Policies for Energy Market Transformation

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Smart grids: an integrated perspective on efficiency, from supply to demand

by

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Smart Grids

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Smart grids

Information and system management in real time

Smart grids mark a new development on the path towards greater consumer empowerment, greater integration of renewable energy sources into the grid and higher energy efficiency and make a considerable contribution to reducing greenhouse gas emissions and to job creation and technological development in the Union (COMMISSION RECOMMENDATION 2012/148/EU of 9 March 2012)

Introduction to Smart Grids

The Smart Grid is an electricity grid that uses two-way ICT technology to optimise supply and demand. In addition to this it aims to increase the security of supply to the customers. Implemented in the right way it promises improved reliability by enabling quicker and more effective response to outages, greater customer awareness of energy usage and costs, and facilitation of the adoption of new technologies such as renewable generation sources and electrical vehicles. A Smart Grid is utilising digital technology. It overlays the ordinary electrical grid with an information and net metering system, which includes smart meters. Smart Grids are being promoted by many governments as a way of addressing energy independence, global warming and energy resilience / emergency issues.

Smart Grids are made possible by applying sensing, measurement and control devices with two-way communications to electricity production, transmission, distribution and consumption. Smart Grids communicate information about grid condition to system users, operators and automated devices, making it possible to dynamically respond to changes in power grid condition.

Included in the Smart Grid is an intelligent monitoring system that keeps track of all electricity flowing in the system. There is also the capability of integrating renewable electricity resources from solar and wind sources as well as switching to other modes of generation such as local power production. When power is least expensive the customer can allow the Smart Grid to turn on selected home appliances. Also factory processes that can run at arbitrary hours can be started by the grid. At peak times the grid could turn off selected appliances to reduce demand.

A Smart Grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies in order to:

- enable the current electricity grid to handle decentralised volatile electricity generation on all grid voltage levels in a sustainable way;
- significantly reduce the environmental impact of the whole electricity supply system;
- allow customers to play a part in optimising the operation of the system;

- lower the CO_2 emissions of the energy supply chain, in production and consumption;
- provide customers with more detailed information and options for how they use their supply;
- help customers to reduce their energy consumption;
- better facilitate the connection and operation of generators of all sizes and technologies;
- facilitate Demand Side Management to better manage power demand, particularly as renewable sources of energy are deployed;
- facilitate Smart Grid beneficial shifts in the modality of energy generation resources at the local level;
- maintain or even improve the existing high levels of system reliability, quality and security of supply;
- foster market integration towards a European integrated energy market.

Next to these benefits, the Smart Grid also includes challenges, such as cyber security and the possibility of remote control of appliances within the home, the joint responsibility for supply by a large set of competing organisations, and the need for the regulatory framework to adapt while fostering both economic and security issues. The challenges include keeping up resilience and robustness of the Smart Grid, with the ability to keep up its indispensable core functionalities (i.e. delivering electricity / energy). This should be the case even under crisis conditions, at least at the same level demanded of the current electricity grid.

Smart Grids thus encompass a much wider area than smart metering. Smart metering is an important first step towards a Smart Grid. Smart meters bring intelligence to the 'last mile' between the grid and the final customer. Without this key element, the full potential of a Smart Grid may not be realised. Being that only few countries in Europe have undertaken a full deployment of smart meters actors involved in the sector should draw from existing experiences and take account of best practices in place.

Other areas need to be addressed in parallel. One is the continuous development of the electricity grid's ability to electrically maintain the balance of electricity generation and consumption in a way compatible with the electrotechnical properties of the grid. This is getting a more and more complex task. In addition to smart metering, any thinkable sustainable solution for the complete change to renewable and sustainable energy sources; i.e. they will require a smarter layout of the large scale and local electrotechnical functionalities of the grid infrastructures as well as smarter ICT-based solutions - decentralised and within the critical operational core of the grids.

The course of Smart Grid adoption in Europe is far from clear. The underlying technologies remain expensive; their business case relies on assumptions of significant changes in customer behaviour; and cost-effective integration of existing systems and emerging technologies is not yet proven. The business model in many cases is still emerging, especially for customer applications, as regulators, utilities and third-party service providers define their roles and set technology standards. Many core systems remain unproven and currently a limited number of Advanced Metering Infrastructure (AMI) systems have been deployed in Europe.

There are some challenges and uncertainties for Smart Grid deployment. These are mainly dealing with cyber security and data protection (from a consumer perspective) and actual savings and costs (from a deployment perspective). Therefore, efficient measures safeguarding consumer protection should be in place before Smart Grids and smart meters can be deployed. In particular, the security of the Smart Grid and its susceptibility to hacking and attack need to be ensured. Also for the likely introduction of new energy deals which involve networks or suppliers remotely controlling appliances within a customer's home to help balance the power grid. While new deals may offer benefits such as lower cost tariffs to customers who participate, careful consideration will have to be given to the protections needed around these innovations.

The development of Smart Grids will be facilitated by the wide-scale deployment of electricity smart metering, as envisaged in 3rd Energy Package, directive 2009/72/EC (31). The complete Smart Grid deployment is a gradual evolution, not a 'roll-out' revolution.

Font - Essential Regulatory Requirements and Recommendations for Data Handling, Data Safety, and Consumer Protection

Why the smart grids?

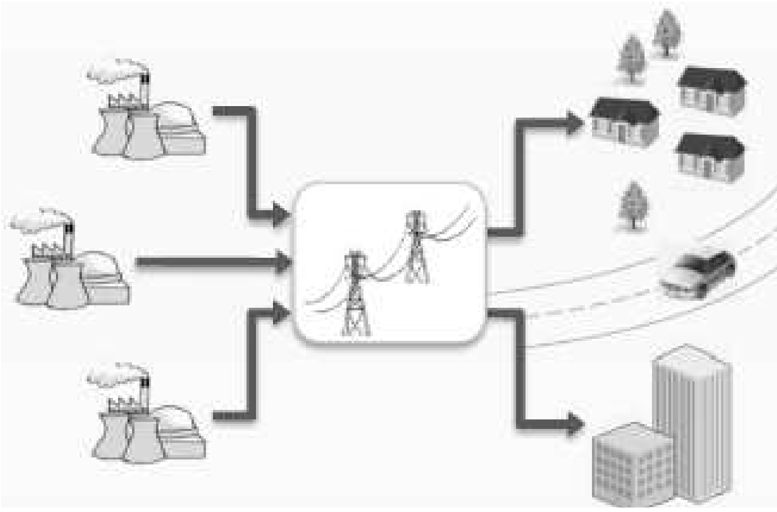
Conventional power grids (sec. XX)

In the last century power grids were characterized by:

centralized and controllable production

stable patterns of consumption

unidirectional and predictable flows



Unidirectional flow of energy

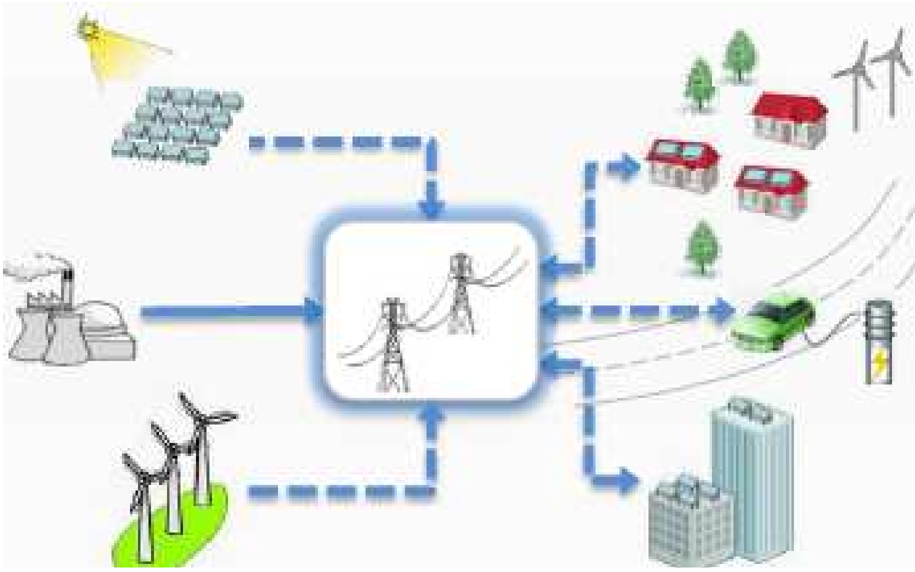
Smart grids (sec. XXI)

The electricity distribution in the twenty-first century requires solutions adapted to a new operating paradigm:

Distributed and intermittent production

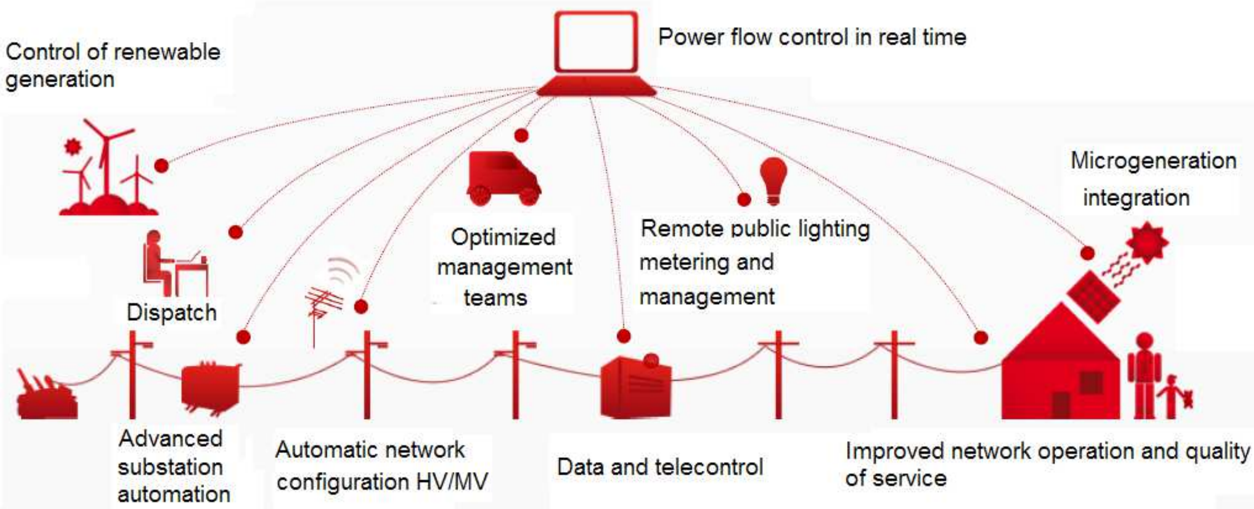
Balance consumption / production unstable

Bidirectional and unpredictable flows



Bidirectional / intermittent flow

Management capacity of information and network supervision plays a central role in responding to new challenges



Supervision and control of the distribution network

Data from mainland Portugal in 2014:

988 renewable energy producers - 5026 MW connected to the national grid **

High Voltage Grid (HV) – 9.000 km; 412 substations; 283 customers in HV

Medium Voltage Grid (MV) – 74.000 km; 66.000 Transformation Stations; 23.000 customers in MV

Low Voltage Grid (LV) – 140.000 km; 6.000.000 customers in LV

25.000 Microproducers (90 MW)*

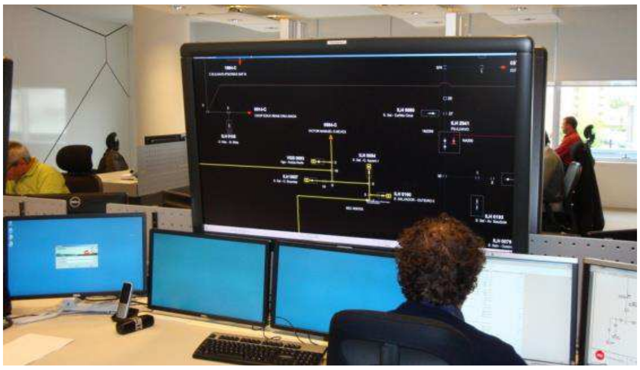
1.200 Miniproducers (52 MW)*

*Installed power; Accumulated 1st trimester 2014

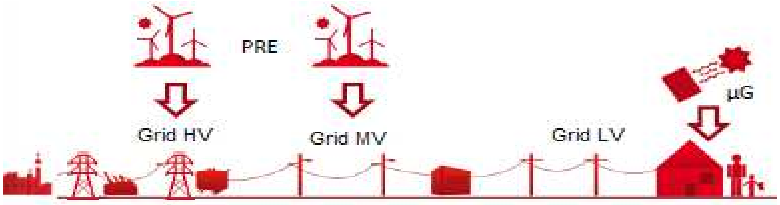
**Installed power; Accumulated 2nd trimester 2014

Managing increasingly complex networks leads to increased smart grids.

EDP, Investment in modern SCADA systems allows increasing information processing capability Schematic Elimination of paper.



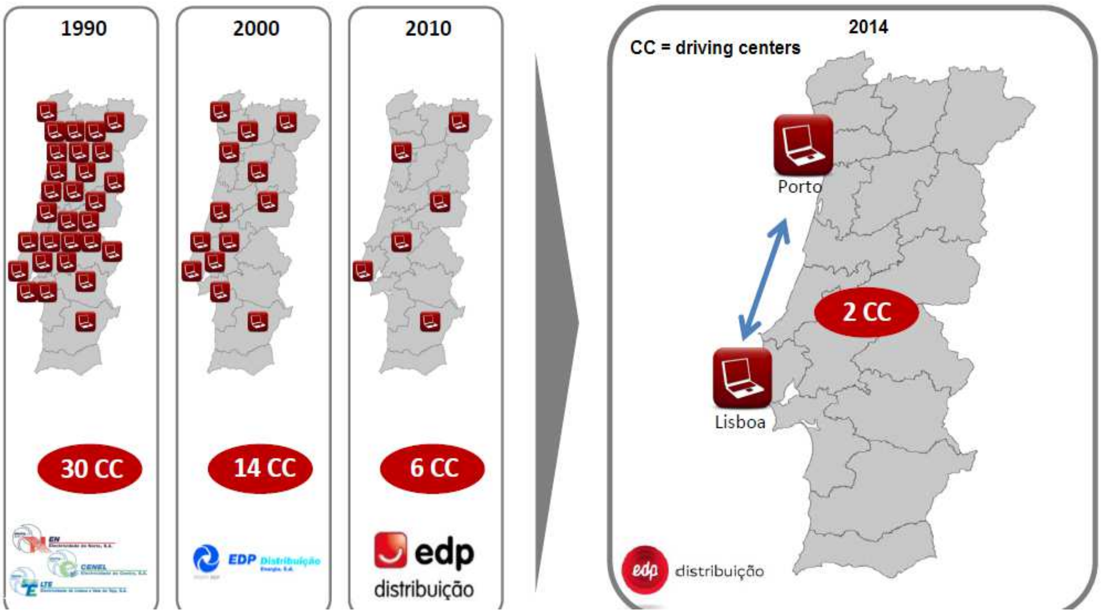
Digital schematic



Power Flow in real time

Fault location

The reorganization and integration of driving centers strengthened the effectiveness in monitoring the network.

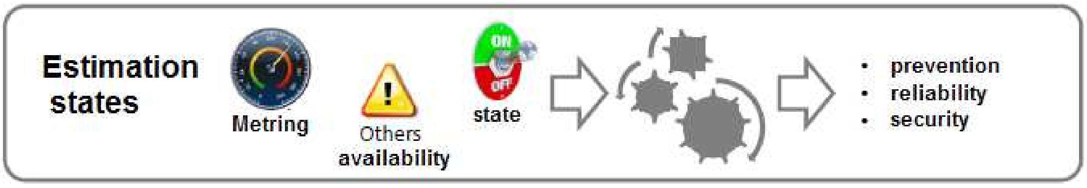


with 30 drinving centers in 1990 went to 2 in 2014

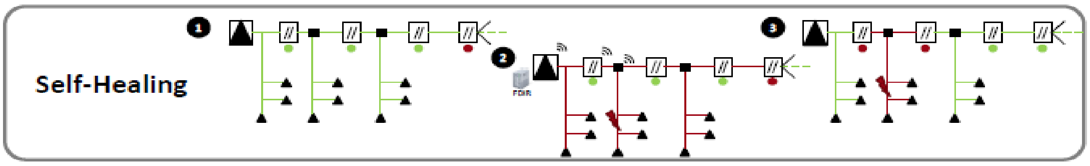
Effective management of large volumes of information allows improve the supervision and operation of the network in real time

Information management

Knowledge State system

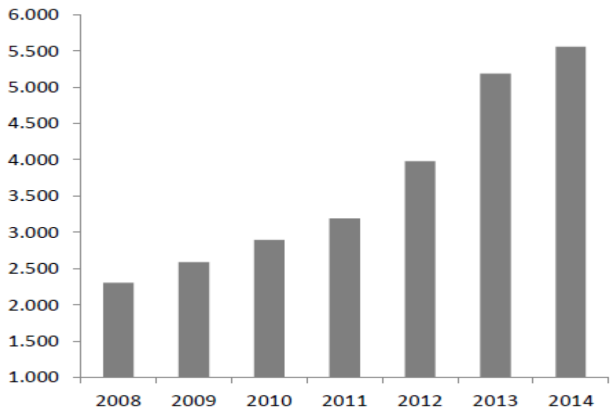


Automation and control



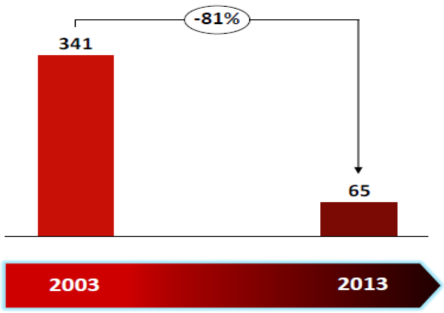
Maximization potential human

In Portugal the size and efficiency of the network remote control system have increased consistently

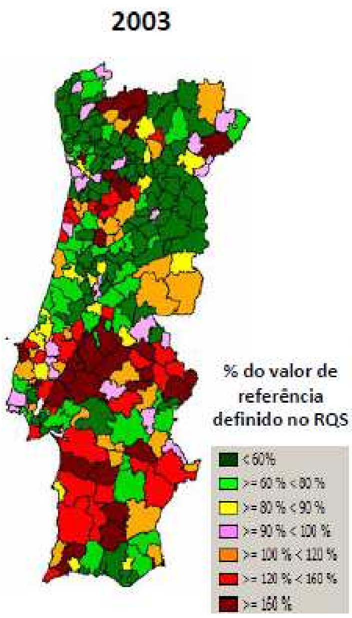


Number of remote points of the MV network

The investment in automation / supervision network was essential the improvement of quality of service in the last decade. Less time of supply interruption (TIEPI).

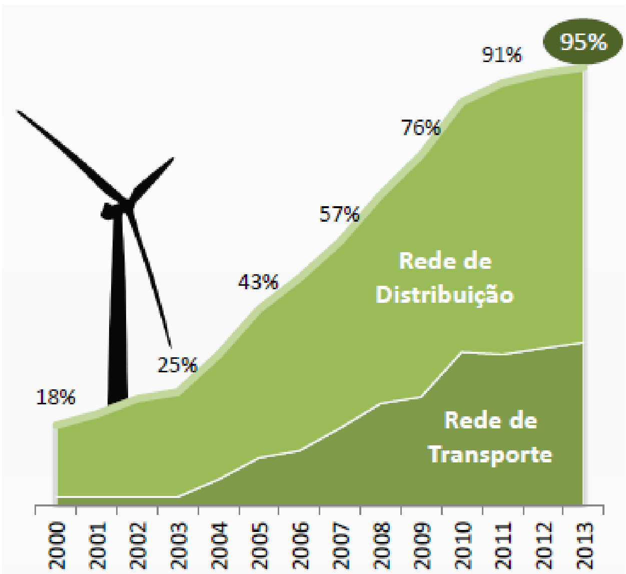


Improvement of service quality: developments in TIEPI in MV in minutes



Reduction of asymmetries

The greater efficiency in network management has allowed successfully integrate large amounts of renewable energy production in national distribution grid.



Renewable energy production power in proportion of the peak consumption in 2013
(Special Regime Generation, including renewable and cogeneration).

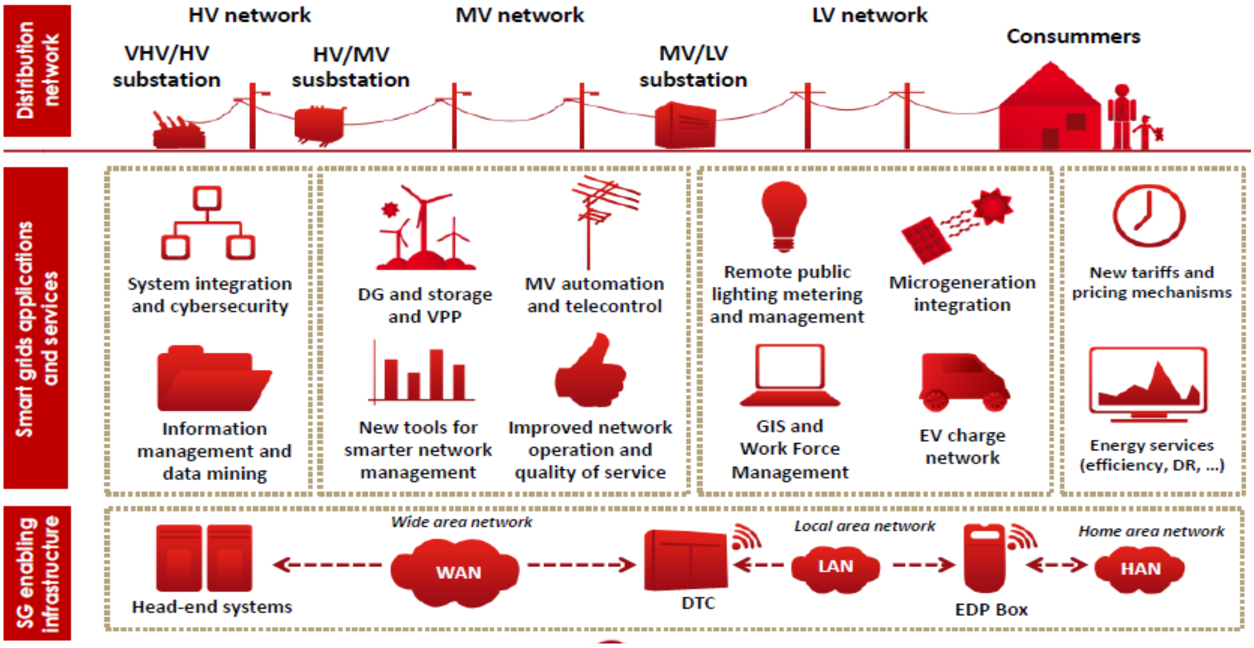
Intelligent networks create new possibilities for the optimization of distributed generation and charging electric vehicles, since it broaden surveillance capacity to the low voltage grid.

Had to develop a smart grid from electrical production to demand that includes bidirectional communication networks, which paticularly security and to develop smart meters that meet these needs.

Inovgrid project of EDP

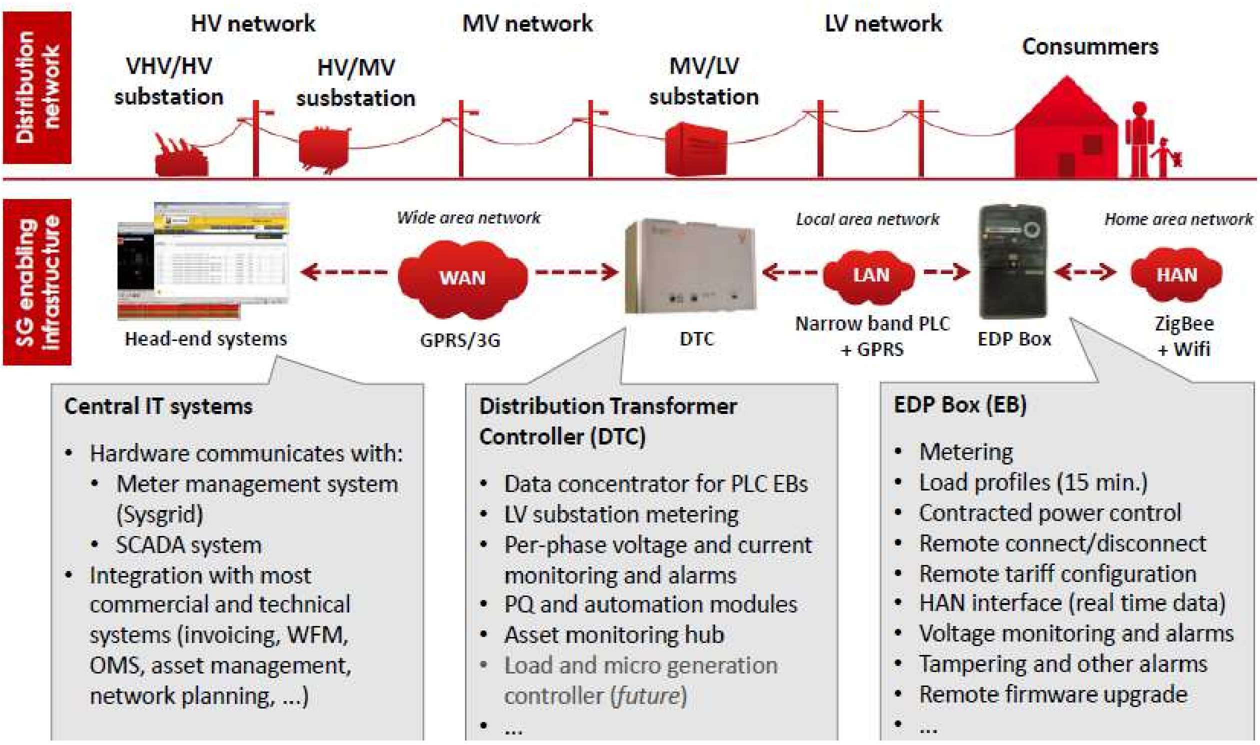
With “Inovgrid” project of “EDP Distribuição SA” plans to extend the powers of supervision to the low voltage grid.

EDP actively seeks a gradual and integrated approach towards a smarter distribution grid – the Inovgrid project.



Inovgrid architecture

The main elements in the Inovgrid architecture cover the LV network and provide access to commercial & technical data



Example in application of Inovgrid - Évora Inovcity

The future is being born in Évora, Portugal, in 2010. Évora is one of the first Smart Cities. The Inovcity is the first implementation of Inovgrid. Évora has been selected as the living lab for the Inovgrid project:

1- Évora municipality:

- •54.000 inhabitants
- •1.307 km2of area (urban and rural)

2- The project includes:

- •infrastructures
- •New services and products

3. Involvement of the major players of the municipality

4. Coordination with the national electric vehicle charging network

The city of Évora is a Unesco World Heritage Site

This World Heritage City is the first urban area in Portugal to hook up to the intelligent energy grid. By promoting energy efficiency, microgeneration and electrical mobility, this will be a shining example of sustainability for the whole country. What has changed?

31000 residential customers in Évora are part of inovcity project

1 EDP BOX on each inovcity's customer house. An equipment allows among other features, make the readings remotely and operations;

Billing based on actual consumption accessible to all, allowing consumer control via a computer or smartphone;

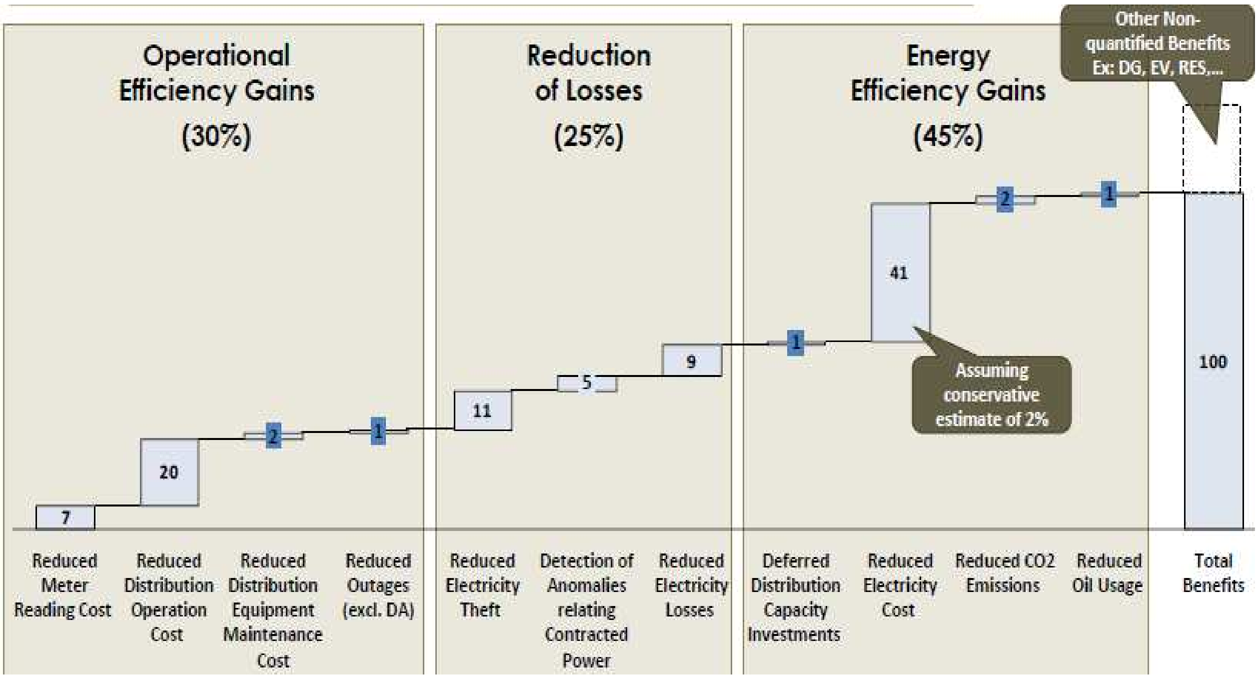
More than 1000 selected customers access to new products and services, as well as the simulation of new rates;

Greater capacity to integrate renewable energy and electric vehicle;

Improved ability to detect and resolve failures of electricity distribution network

By 2020 it is expected that 80% of European electricity distribution networks are composed of smart grids;

The cost-benefit methodology was used to quantify Inovgrid value creation potential, resulting in clearly positive result.



Details of the quantified Benefits of Inovgrid (%)

A mix of initiatives was used to raise awareness and create a special Inovcity dynamic, promoting costumer engagement.

Initiatives to promoting Inovcity

An energy efficiency study was conducted to understand the potential impact on energy use by residential consumers.

Independent Control Group, outside Évora Inovcity (~1k consumers):

•Same climatic and environmental conditions as Évora consumers;

•Identical socioeconomic characteristics;

•BaU treatment and no exposure to the Inovcity dynamic.

Évora Inovcity Global Group (~30k consumers)

•Invoices based on real consumption;

•Online access to detailed consumption data (e.g. load diagrams);

•Energy efficiency tips (mailing).

•Exposure to the Inovcity dynamic (advertisements, conferences, local initiatives, media).

Évora Inovcity new products and services Test Group (~1.2k consumers)

•Consumption monitoring equipment (e.g. displays, smart phone apps, PC software);

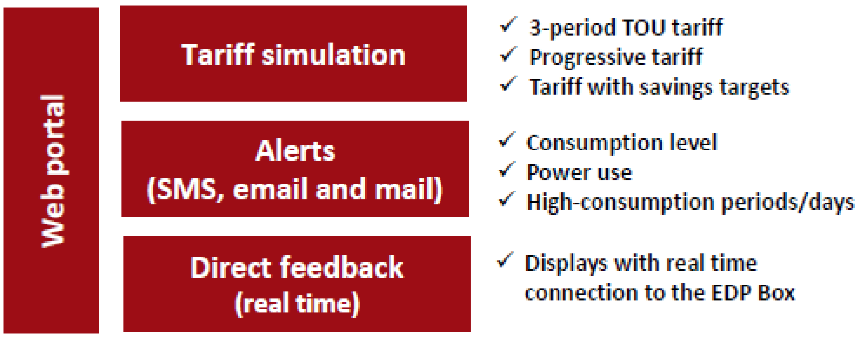
•Personalized consumption alerts and reports (SMS, email);

•Innovative tariffs.

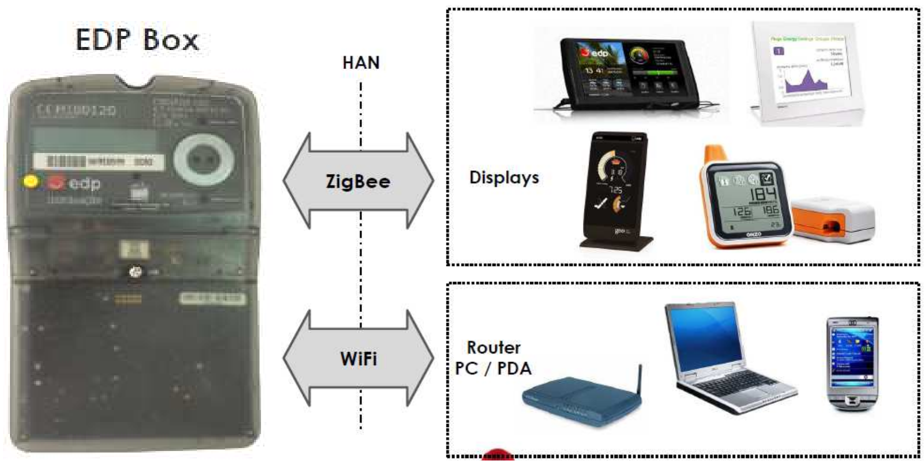
The results show that the implementation of the Inovcity dynamic led to an increase in energy efficiency of around 4%.

A pilot group of residential consumers in Évora was used to study the impact of innovative products and services.

Products and Services tried in Évora:



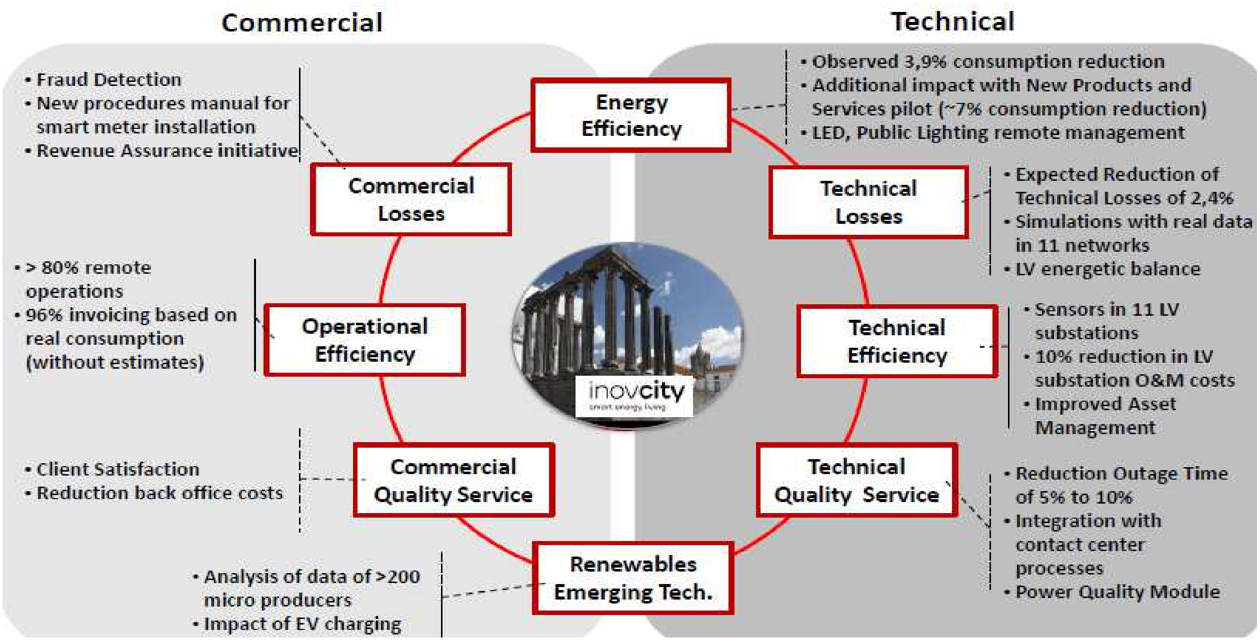
The EDP Boxes of consumers of the Test Group were equipped with a HAN comms module, providing real time information.



HAN –Home Área Network

Results from the study suggest that the new products and services have the potential to promote energy savings of ~7%.

The Inovcity pilot allowed the test of several concepts and value drivers and was used to validate EDP's business case.



Following the Inovcity pilot, EDP is extending the deployment in order to consolidate knowledge and test different technologies:

New technologies (PLC Prime)

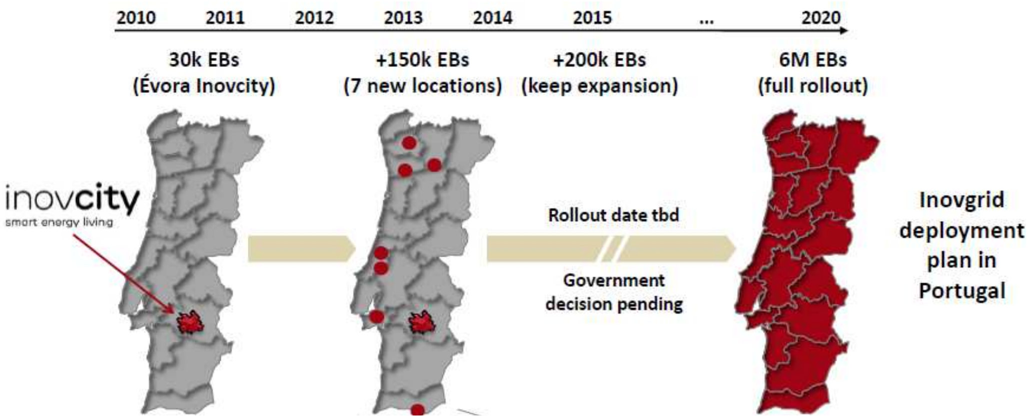
Different social and environmental characteristics

Different grid conditions

New smart grids applications

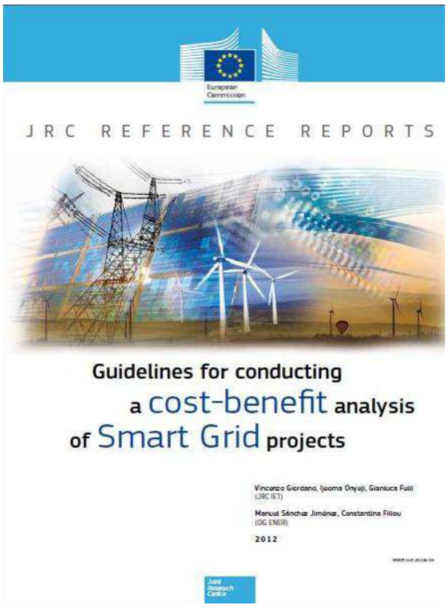
Increasing business process integration

EDP intends to implement the Inovgrid throughout the mainland Portugal by 2020



Inovgrid deployment plan in Portugal

Inovgrid has been selected among 220 smart grids projects by "Joint Research Centre of the European Commission" (JRC) for cost-benefit analysis of Smart Grid projects and "Eurelectric" as the single case study for testing and validation of a Business Case assessment methodology (EPRI).



Guidelines for conducting a Cost-benefit analysis of Smart Grid projects

"The goal of this report is to provide guidance and advice for conducting cost-benefit analyses of Smart Grid projects. .. A European Smart Grid project (Inovgrid, implemented in Portugal) has been used as case study to fine-tune and illustrate the proposed framawork."

With Smart Grid Advantages in home

In intelligent homes, consumers can view and monitor consumption throughout the day. They know exactly when, how and where they use energy. And that's not all. They knows what time of

the day they consume more and when they can use electricity at a more favourable price, being able to programme their home appliances to operate during those periods.
Estimated bills will be replaced by real time consumption management, minimising costs. New services and tariff plans are available adapted to consumer profiles and the home automation solutions may be available. Based on remote management, fault detection is automatic and services such as changes in tariff plans and power can be activated remotely.
Anybody can generate energy at home, for their own use or to sell to the grid. The consumer becomes a producer and seller of energy and will be able to install solar photovoltaic panels or small wind turbines at home. In the event of a fault in a residential area, the production from a house or a group of neighbours may ensure the supply of electricity to several other houses or to the whole neighbourhood.

With Smart Grid Advantages in microgeneration

To talk about microgeneration is to talk about an energy revolution. The intelligent energy network will boost the volume of energy that any users of this intelligent network can produce at home.
Consumers become both producers and sellers of energy, and will be able to more easily install solar photovoltaic panels or small wind turbines at home and sell energy to the grid if they want to. In the event of a fault in a residential area, the production from a house or a group of neighbours may ensure the supply of electricity to several other houses or to the whole neighbourhood.
They will be offered a range of new services and tariff plans adapted to their consumer profile. Energy management becomes more efficient, since the energy balance between what is consumed and what is produced can be consulted online, showing exactly the times of the day when energy is consumed and produced.
The intelligent energy network and the inovgrid project open the doors for a new generation of microgenerators. With lower costs, more confidence and an increasingly lower environmental impact.

With Smart Grid Advantages in company

The InovGrid project makes Portugal more attractive in terms of investment because it encourages manufacturing projects and centres of expertise creating employment and exports, as well as scientific research projects, in collaboration with the academic sector.
This project provides companies with innovative tools that offer both extremely detailed and reliable control of their energy consumption. Adjusting energy consumption to their activities can

result in higher levels of efficiency and a reduction in consumption, key factors of success in the market.
Moreover, energy service companies can offer more and better products and services on this innovative platform

With Smart Grid Advantages in mobility

Electric vehicles are no novelty, since it is more than 100 years since the first electric cars were invented. Today, the so-called “electrification of transport” is once again receiving attention, having been presented as a measure that can make a major contribution to reducing greenhouse gas emissions and environmental pollution, while also offering the benefit of greater economic development.
Guided by its principles of sustainability, energy efficiency and innovation, EDP is supporting the creation of a network of recharging points, which will be developed faster and more efficiently with the creation of an intelligent energy network.
This intelligent network will support the recharging of and uploading from electric vehicles, in other words receiving energy from the electricity network when it is available and at its lowest price and returning energy to the electricity network when there is greater need and at a price that reflects added profitability for the user.
With the intelligent network, it is possible to maintain almost real-time control of energy consumed at these recharging stations, which will allow consumers to calculate the share of consumption allocated to the electric vehicle charged at their home

With Smart Grid Advantages in city

Replacement of traditional lamps by LED technology luminaires – and this is not a minor step: it means a 40% to 50% reduction in electricity consumption
Regulation of lighting in accordance with requirements and natural light conditions – in the evening, the lighting is activated and progressively increases in intensity with the reduction in sunlight, thus preventing unnecessary consumption.
Reduction of lighting intensity, during the off-peak hours (between 2:00 and 5:00) while maintaining minimum safety conditions.
Adoption of dynamic control systems that manage light intensity depending on the presence of vehicles or people, on ambient light intensity and on ambient conditions.
This is the path that we will follow for a more sustainable future, marked by a balance between safety, comfort and rational use of energy.

Efficient traffic lights - LED technology is also used in the city's traffic lights, a more efficient solution since it contributes to energy savings of around 80%, when compared with incandescent lamps.

Besides energy efficiency and a reduction in CO_2 emissions, the advantages of LED extend to safety issues and maintenance costs. The former because the range of the light beams is greater, which means that they are visible in less favourable weather conditions.

Bibliography and fonts:

http://www.inovcity.pt/en

Paulo Líbano Monteiro, EDP Distribuição, Inovgrid, EDAL, 7th International Conference, Coimbra, September 2013,

João Torres, EDP Distribuição, Redes Inteligentes, presentation on July de 2014

Definitions by 2012/148/EU:

'**smart grid**' means an upgraded energy network to which two-way digital communication between the supplier and consumer, smart metering and monitoring and control systems have been added; (The European Smart Grid Task Force defines smart grids as energy networks that can efficiently integrate the behaviour of all users connected to them in order to ensure an economically efficient, sustainable power system with low losses and high quality and security of supply and safety: http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group1.pdf)

'**smart metering system'** means an electronic system that can measure energy consumption, adding more information than a conventional meter, and can transmit and receive data using a form of electronic communication (Interpretative note on Directive 2009/72/EC concerning common rules for the internal market in electricity and Directive 2009/73/EC concerning common rules for the internal market in natural gas - Retail markets, p. 7.);

Smart meter rollout (implementação de contadores inteligentes)

The EU aims to replace at least 80% of electricity meters with smart meters by 2020 wherever it is cost-effective to do so. This smart metering and smart grids rollout can reduce emissions in the EU by up to 9% and annual household energy consumption by similar amounts. To measure cost effectiveness, EU countries conducted cost-benefit analyses based on guidelines provided by the European Commission. A similar assessment was carried out on smart meters for gas.

A 2014 Commission report on the deployment of smart metering found:

- close to 200 million smart meters for electricity and 45 million for gas will be rolled out in the EU by 2020. This represents a potential investment of €45 billion
- by 2020, it is expected that almost 72% of European consumers will have a smart meter for electricity. About 40% will have one for gas
- the cost of installing a smart meter in the EU is on average between €200 and €250
- on average, smart meters provide savings of €160 for gas and €309 for electricity per metering point (distributed amongst consumers, suppliers, distribution system operators, etc.) as well as an average energy saving of 3%.

Conclusion

Smart grids are energy networks that can automatically monitor energy flows and adjust to changes in energy supply and demand accordingly. When coupled with smart metering systems, smart grids reach consumers and suppliers by providing information on real-time consumption. With smart meters, consumers can adapt – in time and volume - their energy usage to different energy prices throughout the day, saving money on their energy bills by consuming more energy in lower price periods.

Smart grids can also help to better integrate renewable energy. While the sun doesn't shine all the time and the wind doesn't always blow, combining information on energy demand with weather forecasts can allow grid operators to better plan the integration of renewable energy into the grid and balance their networks. Smart grids also open up the possibility for consumers who produce their own energy to respond to prices and sell excess to the grid.

Fonts:

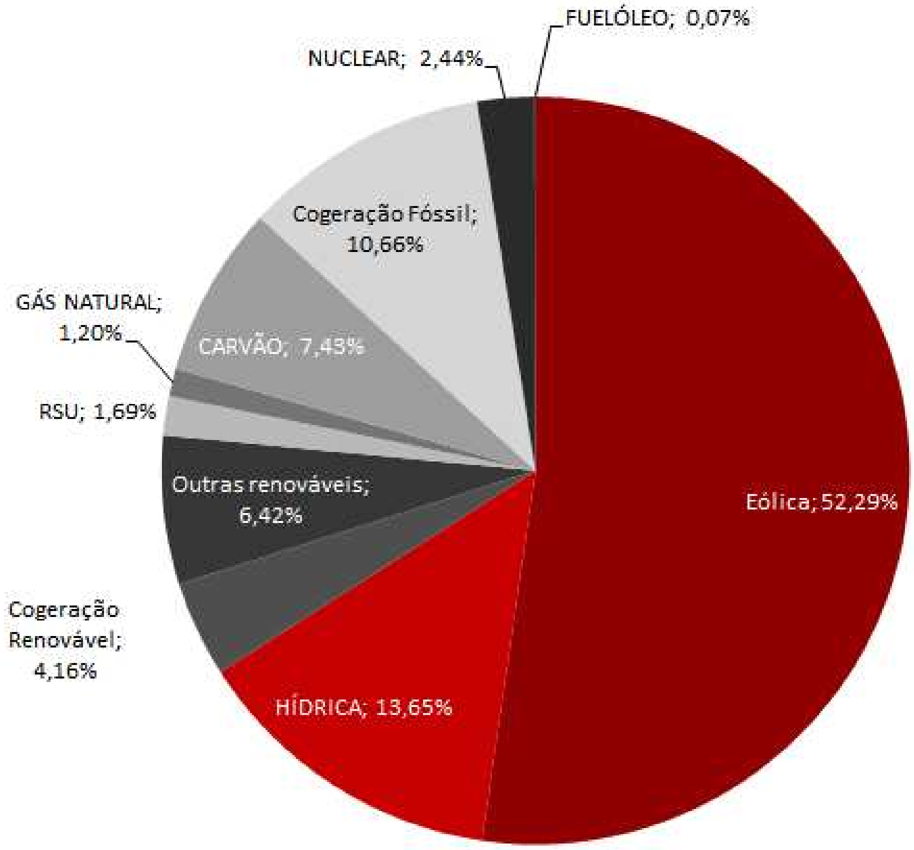
http://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters

Legislation

Common Rules for the Internal Market in Electricity Directive (2009/72/EC)
Common Rules for the Internal Market in Natural Gas Directive (2009/73/EC)
Directive on the Processing of Personal Data (1995/46/EC)
Energy Efficiency Directive (2012/27/EC)
Regulation on guidelines for trans-European energy infrastructure ((EU) No 347/2013)
Commission Recommendation of 9 March 2012 on preparations for the roll-out of smart metering systems (2012/148/EU)
Commission Recommendation of 10 October 2014 on the Data Protection Impact Assessment Template for Smart Grid and Smart Metering
Directive 2014/94/EU on the deployment of alternative fuels infrastructure

Annex

The origin of electricity in Portugal during 2014, sold by EDP Serviço Universal SA.



Allocation by electricity technology

More than 50% of the electricity consumed in Portugal comes from renewable technologies:

Font: http://www.edpsu.pt/pt/origemdaenergia/Pages/OrigensdaEnergia.aspx