INOVCITY - BUILDING SMART GRIDS IN PORTUGAL

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ABSTRACT

The strong regulation pressure and the macroeconomic changes in Europe with special impact in Energy Markets, defined the need to bring intelligence in to LV energy distribution networks – Smart Grids. This is the main aim of InovGrid one of the important projects in place on EDP Distribuição, Portuguese DNO.
InovGrid project is the response of EDP Distribuição to these challenges, and is structured around three pillars: (1) Smart metering, designed to implement system-wide Automation Meter Management (AMM) capabilities; (2) Smart Grids, aimed at improving the efficiency and reliability of the grid through the introduction of a new level of intelligence on it's management systems; and (3) Micro generation, consisting on the adaptation of the grid to the growing demand for the connection of micro generation units.

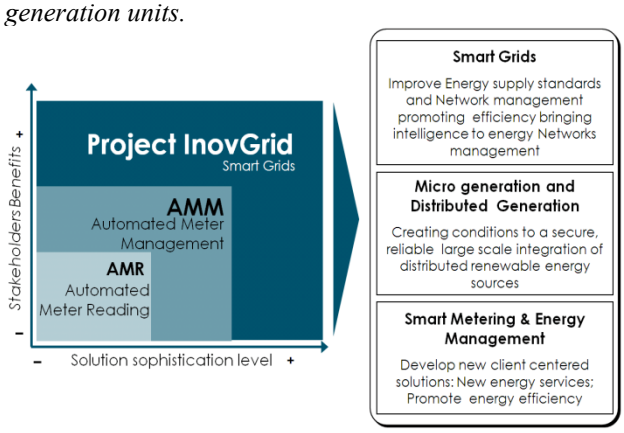

Fig 1 – InovGrid Pillars

The main goal of the project is to use innovation process to build intelligent energy networks in intelligent cities (InovCity) making significant contribution to population life stile and utilities operations management improvements.
This paper tries to illustrate the firsts steps undertaken in the construction of the first InovCity .Special importance is given to all the steps and pilots driven to improve process implementation.

INTRODUCTION

The main drivers for the project InovGrid are sustainability, superior quality on energy supply and security of energy distribution networks, Client Empowerment and Decentralized Generation.

Using real information from several smart meters/smart grids pilot implementation, it shall be possible to start establishing the framework that will drive towards a societal cultural mindset change based on customers behaviours and involvement on the energy issues, either by showing the savings they can have by being more energy efficient users (Sustainability) and showing that a more intelligent energy network could lead to optimization in quality of service (Superior quality on energy supply and security), market operations and costs reduction, as well as trough new added-value services, energy management applications and gadgets to improve involvement (Client empowerment), interaction and integration with local distributed generation and electrical mobility (Decentralized generation).

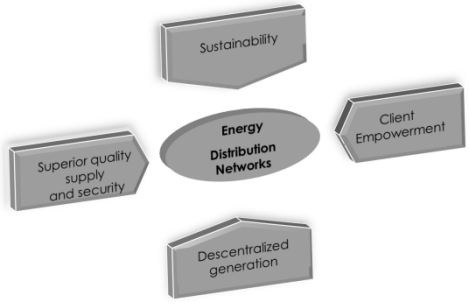

Fig 2 – InovGrid main drivers

INOVGRID TECHNICAL PLATFORM

To obtain this objective technical platform was designed with specification of all needed equipments and platforms using internal knowledge, Portuguese universities, external consultants, R&D and industrial companies' collaboration.

The designed solution that is actually being implemented is supported by the following elements (1) Energy-Box, Intelligent network equipments, installed in the consumers electric installation, that assure energy metering, providing clients energy management information and deliver utilities important network management information, (2) DTC- Distribution transformer controllers, that are installed in transformation cabinets that process and deliver information of all Energy Box and at the same time provide remote control and protection functions to electric equipments installed in transformation cabinets (3) Information Systems (Scada and Sysgrid) that are going to integrate and process all the information (4) an

important communication network that establishes link between all the these agents and that is comprised between clients installations and the control canter were are managed the information systems.

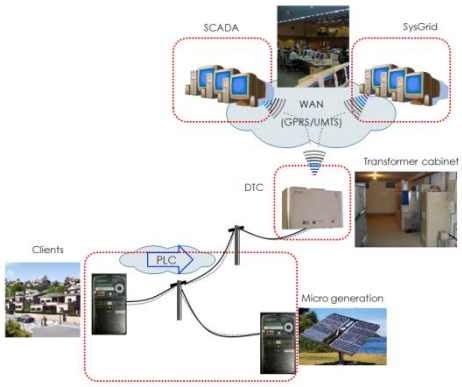

Fig 3 – InovGrid technical platform

Energy Box

The Energy Box is an energy management device, installed in clients' electric installation, and, in the smart grids concept is the network node close to the client including the functions of load controller and micro generation controller.
More than smart metering equipments provides technical information for better network management and are design to be client gateway for value added services, aiming for home management, and implementation of sustainability process and intelligent energy usage.

Energy Boxes can be remotely accessed. The equipment connection cover was designed to include a communication module. This module, by default uses PLC communication protocol, and establishes a bi-directional communication with DTC.
The main reason to the communication modular integration in Energy Box is permitting the complementary communication technologies usage such as GPRS, RF Mesh modules or other communication technologies, being the communications one of the most important key factor for InovCities development.

Fig 4- Energy Box and PLC communication module

In InovCity Energy Box are replacing conventional metering equipments in clients LV electric installations. The Energy Box integrates a four quadrant measuring unit certified to measure reactive energy, (capacitive or inductive) and active energy (consumed or produced from or to the LV network), making possible, micro generation units management using only one metering equipment. Energy Box has data storage capability to build consumption profiles that can be useful to clients energy advisors and for the adoption of billing plans suitable for clients real energy needs. This information can be used in client energy management systems which can be, directly or remotely connect with energy box.
Other important features are the, anti fraud mechanism and QoS online reports, alarms and indicators that allow major improvements on network management and operation since we can automatically detect, using pattern fault recognition, or other malfunctions on client energy supply and in distribution networks.

The information available in automatic scroll in Energy Box display makes possible to clients visualize instant consumption, voltage levels and peak power consumed or produced to network. The energy boxes are factory programmed to register consumption in a triple tariff system to illustrate the multiple tariff system usage benefits. The use of this information makes possible to implement a basic visual energy management system giving clients potential information on the multiple tariff usage benefits.

DTC- Distribution Transformer Controller

The DTC is the brain of the smart grid. This equipment installed in MV/LV transformation cabinet (1 DTC per power transformer) centralizes the communications between all the Energy Boxes and the information Systems. At the same time it provides remote control and monitoring of several equipments, sensors on the transformation cabinets such as switchgears, MV/LV transformer units load monitoring, cabinet temperature and Public Lightning control.
The communication between DTC and Energy Boxes uses PLC technology by default (having the capability to use other alternative communication technologies). Between DTC and information systems, either commercial or network management, by default uses a GPRS communication protocol (although it allow the usage of other technologies).

Fig 5 – Distribution transformer controller - DTC

The DTC has the ability to process al the information requests and actions to be remotely made by Energy Box, centralizing information and functions associated with customers commercial services and at the same time develop relevant functions and measurements to improve

network asset management and control.

FIRST PRE-PILOTS *IMPLEMENTATION*

The objectives of the first pilot were developed to provide real and intensive tests in special LV network conditions for better knowledge of the chosen technological solution and components behaviour on real applications, with special impact on communications.
The locations of the fist implementation pilots were strategically defined, to provide national dimension for the project and at the same time test the technologies in different network environments. In the chosen locations special contacts were made with municipalities' councils to present the project and involve all the local institutions. Special campaigns were made to inform and involve all the clients, in the installation process giving information of al the new capabilities delivered by InovGrid.

Fig 6- First Pilots Implementation on Portuguese territory

The technology tests were made in the several conditions to reveal the potential problems and new developments to be implemented in the designed solution and developed equipments.
We choose for the first project installations, old LV networks comprised with overhead lines and underground cables with different constructive technologies (alloy and copper) in extreme operation conditions, with different clients profiles like residential clients and industrial small facilities connected in low voltage networks.

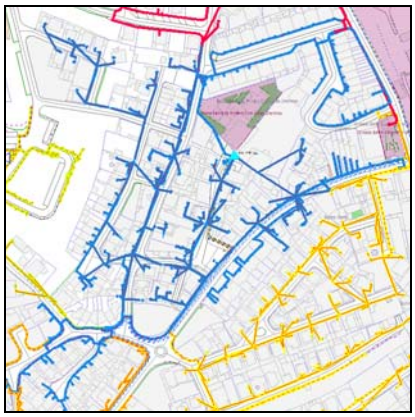

Fig 7 – Low voltage network topology

In the initial tests were involved more than 1000 clients, most of them located in Lisbon distribution networks, due to the proximity to the decision centre, and technology partners proximity, and to diverse network conditions that can be found on this geographical area? The first installations helped equipments and installation process development with main impact on PLC communications improvement, in the definition and test of alternative communication technologies, and improvements on the Energy Box installation process.

ENERGY BOX INSTALLATION PROCESS

The Energy Box is equipment that is going to be present in customers homes. More than all the developed communication campaigns to involve customers we had the need to design the installation process and train and teach our installation teams to all the new functionalities brought by these new equipments giving them knowledge to answer all client questions and resolving all doubts in the installation process.

The clients connected in low voltage with contracted power below 41,4 kVA, characterized as Normal Low Voltage clients represent more than 90 % of the total consumers supplied by EDP Distribuição LV networks. This is the main segment of clients to whom InovGrid wants to present new value added services.
The electric tariff system applied to these clients in the commercial energy contracts implicates the decision on two factors, the power needed on client electric installation and the tariff system type that can vary between single price tariffs to multiple price tariff incentive major consumption in off peak periods.

The power regulation is assured by power switcher regulator installed and managed by EDP Distribuição and that in most cases defines the frontier between the distribution network and the client installation. This switch in some case can have differential protection characteristics. The tariff definition is set on the installed electronic metering devices by an external computer or PDA.

The energy box installation connections and dimensions are similar to the conventional meter.
The Energy box constitution includes an internal power limiter switcher that can be regulated together with tariff definition by a computer, PDA or remotely via the information systems. In Energy Box installation the contracted power is regulated by the internal power limiter switcher being the existing one regulated to its maximum allowed power. In the process definition was decided to keep the existing power switcher in clients installation due to legislation conformity, to guarantee the differential protection when applied and last but not least to simplify the installation process avoiding the exhaustive alterations on client electric installation.

Special WFM (workforce management) process was also defined to support the installation process. The work assignment to the teams on the field relies on internet based system and is managed in back office workplaces where the tasks can be remotely assigned to the teams on the field. The field teams have a PDA with a specially developed application which receives work tasks from the back office; these tasks contain detailed information leading to the full understanding of the work needed, and also some more data held in the corporative systems that might be useful for any complementary job.
The developed application sends information to update the corporative information systems and at the same time has the capability in the installation process to parameterize the contracted power and tariff, associated to client commercial contract, in energy box by an optical device usage.

Fig 8 –WFM Platform

DEPLOYING INOVCITY

The selected location for InovCity was the City of Évora (an Unesco World Heritage Monument) with an area of 1.307 km², around 54.000 inhabitants and the network and customers diversity needed to allow the more meaningful range of variables that will be present in a nationwide rollout.

Fig 9 – Évora City and Évora InovCity Showroom

The InovCity is being designed not only as a Smartgrid project, addressing the intelligent network management, smart metering and consumer empowerment, distributed generation but also as a process to integrate other innovation projects of EDP.
Using the InovGrid project framework advantages, enables an easier field deployment for other innovation projects, obtaining more quicker and accurate results and making possibility to measure the impact of such results in the distribution network management. At the same time as new innovation projects integrates InovGrid platform allows an easy future implementation upon the InovGrid national rollout.

What is being made in InovCity?
With the EB and DTC rollout almost concluded, involving all Évora customers and transformation cabinets there're many simultaneous activities happening in InovCity.
Several activities around InovGrid project benefits investigation are being developed. Working with the real data obtained from the InovGrid framework we will measure major advantages on customer value added services and operational network management, and build an accurate business case for the national rollout.

Energy Efficiency programs

The energy efficiency is one of the main important key factors on InovGrid Project. In InovCity many projects are being developed to implement a sustainable energy usage. There are pilots ongoing to engage customers, on home display units usage, that connect with Energy Box and provide real time information about energy consumption, giving potential information on where energy savings can be made and the energy usage environmental impact. Other pilots are implementing new Time Of Use programs and "target kWh" tariffs, making customers more aware of their energy consumption throughout the day and encouraging them to make choices to change their energy consumption behaviors. Alerts are being sent to customers giving them the information needed to take energy consumption control. We are also stimulating energy efficiency communities creation where customers can share their results, get advices and become more involved.

Energy efficiency is an area that is not only being addressed in residential customers but also in C&I customers, raising the bar for the energy efficient results in InovCity.
There are around 1400 residential customers and 340 C&I customers involved with this energy efficiency programs as well as control groups both inside and outside InovCity. The selection of the customers was made in order that the results obtained are statistically meaningful.

Fig 10 – InovCity available Energy Charts

Still around energy efficiency, there are also activities being made with focus on technical and commercial losses reduction on LV network operation. Using the InovGrid framework relevant LV networks are selected to test technical losses measuring and control. Full networks topology(physical) is critical and the process includes, measurements on the active and reactive energy flow of each circuit, several LV different configurations network analysis to obtain the best cost/benefits ratio results using testing scenarios that include microgeneration, balanced phases, load per circuit, reactive energy, voltage profile, among others.
Commercial losses approach is being tested measuring LV networks energy balance and flow, analyzing Energy Box alarms, and relating this information with the customers energy consumption and commercial information allows faster detections of abnormal situations and to take immediate actions upon them. Remote disconnection and the elimination of estimated billing both help to reduce commercial losses.

Emerging technologies

Emerging technologies are also being studied and their impact/benefits being measured in the InoCity. Renewable sources integration, energy storage, and the Electric Vehicle (EV) charging grid are part of the InovCity project.
Promoting more renewable implementation, studying the limits for passive and active control of microgeneration, knowing the more efficient balance of demand and microgeneration in a LV network is one of the activities being performed in InovCity.
InovCity (Évora) is also one of the 25 cities selected for the pilot group to deploy the national EV charging network, with the InovGrid platform being an enabler to study the impacts/benefits in the LV networks.

Fig 11 –InovCity Website (www.inovcity.pt)

Another emergent technology being deployed in InovCity, aims an area that has major importance on general population on EDP Distribuição, reputation and QoS – public lighting.

Increasing the efficiency of public lighting, and providing to the customer (municipality) more flexible control and better information to make decisions will change the public lightning costs and its management strategies.
In InovCity traditional lighting is being replaced by LED lighting in some central locations. Light regulators, presence sensors, flexible tools to control and operate the public lighting grid (via Web Portal) are some of the innovation features being installed, aiming at a better management of the public lightning grid by the DSO and the municipalities and energy efficiency.

CONCLUSIONS:

InovGrid project aims at the development of InovCities, where intelligent network management, energy efficiency and renewable sources integration are key drivers. Évora is the first InovCity being implemented in the InovGrid project.
In Évora InovCity, the relationship and communication with local stakeholders is a key part of the deployment and the success of the project.

As in all smartgrid pilots the communication network is a key aspect to a successful implementation, and InovCity is the perfect location to test several types of communication technologies, performing costs/benefits analyses of each solution, test new solutions that are made available and providing better information for the correct choices to be made aiming, at the national InovCity rollout.

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