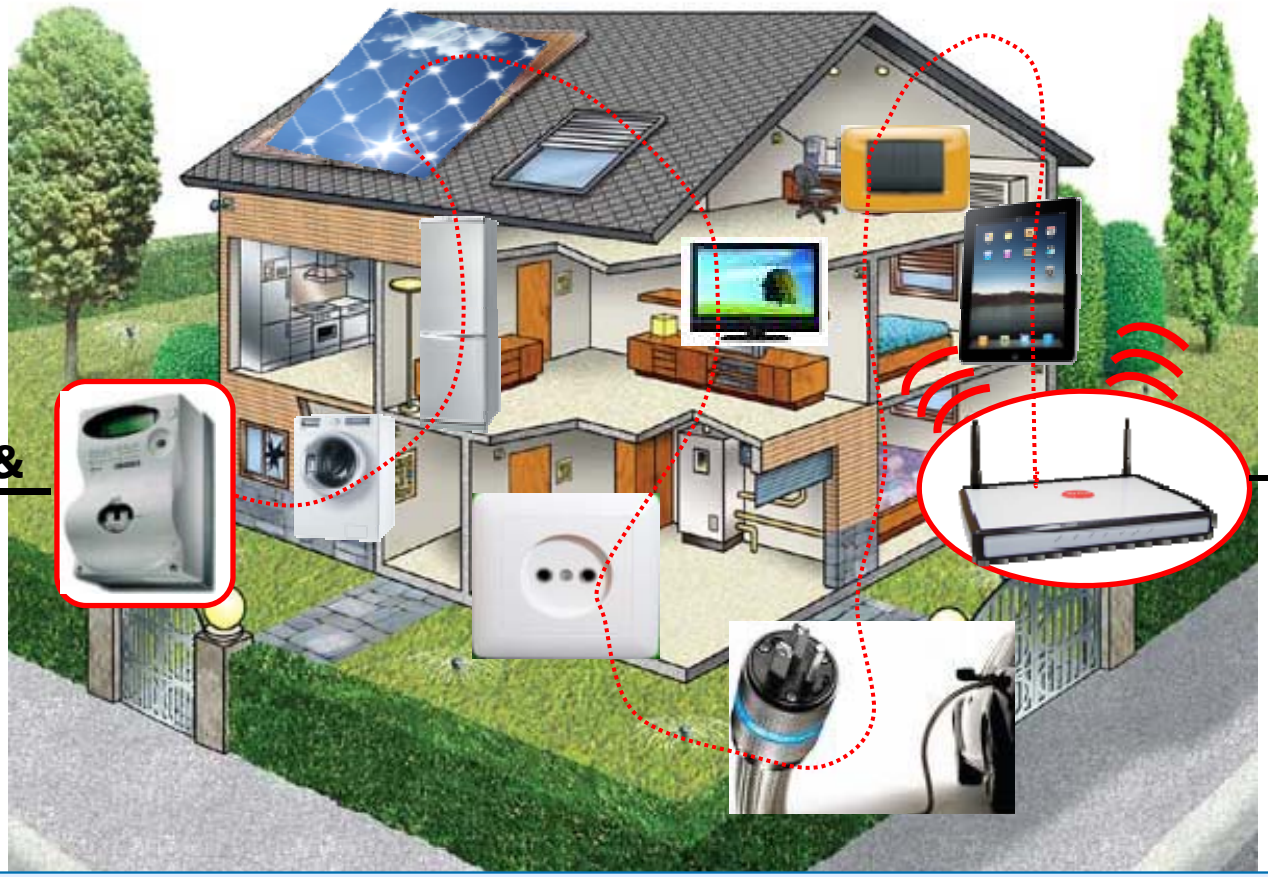
2011 95%

(Cities with plants)

(source GSE, 2011)

Energy@home: an eco-system of interacting devices & sub-systems

Grid network & Telegestore



TLC network & TI cloud

The home bus is the technical enabler:

- to coordinate (between appliances and sub-systems) to increase efficiency
- to make appliances, meters, & other home devices actors of the cloud
- to implement a service platform for new value added services (not limited to electricity)

Energy@home Association

Mission

Develop & Promote technologies and services for home energy efficiency based upon device-device communication

Non-profit Association founded on July 2012

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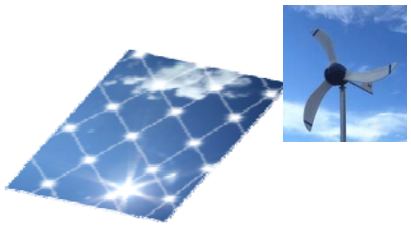
The association is open to new parties

Vision

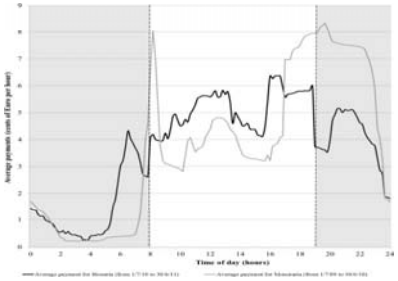
holistic approach towards energy efficiency: the house as an eco-system of interconnected and interacting user devices, home appliances, and sub-systems

- **coordinated energy consumption optimization between all the appliances**



- **energy micro-generation and consumption**

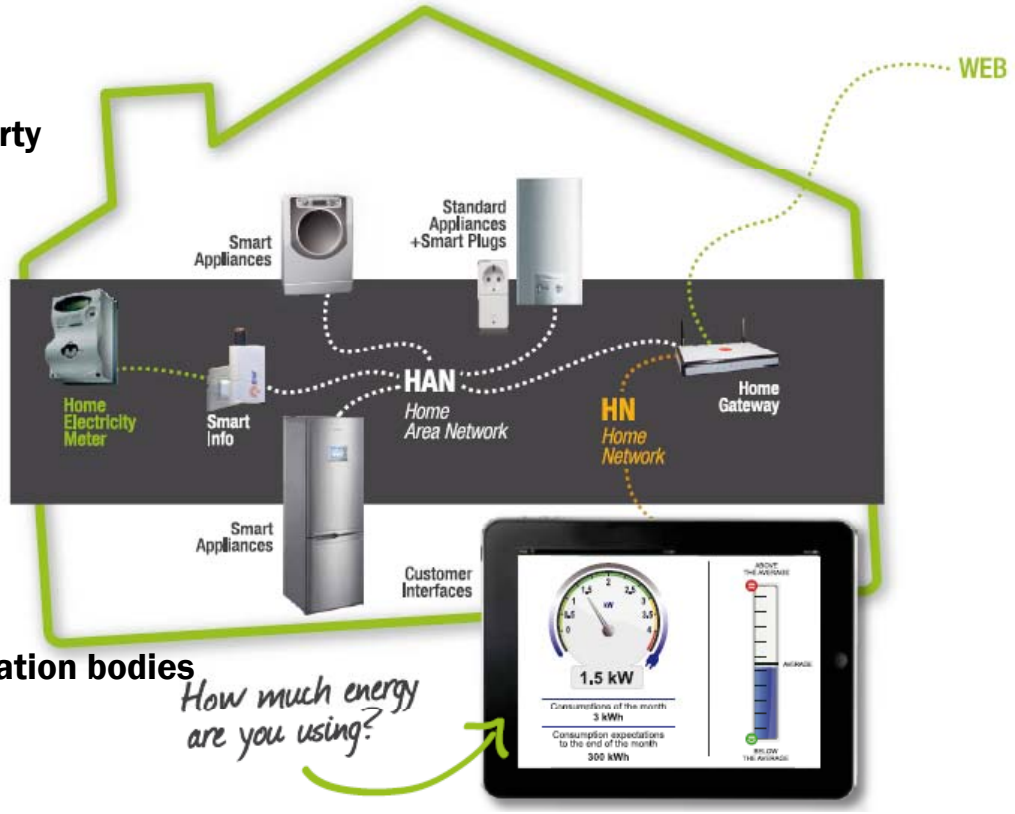
- **education of the consumer to a virtuous use of appliances towards a more sustainable lifestyle**



- **time of use and dynamic tariff schemes**

Energy@home approach

- **Open association**
  - The participation is open to any interested party
- **Interoperability among vendors**
  - Device-to-device communication
  - Sub-system to sub-system communication
- **Open specifications**
  - Public available
- **International-level specifications**
  - Through collaboration with proper standardization bodies



Achieved results, so far

- Technical specifications of the Home Area Network currently under standardization within the ZigBee Alliance
- An interoperable fully-integrated system comprising smart gateway, smart meter, smart plugs, and smart domestic appliances
- Interoperability test events (including some ZigBee events hosted by Energy@home)
- An Italian field trial involving 50 users
- A field trial in The Netherlands involving 300 users where Enexis utility is using the E@h protocol
- Foundation of the Energy@home Association

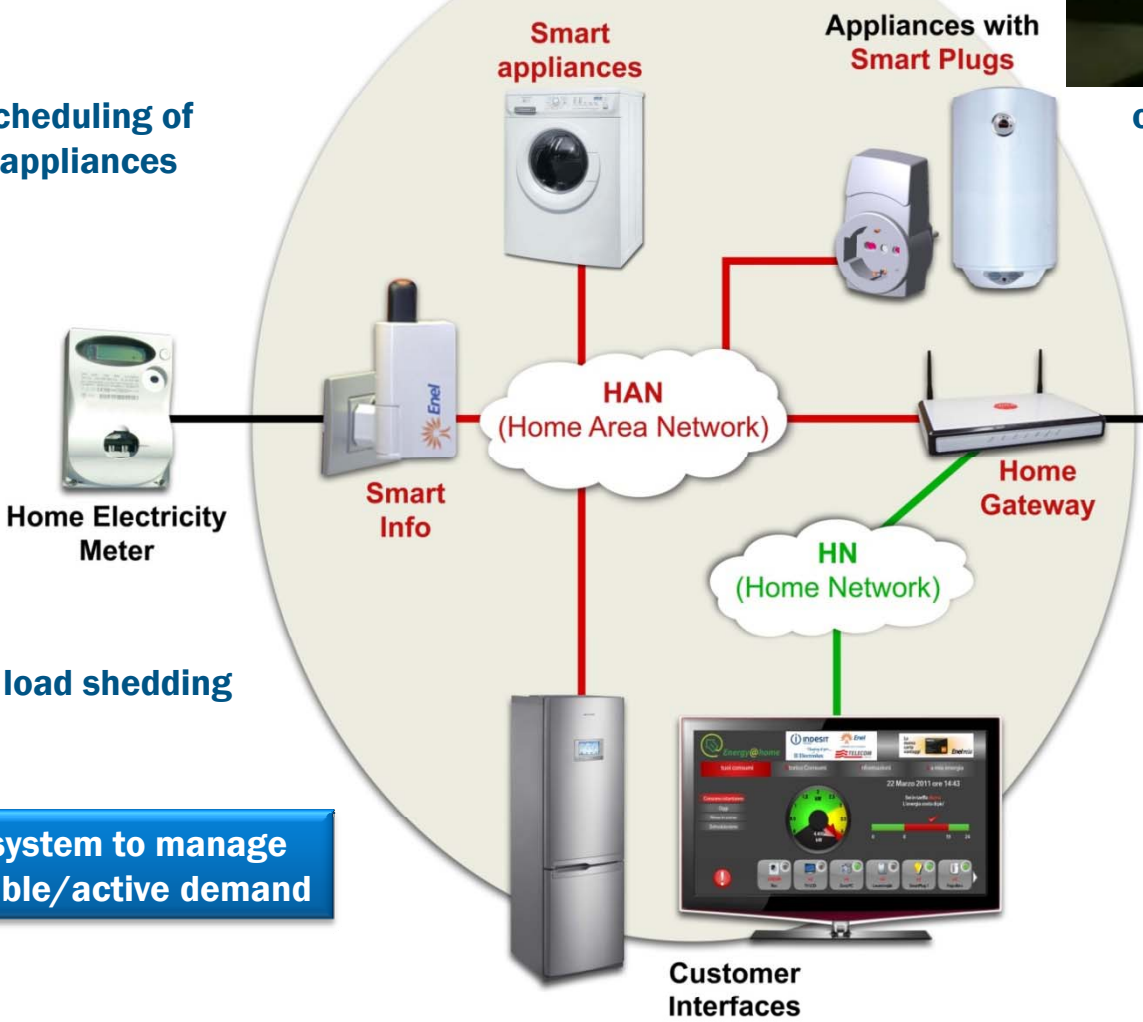
Architecture & Functionalities

overload control

scheduling of appliances

control of stand-by consumptions

load shedding



visualization of cost

A system to manage flexible/active demand

user awareness

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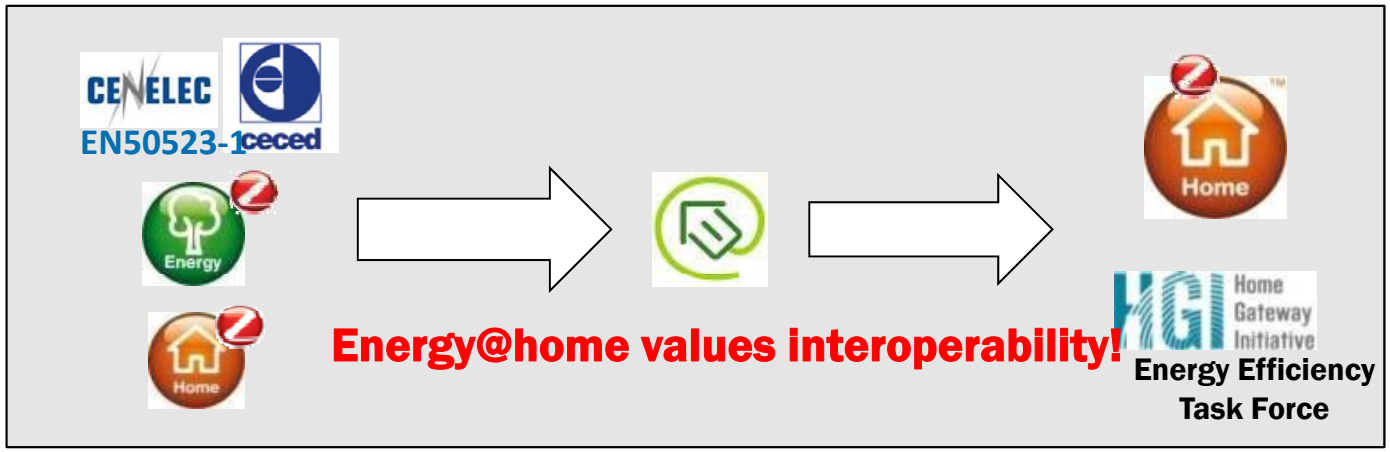
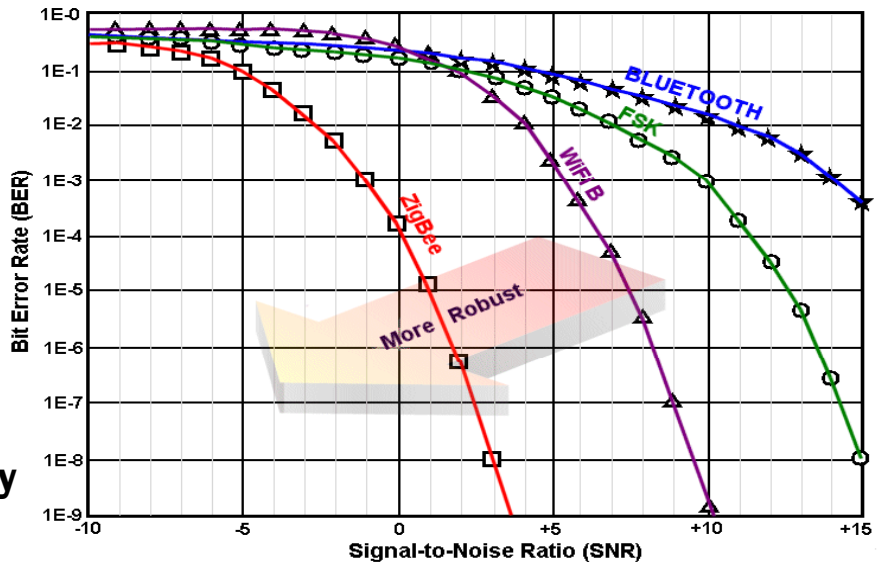
Energy@home 2012 specifications

- Energy@home 2012 specifications:
  - Define the wireless protocol, the data model, the set of application messages, and the sequence activity diagrams
  - extend the existing EN50523-1 (standard CECED-Cenelec EN50523-1: “Household appliances interworking”) and ZigBee Home Automation profile by integrating power meter device and connected appliances
  - submitted to ZigBee, CECED, HGI
- Expected to be integrated in ZigBee Home Automation 1.2 by 1Q2013
  - ZigBee interop events have been hosted by Energy@home



Why ZigBee Protocol

- **Cost**
- **Performance**
  - Energy efficiency
  - Performance in low SNR environments
  - Extended coverage through mesh topology
- **Openness & Diffusion**
  - Open specifications
  - Multiple vendors,
  - Large availability of products
  - Certification Program available
- **Extendible**



Excellent performance in low SNR environments

Specifications of Public Profiles

Other protocols might be adopted depending on Energy@home Members Products

Devices in Energy@home: ENEL Smart Info

Metering Data	
Metering data	Active and negative energy in current billing period and in different tariff intervals.
	Active and negative energy in previous billing period and in different tariff intervals.
	Maximum power of active and negative energy in current billing period and in different tariff intervals
	Maximum power of active and negative energy in previous billing period and in different tariff intervals
	Average positive and negative power (different integration periods)
	Reactive Energy in different billing periods and tariff intervals
	Instantaneous power
	Active and reactive energy of current day and previous one.
Contractual and configuration information	Contractual power and power thresholds.
	Customer ID
	POD (Point of delivery) code
	Tariff intervals
	Credit left (for pre-paid contracts)
	Date and time (from the Smart Meter)
	Last alarm with type and timestamp
	Meter device details
	Bidirectional transmission of custom data.

Enel Smart Info has been designed to provide end users with the certified information on electricity consumptions managed by the electronic smart meter.

It can be plugged in every domestic socket to start data collection from the smart meter through powerline.

Devices in Energy@home: Smart Appliance

Smart Appliance

Definitions:

AHAM, USA : "*appliances which monitor, control and protect their electrical energy usage in response to customer needs*"

CECED, EU: "*a household appliance that makes use of an intelligent power management strategy to optimize the load on the power distribution grid: it lowers energy cost (for consumer and utilities) and increases the overall efficiency of the system*"

Both agree that:

1. **Pricing must provide incentives to manage energy use efficiently and enable consumers to save money**
2. **Communication Standards must be open, flexible, secure, and limited in number**
3. **Consumer Choice & Privacy must be respected: the consumer is the decision maker!**

Smart Appliances in Energy@home

Status

- time to end, current cycle & phase, start & end time

Fault states

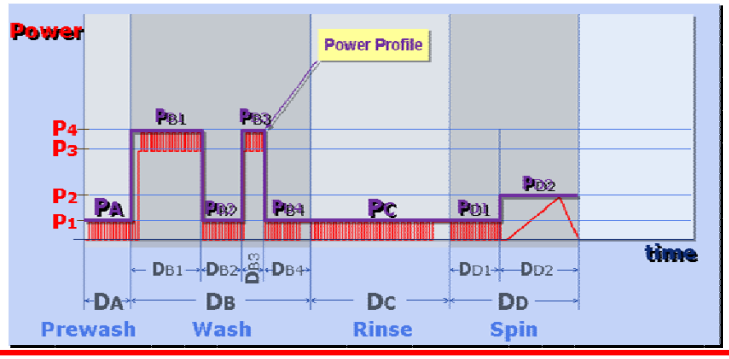
- warnings, faults

Remote maintenance

Appliance Power Profile

sequence of electrical loads activation/ deactivation (***Power phases***); basic "uninterruptable" elements:

- ✓ Expected duration
- ✓ Peak Power consumption
- ✓ Maximum activation delay
- ✓ Expected Energy consumption



The Devices: Broadband Gateway as the Energy Box

from Connectivity to Value Added Services

- **Enables always-on connectivity of home devices**
  - is connected to the broadband network
  - is always-on, power consumption < 10W
  - provides multiple network interfaces (WAN xDSL, LAN Ethernet&WiFi, HAN target ZigBee)
  - acts as the ZigBee controller and the Trust Center of the HAN
  - Provides API's to discover, manage, and communicate with HAN devices
  - Is the execution environment for managed applications

Enables development of VAS's at home

- is a managed Linux device, target 256 MB RAM
- runs the OSGi framework to host TI applications and 3rd party applications
- is connected to the service platform in the cloud
- Implements the energy box algorithms

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User Interface: do we need a new device as a customer i/f?

In Home display






In Home Displays?

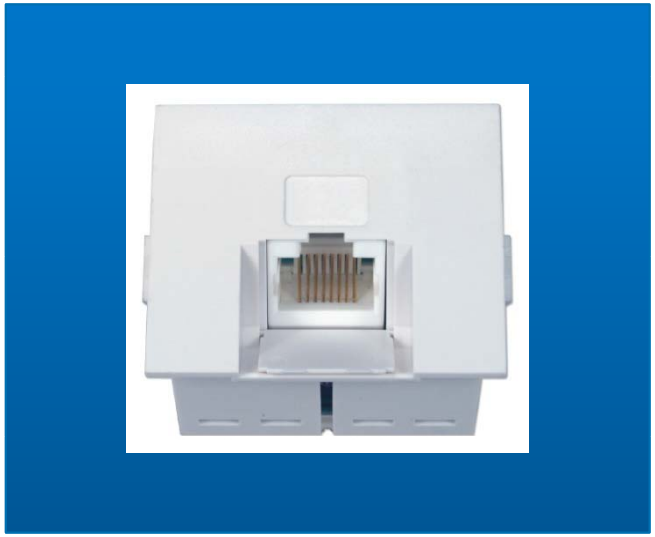
Future directions

- The data & application layer

- The control layer
  - AAA of Energy
  - How to enable users to exploit variability of energy cost
- The protocol layer
  - Focus to higher level protocols & interfaces: gateway-to-cloud, cloud-to-services
  - Integration of IP-ready appliances

AAA services for energy

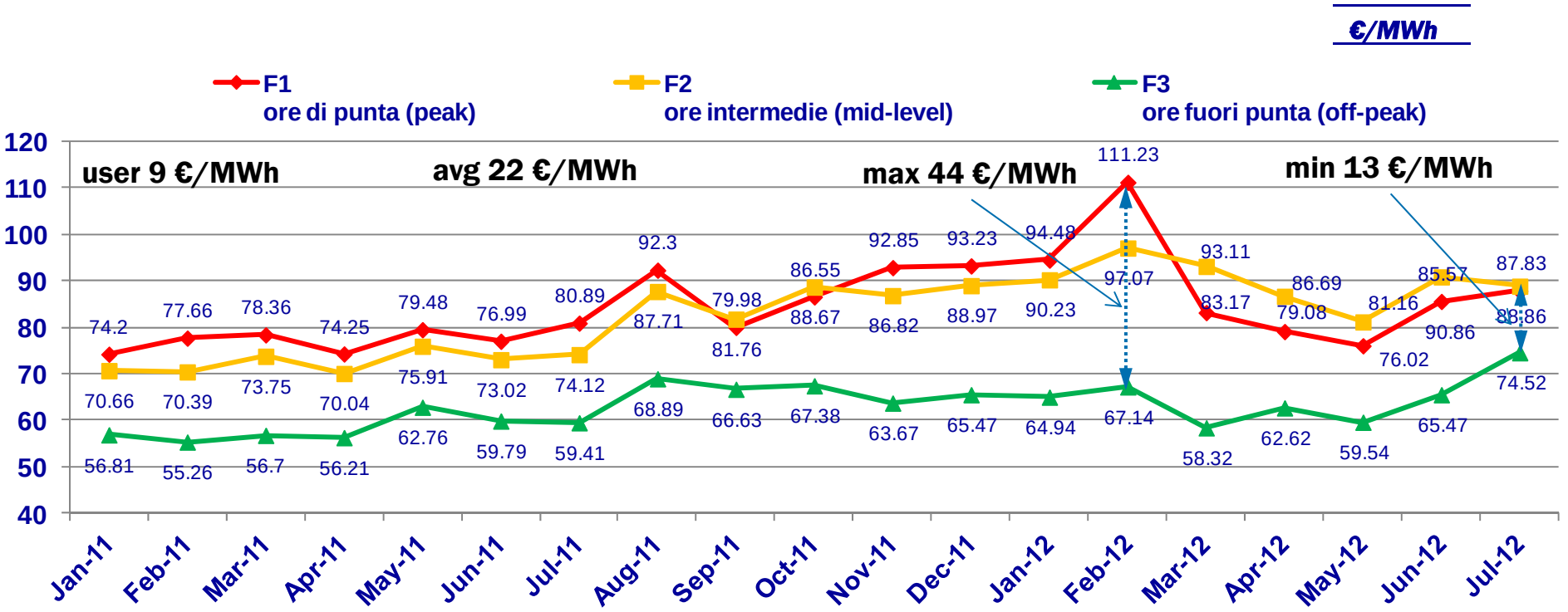
Vision: ICT enables the Service Layer to the Grid



The electrical socket will become more similar to the Power Over Ethernet socket (power, authorization, communication, logging)…

By adding AAA services, ICT enables control over which users and which devices are allowed access to which services, and how much of the resources they have used or are allowed to use

How to enable users to exploit the high variability of cost?



Average cost of energy in different time ranges

F1: Mon- Fri 8.00 - 19.00;
F2: Mon – Fri 7.00 - 8.00, 19.00 - 23.00; Sat 7.00 - 23.00;
F3: Mon– Fri 23.00 -7.00; Sun e holidays 24 hours

Source: GME

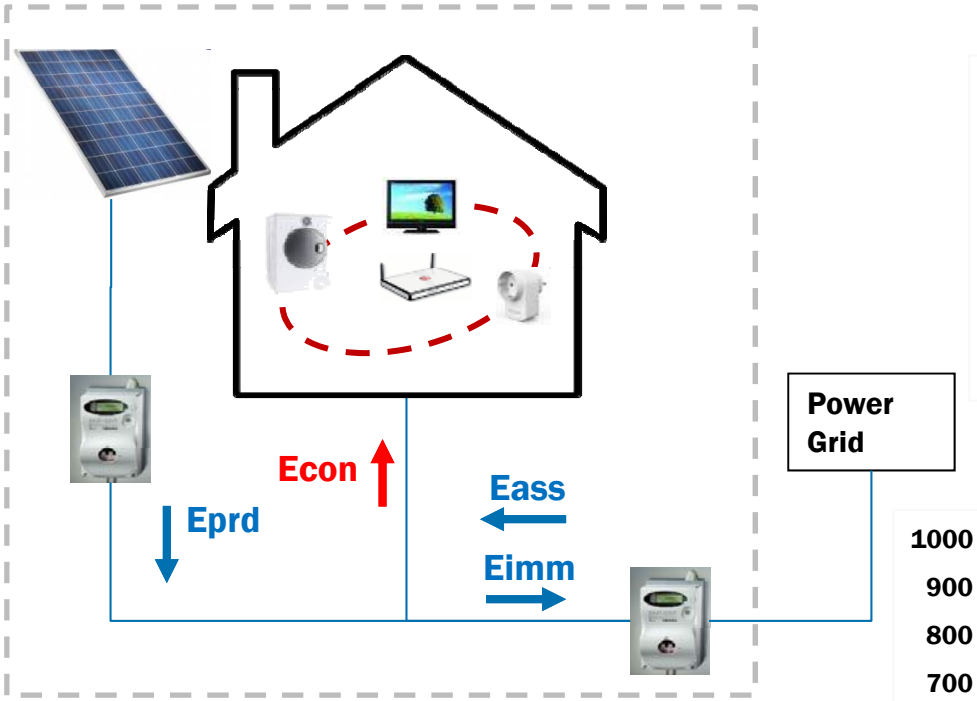
Issues:

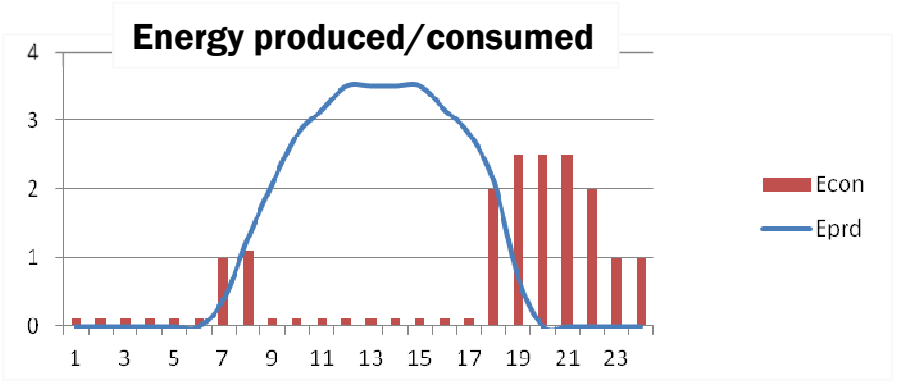
1) **How to enable users to exploit such a variability?**
2) **How to enable retailers to provide so variable tariffs?**
3) **Which tariff schemes are best suitable?**

Future directions

- The data & application layer
  - Benchmark and user comparison => Design of stimuli to incentivize efficiency
  - Active Demand & Synchronization of loads with micro-generation
  - Non Intrusive Load Monitoring
  - Dual-fuel heating
  - Occupant Behavior
- The control layer
  - AAA of Energy
  - How to enable users to exploit variability of energy cost
- The protocol layer
  - Focus to higher level protocols & interfaces: gateway-to-cloud, cloud-to-services
  - Integration of IP-ready appliances

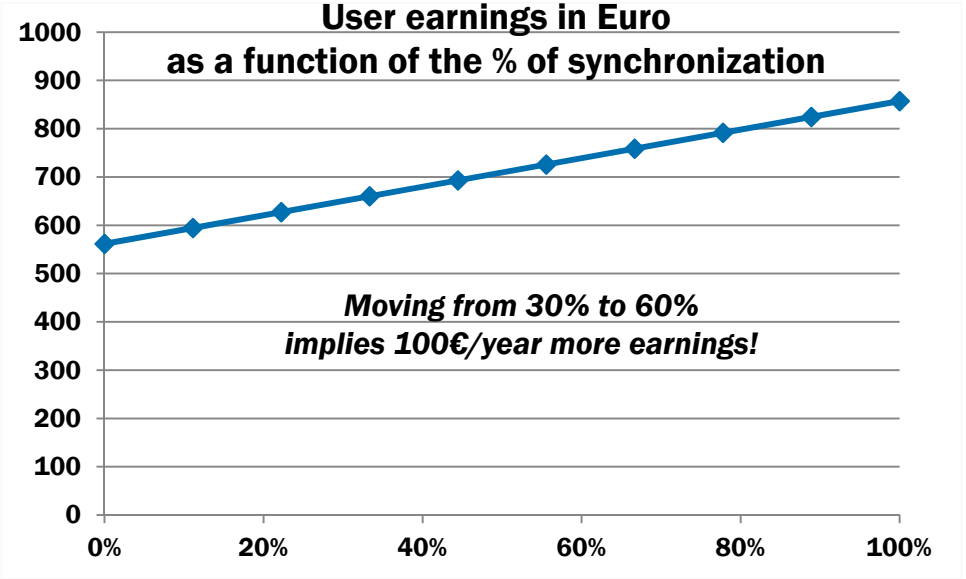
Synchronization of loads with micro-generation





A premium tariff is provided to incentivize produced energy which is locally consumed and not injected in to the grid

i.e. synchronization of loads with generation



(V Conto Energia, user with 2.7 MWh/year and 3 kW of contract))

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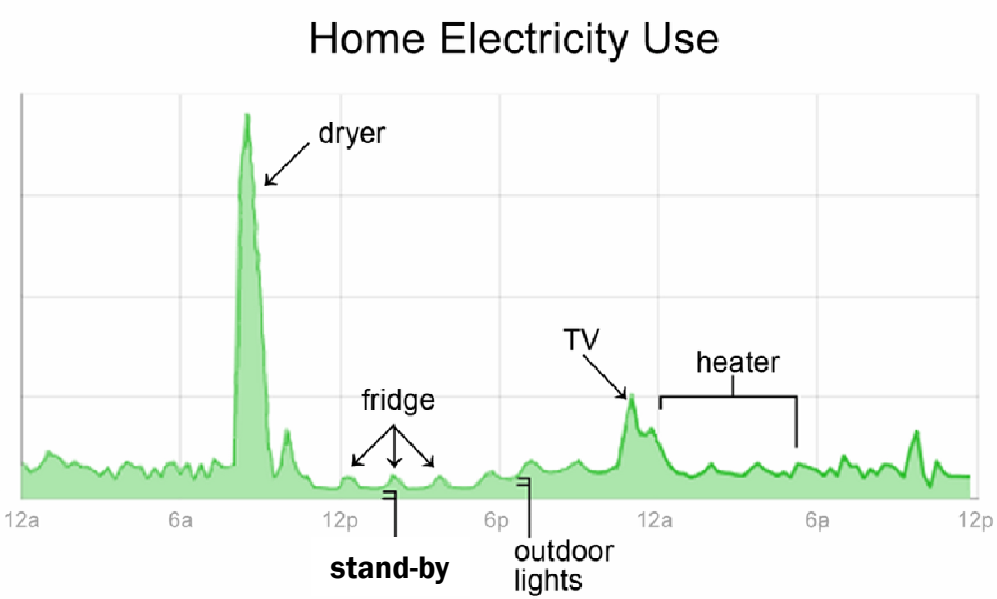
(courtesy of S. Brambilla, Enel)

Non Intrusive Load Monitoring



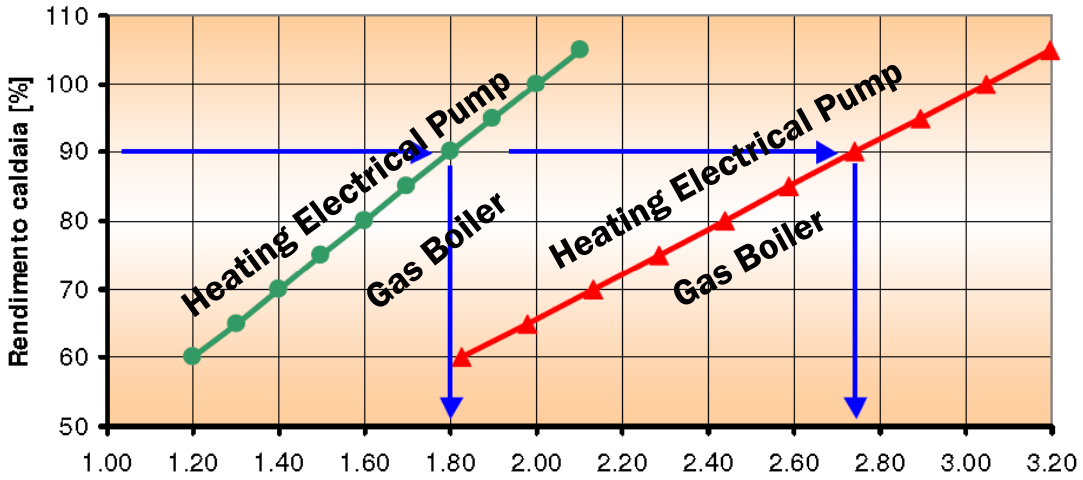
Smart Plugs

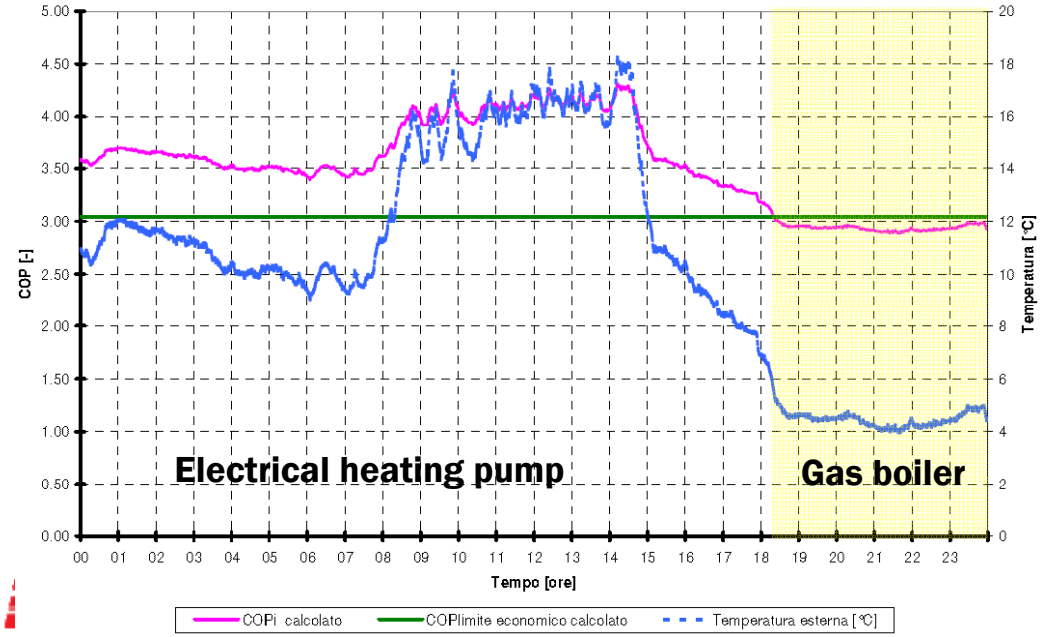
Meter interface (Smart Info)

active & reactive power

1. **Automatic Identification of the Load connected to the Smart Plug**
   - **Fasten provisioning phase, less burden to users**
2. **Automatic Identification of energy consumption of individual appliances from aggregate measurements**
   - **Reduced number of smart plugs, less cost to users**

Dual-Fuel Heating





COP (coefficient of performance) of heat pumps mainly depends on ext temperature

Convenience of using electric heat pump vs gas heating can be calculated either maximizing the economic (€) or environmental (CO2) benefit or a combination of both

Experimental data from RSE highlights a saving in the energy bill between 4 and 12%

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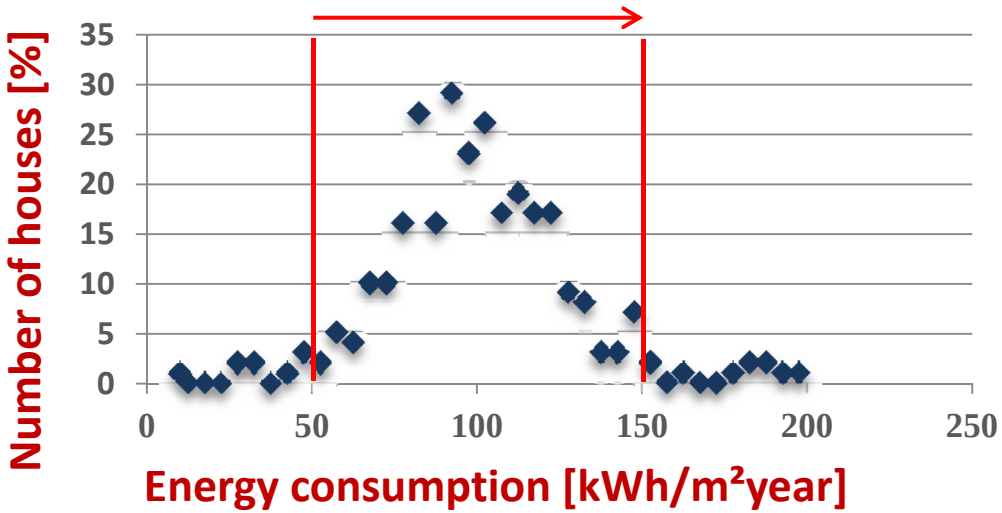
Occupant Behaviour

SPACE HEATING ENERGY DEMAND IN 290 ”IDENTICAL” HOUSES IN DENMARK



HIGHEST CONSUMPTIONS MORE THEN

3 TIMES

HIGHER THAN THE LOWER ONES

OCCUPANT BEHAVIOUR IS A CRUCIAL ASPECT INFLUENCING THE REAL BUILDING ENERGY CONSUMPTION

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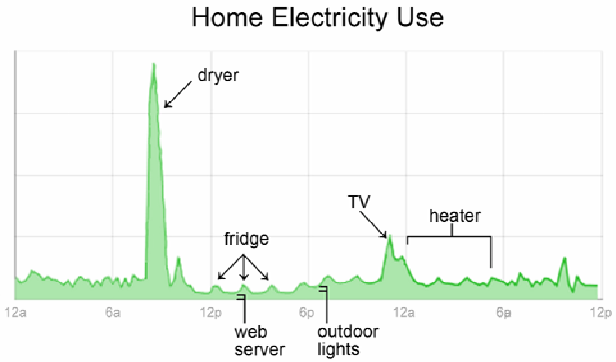
[1]Polytechnic of Turin (Italy) – Energy Department
[2]Denmark Technical University DTU– Department of Civil Engineering

Conclusions

Goals for Smart Consumption:

- flexible & controllable demand
- flexible & controllable generation
- user awareness (beyond the bill)
- user empowerment

ICT: Protocol + Control + Data Layer



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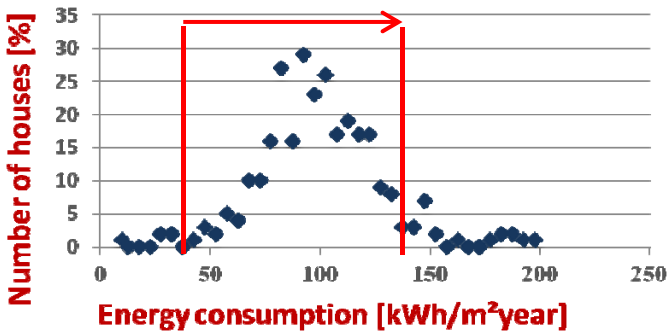
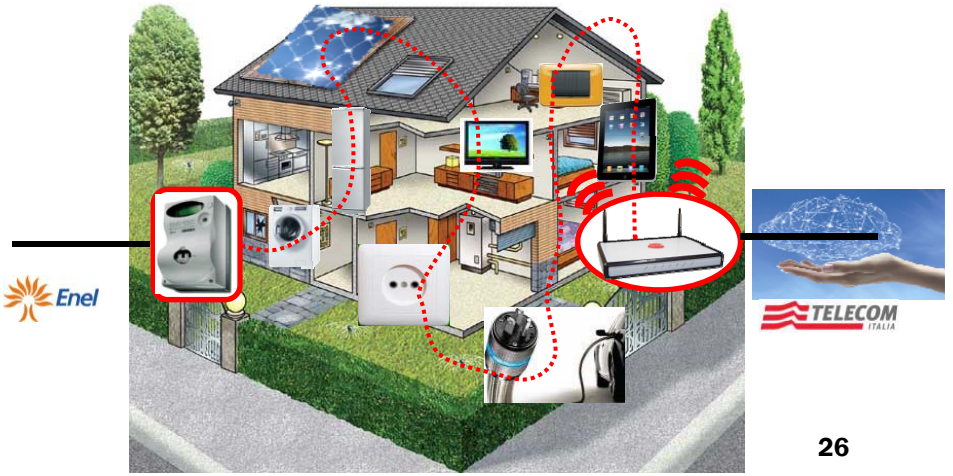
Occupant Behavi...





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