Advances in Smart Grids - Benefits on Sharing Background Experiences from Portugal, Central Europe and Brazil

ABSTRACT

This paper presents ELECON - Electricity Consumption Analysis to Promote Energy Efficiency Considering Demand Response and Non-technical Losses, an international research project that involves European and Brazilian partners.

ELECON focuses on energy efficiency increasing through consumers' active participation which is a key area for Europe and Brazil cooperation. The project aims at significantly contributing towards the successful implementation of smart grids, focussing on the use of new methods that allow the efficient use of distributed energy resources, namely distributed generation, storage and demand response.

ELECON puts together researchers from seven European and Brazilian partners, with consolidated research background and evidencing complementary competences. ELECON involves institutions of 3 European countries (Portugal, Germany, and France) and 4 Brazilian institutions.

The complementary background and experience of the European and Brazilian partners is of main relevance to ensure the capacities required to achieve the proposed goals. In fact, the European Union (EU) and Brazil have very different resources and approaches in what concerns this area. Having huge hydro and fossil resources, Brazil has not been putting emphasis on distributed renewable based electricity generation. On the contrary, EU has been doing huge investments in this area, taking into account environmental concerns and also the economic EU external dependence dictated by huge requirements of energy related products imports. Sharing these different backgrounds allows the project team to propose new methodologies able to efficiently address the new challenges of smart grids.

KEYWORDS: Demand response, energy efficiency, international cooperation, smart grids.

1. Introduction

Environmental, economic and sustainability concerns have been the main factors that determined the increasing importance of energy policies, all over the civilized world and especially within the EU. Some relevant results of these policies can presently be seen, with significant increase of distributed and renewable based electricity generation over the EU (Klessmann, 2011) and increasingly competitive electricity markets (Shahidehpour, 2002). Although the impact of these changes can be considered very relevant not only for the EU itself but also for the entire world, other types of changes are required so that the overall efficiency of the electrical systems is increased. In the power industry, energy efficiency must be pursued considering the overall system efficiency, from generation to the final use of electrical energy by end consumers. This implies getting the highest possible benefit from the primary sources that are used to generate electricity, in large power plants as well as in medium, small and micro size generation equipment. The efficient generation of electricity is only one way to pursue energy efficiency. Making the most of the primary energy sources that are used in the power sector requires new technologies and methods applied to electricity transmission, distribution, utilization and to the storage of energy. New operation methods and new business models still have a huge potential for enhancement in this area.

Going one step ahead in energy efficiency increasing requires taking advantage of the contribution of each one of the involved players, namely aiming at a more consumer focused operation paradigm. Consumers have traditionally been looked at as unable to intelligently manage their electricity behaviour and as not having the required maturity and tools to actively participate in power systems business. Presently we are in the advent of a crucial change in this paradigm, with electricity consumers being finally recognised as active and very relevant players. Turning this concept into a successful reality, able to significantly contribute to a more sustainable power industry is, however, a huge challenge (Federal Energy Regulatory Commission [FERC], 2010) (Faria, 2011) (Soroudi, 2011). Introducing new operation methods, tools and new business models, able to sufficiently interest electricity consumers to participate in the overall efficiency goals, are key points that must be addressed. At this stage, EU is in a good position for being able to show its consolidated background in the energy policy field and rapidly advance towards actual and effective real world changes in this area. In this process, it is of most importance to ensure the transfer of knowledge to third party countries, namely the ones evidencing consolidated economic growth and prominence in the energy sector. Furthermore, learning from the relevant previous experience of these countries is an opportunity that should be taken.

The ELECON project focuses on the above referred area of consumer centred power system and electricity market operation with the aim of increasing energy efficiency by means that are not traditionally used for this effect. The increase of energy efficiency is a must for the European Union in order to reduce the external energy dependency and the Green House Gas (GHG) emissions and to improve the companies' competitiveness. Increasing energy efficiency is a major goal that must be prosecuted using the already known and established means but also the new opportunities that arise by the new power systems and market operation paradigms. From these, the paradigm of smart grids (Farhangi, 2010) is especially relevant as it is able to put together the whole set of new organization and operation methods, the physical infrastructure, as well as the participating players and the corresponding decentralized decision making and control hierarchy. Concisely, one can say that smart grids are able to accommodate a large penetration of distributed and renewable-based electricity generation and the competitive and active participation of the involved players. Due to its increasing importance, energy storage units and their management is very relevant in this context.

These new paradigms bring new opportunities for the consumers' participation. Each consumer can improve its consumption efficiency and reduce the energy bill through adequate management of the electrical equipments and by participating in demand response events. Demand response can be defined as "the changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive". For the consumers, financial benefits are mainly the bill savings and the incentive payments earned due to the adjustment of their electricity demand in response to time-varying electricity rates or incentive-based programs. Demand response also improves the power system efficiency as it enables a rapid and cheap solution to peak and incident situations that would require huge additional investments otherwise.

Non-technical losses (named like this by opposition to technical losses, due to the physical characteristics of the electric system) are due to energy that is being consumed without being metered as regular consumption (Ramos, 2012a) (Ramos, 2012b). These are almost always deliberated situations that cause higher system inefficiency, leading to higher costs and putting paying consumers in unfair situations. These situations should be identified and corrected. Electric power losses correspond to the difference between the energy generated/bought and that which is billed. These losses can be divided into two distinct types: 1) technical and 2) non-technical. The former are due to the physical characteristics of the equipment (i.e., energy lost during the energy transport, transformation, and measurement). Non-technical losses, also referred to as commercial losses, are generally associated with the commercialization of the energy and involve energy which is delivered but not billed. The non-technical losses can be defined as the difference between the total loss and technical losses, and they are strongly linked to illegal connections in the distribution system. Traditionally, non-technical losses are much higher in countries in which the power system industry and/or the society itself are less organized. Considering the countries participating in this project, non-technical losses are much higher in Brazil than in European countries.

The restructuration of the power industry business, leading to competitive electricity markets and to the privatisation of a large number of companies, recently brought the issue of non-technical loss detection to the foreground and made it a greater concern than before. Smart grids are the new power system paradigm which should be achieved in the coming years. In the new context, the number of players involved in electricity transactions dramatically increased. Moreover, this number is successively increasing and smaller size companies are involved (e.g. small size distributed generation producers, aggregators, virtual players, suppliers, and even small size consumers in what concerns their participation in demand response events). Billing is becoming much more complex than in the previous power industry organisation in which it was undertaken by a small number of large companies in a very organised and controlled context. On the contrary, in the new context billing becomes a decentralised process and a single consumer bill is the result of parts of several distributed billing processes that may involve a large number of players. Industry regulation and the highly competitive electricity markets require the use of supervision procedures able to assure the correctness of the billing process. This is why ELECON is addressing the issue of non-technical loss detection as it is a very promising approach to the new paradigm of smart grids and competitive electricity markets. In this context, it will gain more importance for Brazil and become a very important issue for European countries. ELECON will address this issue from the point of view of real-time non-technical loss detection to be used in a decentralised way in smart grids for individual players use and also for regulatory purposes.

For both the two above referred goals (i.e. putting into practice well succeeded demand response programs that are of real value for the system efficiency increase and identifying non-technical losses situations), the existing consumption data must be analysed. Effective methods should be developed and adopted for this purpose, having as input data the huge amounts of data that result from the power system operation, from electricity meters, and from external factors (meteorological parameters as temperature and humidity, petroleum and other goods prices, etc.) and having in mind the specific goals for which it is being undertaken.

In the last decade, we have seen a substantial growth of Distributed Energy Resources (DER) in Europe, with distributed and renewable based generation having already a relatively high importance in several countries. This lays the basis for the future smart grids which should accommodate a large quantity and diversity of DER in the scope of a multiplayer competitive environment. Communications and control are two key issues for the success of future smart grids. With intensive penetration of DER, these must take over some of the responsibilities traditionally assumed by large conventional power plants. They have to provide flexibility and controllability necessary to support economic and secure system operation. This represents a shift from traditional central control philosophy presently used to control typically hundreds of generators to a new distributed control paradigm applicable for operation of hundreds of thousands of controllable generators and loads. Power systems operation methods must be deeply changed adopting new paradigms. Control and decision making must be decentralised with operational decisions and control laying on a large set of active players of very diverse types and sizes. Electricity consumers will become active players participating in the system operation in a strategic way. There are two key issues that must be addressed so that the new paradigms can be successfully implemented in practice: two-way communications and distributed control. These aspects should be considered together with the smart grid concept and, more specifically with the active consumer paradigm so that the proposed models can be successfully implemented in practice.

Energy storage (Styczynski, 2011) (Lombardi, 2011) must be given special attention in this context as it can play a very relevant role in the integration of renewable sources and it can improve the efficiency and reliability of the whole system by reducing peak power demands, i.e. by enabling a "peak shaving" effect in load diagrams. Energy storage technologies include natural and pumped hydropower, battery storage, flywheel storage, compressed air energy storage, Superconducting Magnetic Energy Storage (SMES), supercapacitors, and Vehicles to Grid (V2G), i.e. electric vehicles that have the ability to provide power to the grid while parked. As the price of energy storage means is still very high, their management should be done in a strategic way and integrated with the management with the other available resources. Combined strategic management of storage and demand response resources can be very effective in peak shaving and so reducing the requirements for spinning reserves and deferring or even avoiding the need for huge network and/or generation investments. Moreover, the combined use of storage and demand response is very relevant to face intermittent renewable energy sources.

2. ELECON Contributions for the Success of Smart Grids

The main goal of the ELECON – Electricity Consumption Analysis to Promote Energy Efficiency Considering Demand Response and Non-technical Losses – project is the establishment of a competent and fruitful network between European and Brazilian researchers whose research work contributes to the successful implementation of the smart grid concept. The project aims at advancing on electricity consumption analysis methods (Figueiredo, 2005) and on the way they are used to promote energy efficiency. This use is focused on the design and utilization of demand response programs and on the identification of non-technical losses. On one hand, if adequately used, demand response can play a crucial role for the sustainability of energy systems. On the other hand, the restructuration of the power industry business and the rapid evolution that is taking place towards to real smart grids dramatically increases the number of players involved in electricity transactions, making billing much more complex. In the new context, the identification of non-technical losses assumes a new role and increased importance in the scope of supervision procedures able to assure the correctness of the billing process. The project also addresses the communication infrastructure and the innovative control models that are required to put bring these concepts into reality, considering adequate business models.

ELECON activities are organized in the following seven workpackages:

WP1 – Organisation and management

WP2 – Electricity consumers profiling

WP3 – Non-technical losses

WP4 – Communications and control in smart grids

WP5 – Demand response programs

WP6 – Experimental tests: Europe and Brazil benchmarking

WP7 – Dissemination & Transfer of knowledge

Figure 1 presents ELECON project workflow.

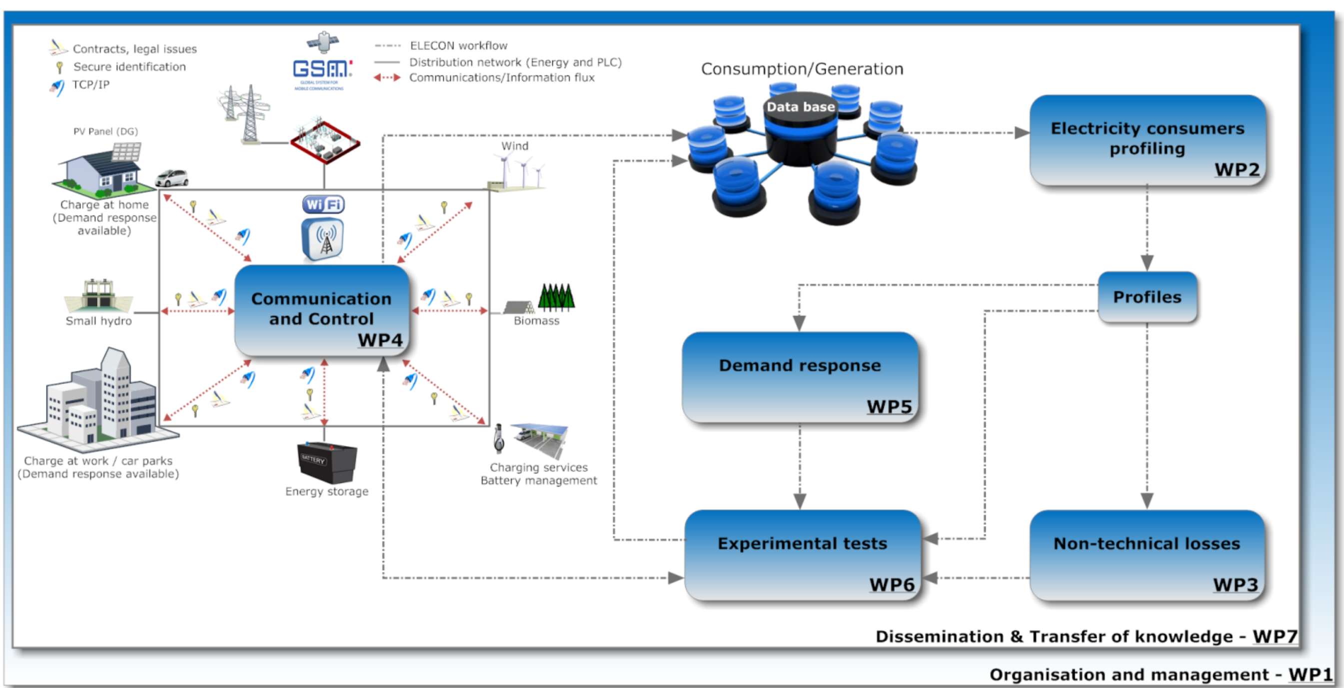

Figure 1 – ELECON project workflow

Workpackage WP1 deals with the organization and management activities that are required for the efficient project execution. Sub-sections 2.1 to 2.5 describe in a concise way the technical workpackages of the projects (WP2 to WP6).

2.1 WP2 – Electricity consumers profiling

Workpackage WP2 focuses on the profiling of electricity consumers. Its main objectives are:

- To organize a library of electricity consumption data

- To propose an electricity consumers profiling methodology

- To undertake electricity consumer profiling and characterisation

- To identify opportunities for efficiency improvement

- To produce a report concerning the obtained electricity consumer profiles and the benchmarking studies.

As metering is an almost universal condition for electricity supply, huge volumes of data result from the metering of electrical installations. Typically, in the past, the distribution companies classified its customers by the commercial indexes, such as consumer's activity type, hired power, tariff option, supply voltage level and location. However, the characteristics of these data are very diverse, namely in what concerns the time metering periods, which range from real-time or short periods to monthly or even more rare meter reading. With the introduction of smart meters a larger amount of data is recorded containing important knowledge that can be found. For suppliers that are not using smart meters, it is usual to undertake periodic metering campaigns that allow better knowledge about consumers' habits and for which small time metering periods (e.g. 5 minutes, 15 minutes) are used. More detailed campaigns, monitoring electrical appliances individually can also be undertaken.

ELECON will collect all the available electricity consumption data gathered by the project partners. This data will be adequately characterised and organised into a digital repository. The obtained data will be subjected to a data analysis and mining process able to output electricity consumers' profiles and to discover relevant knowledge which is implicit in the data. This will depart from the previous experience of the partners in this field, namely IPP, who has previously designed a methodology for similar studies (Figueiredo, 2005). According to the available data, which will be in much larger volumes than the data previously processed by the IPP team, and present a large diversity of characteristics, an electricity consumers profiling methodology will be designed to be used in the scope of ELECON. This methodology based on knowledge discovery process includes a data pre-processing phase, a clustering phase, for which the most adequate method will be determined by experimental studies and, finally, a classification phase (Figueiredo, 2005). This last phase allows obtaining knowledge concerning the electricity consumption, which will be used to compare the habits of consumers with similar characteristics aiming at obtaining efficiency gains. Once the profiling methodology is established, it will be applied to the data previously obtained and the corresponding electricity consumption profiles will be obtained. These will be prepared for several types of data organisation, namely considering consumers of the same region, of the same type, etc. The classification model will allow classifying new consumers in one of the obtained classes. This phase will give as result the characteristics of electricity consumption which will also be prepared for several types of data organisation. This will allow comparing these characteristics between similar types of consumers which may have some distinct characteristics (e.g. the consumers located in different countries, in European countries and in Brazil). These studies will be used as the basis for benchmarking studies between the European countries and Brazil and also between the participating European countries and between the participating Brazilian regions.

Afterwards, the project will identify situations for which the electricity consumption is significantly different in spite of the installations characteristics and purpose being similar. These situations will be faced as possible opportunities for efficiency improvement so they will be analysed in more detail in order to identify the underlying causes for the identified consumption discrepancies.

2.2 WP3 – Non-technical losses

Workpackage WP3 focuses on the non-technical losses. Its main objectives are:

- To identify the relevant opportunities for non-technical loss identification situations in smart grids (SG)

- To propose a methodology for non-technical loss identification situations adequate for competitive SG

- To identify consumer profiles format to be used for non-technical loss identification in competitive SG.

The necessity of the use of non-technical loss detection in new smart grids will be assessed in this workpackage. This necessity arises from the fact that in the new smart grid context the billing process has a complex and distributed nature and involves a large number of players, some of them being small size players with lower background in this field. Moreover, the new competitive environment requires that regulatory entities ensure the correctness of the whole billing process, so that the conditions for a fair operation and competition and for the equality of opportunities are also ensured.

Significant advances have been made in recent years in the area of non-technical loss detection methods, using different techniques of energy measurement and alternative computational methods based on intelligent algorithms, especially soft computing (Ramos, 2012a) (Ramos, 2012b). A novel framework introduced for graph-based classifiers that reduces the pattern recognition problem to an optimum-path forest computation (OPF) in the feature space induced by that graph has recently been adapted to this problem and applied with success. From the undertaken experiments, it is clear that the OPF outperformed the other classifiers for both datasets, in terms of both efficiency and effectiveness. The greater speed of the OPF classifier makes it feasible for real-time training systems in which re-training is necessary after samples from known/unseen classes are added to the training set. Moreover, a real-time system for the detection of nontechnical losses becomes possible, with new consumer profiles quickly added to the system for re-training at minimal cost. Results obtained by UNESP (Ramos, 2012a) (Ramos, 2012b) will be an important departing point for this workpackage.

2.3 WP4 – Communications and control in smart grids

Workpackage WP4 focuses on the communications and control issues in smart grids. Its main objectives are:

- To identify the current practices and the envisaged evolution of communications and control in smart grids in Europe and Brazil

- To propose communications and control in smart grids models, technologic approaches and cost analysis

- To establish the roadmap for power systems communications and control evolution towards smart grids

The extensive use of two way communication, covering all power systems levels, from generation to end consumers, is required for smart grids (Gungor, 2011). Traditionally, two way communications are mostly used at the transmission level and at the higher voltage levels in distribution systems. Moreover, two way communications is mostly restricted to the links between utilities control centres and their most important plants (substations and large power plants) which can be operated in a remote way. Although current power systems still make limited use of sophisticated telecommunications means and only punctually use two way communications, some changes have been occurring. Renewable based plants deployed in the recent years are often equipped with two way communication means that allow their remote operation, even if they are of relatively small size. Recently, several European countries have been making investments in smart meters that open new communication possibilities between suppliers and consumers, which can include real-time metering and two way communications (European Standards organizations - Joint Working Group on Standards for Smart Grids, 2011).

There are several standardized wired and wireless communication technologies available for various smart grid applications. With the recent growth in wireless communication, it can offer standardized technologies for wide area, metropolitan area, local area, and personal area networks. Wireless technologies not only offer significant benefits over wired, such as low installation cost, rapid deployment, mobility, etc., but are also more suitable for remote end applications. Suitable smart grid applications can be achieved through standardized wireless communication technologies, e.g. IEEE 802.11 based wireless LAN, IEEE 802.16 based WiMAX, 3G/4G cellular, ZigBee based on IEEE 802.15, IEEE 802.20 based MobileFi, etc. In what concerns the technologic telecommunications infrastructure, and the use of wireless communication in power systems, the current situation is very diverse in terms of the technologies and of the standards being used and of the extension of two-way and wireless communications use.

Centralised decision making and control is still the current paradigm for power system operation all over the world. Presently, important decisions concerning this operation involve a few active players (mostly utilities and large power plants). However, smaller players and consumers have successively been gaining some more importance due to energy policies focussed on distributed generation and on open competition in electricity markets. Making smart grids a reality requires the use of distributed control, which is a key issue that must be addressed so that the smart grid paradigm can be successfully implemented in practice.

Smart grids must rely on advanced distribution automation which should allow managing traditional assets, as well as DER, including renewable and distributed generation, energy storage and customer loads. Adequate and integrated DER management, considering the diverse available resources, is the key for achieving smart grid goals, increasing the system overall efficiency and stability. Resource management must be made considering operational constraints as well as market issues and commercial relations among the involved set of players (Soares, 2012) (Styczynski, 2008) (Lombardi, 2011) (Cebrian, 2010).

The new kind of management envisaged for smart grids and the subsequent control (Alvarez-Hérault, 2011) (HadjSaid, 2009) (Tranchita, 2009) (Dotta, 2009) are significantly different from the traditional ones as they are based on distributed decisions and must deal with a large set of involved entities whose commercial relations must be taken into account. SCADA (Supervisory Control and Data Acquisition) systems are vital for power systems. Current SCADA adaptation to accommodate the new needs of power systems does not allow addressing all the requirements. In the context of smart grids, SCADA systems must be more decentralized, flexible, and intelligent. They must be designed to support multi-level decentralized decisions and actions, which are the result of smart and strategic behaviour of the involved players, including power suppliers, network operators and users, and also of smart components and control.

This workpackage will conceive plans to make the evolution from the present power systems to future smart grids, in Europe and Brazil. The required investments will be identified and a cost analysis will be undertaken.

2.4 WP5 – Demand Response Programs

Workpackage WP5 focuses on demand response programs. Its main objectives are:

- To produce an updated state of the art of actual demand response experiences

- To identify demand response opportunities

- To propose demand response programs and models

- To implement a demand response simulator

- To produce a report concerning demand response opportunities and programs for Europe and Brazil.

Demand resource value to increase power systems efficiency is widely recognised today (FERC, 2010) (Faria, 2011). However, there is still little knowledge concerning Demand Response (DR) and the ways in what it can be efficiently used. ELECON will collect the information detained by the ELECON partners concerning DR, especially focussing on actual DR programs which are being, have been or are prepared to be used. The 2001 generation shortage in Brazil which forced load reduction in record time will be studied in detail as it can be considered a pioneering experience of DR. A research using bibliographic references as well as the information made available by Independent System Operators (ISOs) all over the world will be undertaken in order to produce an updated state of the actual use of DR.

DR can be used in order to significantly reduce operation costs and/or costs resulting from incidents. If used in a judicious way and if adequate business models are adopted, it results in benefits for the overall systems and also for consumers that can reduce their energy bills by participating in DR programs and events. DR main advantage are its fast availability, when compared with other alternative resources, and its ability to be used in critical moments (e.g. load peak periods and failures causing loss of supply), allowing to avoid or to defer highly expensive investments. Moreover, DR can also be used in periods for which locational marginal prices become too high due to the high costs of the generation resources that must be used if the whole demand is supplied. It is probable that in future, with DR being increasingly used in the scope of smart grids, it will be faced as an ordinary energy resource which use will be determined by its price when compared with the remaining available resources prices (Vale, 2011). ELECON will identify opportunities for DR use that have been experienced in participating countries and that lay in these categories. For that purpose, the team will identify particular situations that should be analysed (electricity prices very high, incidents causing significant loss of supply, use of expensive generation resources) as potential opportunities to use DR.

The project considers already proposed and designed also also new DR programs which are adequate to be used in Europe and Brazil. The assessment of this adequacy will be based on the electricity consumers' profiles resulting from WP2 and on the characteristics of the opportunities identified in this workpackage. These DR programs will be modelled considering the participating entities (ISOs, CSPs – Curtailment Service Providers, aggregators, including VPPs – Virtual Power Players, and consumers of several types), the way they interact, namely in DR events, DR contracts and consumer remuneration methodologies.

The DR programs modelled will be computationally implemented so that they can be used in the experimental tests to be undertaken in WP6. For this purpose, the previously developed DR simulator by the IPP team (DemSi) will be used (Faria, 2011).

2.5 WP6 – Experimental tests: Europe and Brazil benchmarking

Workpackage WP6 will undertake experimental tests concerning Europe and Brazil benchmarking. Its main objectives are:

- To evaluate the impact of using DR programs in the energy consumption profiles in Europe and Brazil

- To evaluate the economic impact of using DR programs to the consumers and to the system operators

- To undertake European and Brazilian benchmarking

The project will prepare a set of scenarios to be simulated. These scenarios concern power system operation according to the smart grid paradigm, i.e. with intensive use of distributed and renewable based generation, and considering demand response and storage as available DER. These scenarios will be designed for each of the countries participating in ELECON, considering the current generation and storage means and several evolution scenarios in what concerns generation capacity for each of the considered generation technologies, storage, and demand response programs use (Martins, 2008a) (Martins, 2008b) (Udaeta, 2010). Several scenarios of load forecast will also be considered.

Computational and hardware tools existing in the laboratories of ELECON partners will be used for the simulation studies. These include simulation software for power systems (professional and house developed, more specific, power flow and optimal power flow computational tools), electricity markets, and demand response. A real industrial SCADA allowing assessing the interaction of distributed control with existing centralized control and a communication infrastructure to test advanced distribution automation functions such as "self healing/defense" mechanisms using and optimal power flow control at the smart grid level will also be used to performance simulation studies in a reduced scale real based distribution network. Each scenario will be simulated with and without the use of DR, in order to evaluate the impact of using DR programs. The impact of the use of DR programs will be evaluated both in the short term and in the long term perspective. Short term analysis allows determining punctual savings and quality gains. Long term analysis allows reflecting these gains on the energy price and taking conclusions about the long term value of DR programs. The impact of DR programs use in consumers profiling will be analysed. All the impacts will be analysed from the point of view of several players, namely the consumers and the system operators. Benchmarking studies with the obtained results for Europe and Brazil will be undertaken.

The value of the use of the proposed non-technical losses based method will be assessed by means of the increased efficiency of the business models that can be adopted and by the additional players they may attract, due to the increased confidence that the method introduces in the system.

3. ELECON International Research Network

The ELECON project puts together researchers from seven partners, with consolidated research background and evidencing complementary competences. The coming together of the partners of this team, with a balanced participation of senior and junior researchers, ensures the capacities required to achieve the proposed goals. ELECON establishes an extended scientific network of seven educational and research entities from Europe and Brazil. ELECON involves institutions of 3 European countries (Portugal, Germany, and France) and 4 Brazilian institutions.

The selection of the particular groups of the network has been based upon the concept of facilitating the scientific demands and objectives of the project. In particular, three institutes from EU and four institutes from Brazil will participate in the project:
- **IPP** – Polytechynic Institute of Porto, Portugal
- **OVGU** – Otto von Guericke University of Magdeburg, Germany
- **INP Grenoble** – Institut Polytechnique de Grenoble, France
- **UNESP** – Universidade Estadual Paulista, Brazil
- **UFSC** – Universidade Federal de Santa Catarina, Brazil
- **IF-SC** – Instituto Federal de Educação Ciência e Tecnologia de Santa Catarina, Brazil
- **USP** – Universidade de São Paulo, Brazil.

Figure 2 presents the geographical distribution of the involved partners as well as their main areas of intervention in the project.

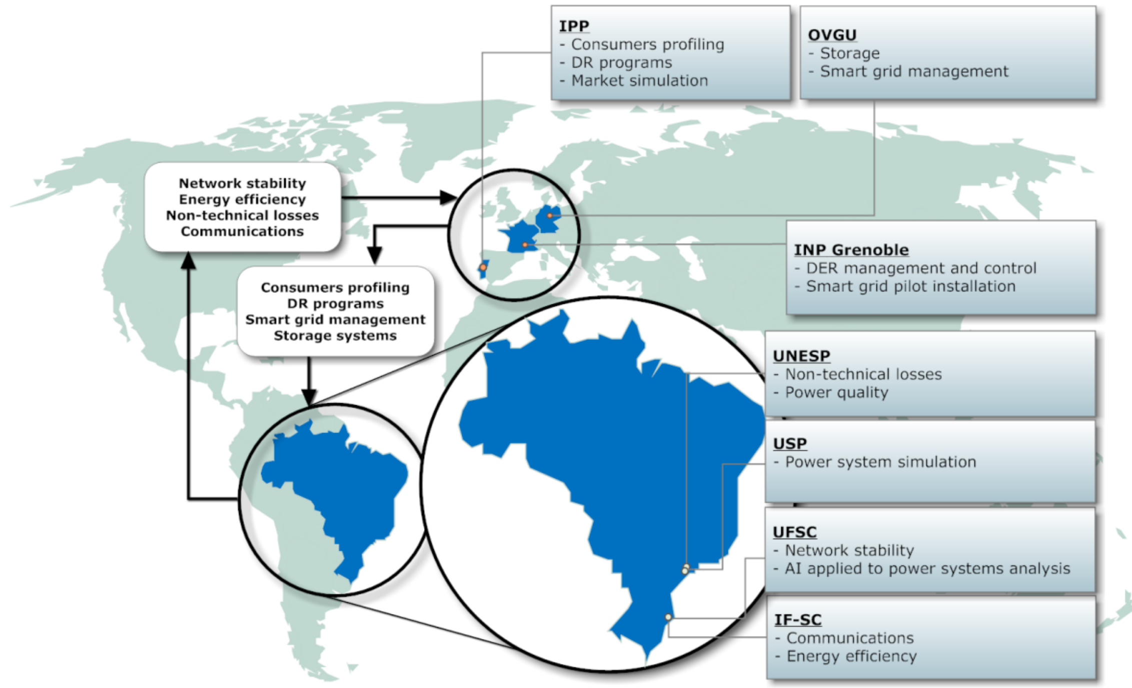

Figure 2 – ELECON partners

The exchange scheme proposed by ELECON consists in a total number of 54 researchers actively involved in the project, from which 19 are experienced researchers (ER) and 35 are early stage researchers (ESR) from all the scientific entities involved. In particular, 27 researchers from EU and 27 from Brazil will work in the project. Special attention has been given to the harmonization of the expertise of each exchanged researcher with the scientific activities of the institute of destination, as well as the workflow of the project and the required time frame. Aiming at the efficient interaction between the participants and the successful accomplishment of the project goals, the project activities have been organized in work packages involving well defined tasks in a successive manner. Additionally, with the purpose of ensuring an efficient transfer of knowledge, during the four years of duration of the project, there will be organised a total of four workshops, 2 in Brazil and 2 in Europe, related to the scientific areas of expertise of the participating groups and complementary training sessions through ad-hoc seminars.

3.1 Why cooperation and research between the European Union and Brazil is important for increasing energy efficiency in future smart grids?

The International Research Staff Exchange Scheme will increase the cooperation between the European and Brazilian partners, with benefits to both parts. Researchers visiting the other part (Europe for Brazilians, and Brazil for Europeans) will learn, teach, and share their vision, initiative, technology, and culture. By working closer, new opportunities of joining complimentary visions and backgrounds will certainly appear and result in new collaborative projects.

Power systems and more specifically energy efficiency increasing through consumers' active participation is a key area for Europe and Brazil cooperation. In fact, EU and Brazil have very different resources and approaches in what concerns this area. Having huge hydro and fossil resources, Brazil has not been putting emphasis on distributed renewable based electricity generation; most of the renewable based electricity generation is obtained by large hydroelectric plants. On the contrary, Europe has been doing huge investments on renewable based electricity generation, taking into account environmental concerns and also the economic EU external dependence dictated by huge requirements of energy related products imports. A significant effort has been made in distributed generation, with generation resources ranging from large to mini and micro size. These two diverse approaches are certainly important for learning from each other about the positive and negative consequences of each resulting generation mix, considering several points of view (economic, environmental, utilities versus consumers, etc.).

As there is little experience in obtaining energy efficiency gains by means of demand response programs, the previous Brazilian experience should be considered as a unique opportunity to take lessons from. In fact, in 2001, when Brazil suffered serious electricity generation shortages, a forced load reduction had to be put in place in record time. Strict consumption rules have been operating from June 2001 to February 2002 with low voltage consumers being subjected to a 20 percent mandatory reduction, with incentives for higher reductions and severe penalties for clients failing to achieve the imposed reductions. Large and industrial consumers have also been subjected to mandatory rules. This process led to better energy consumption habits and to an increase in efficiency (e.g. incandescence bulbs have been almost completely replaced by more efficient discharge bulbs. However, ten years after these events, the good habits are being forgotten as adequate programs have not been put in place during this period. Electricity tariffs have significantly increased making it necessary to provide social tariffs to the most impoverished population. Although the context and philosophy of presently proposed demand response programs are completely different, the results of that 2001 experience are of high value. The consequences for the several types of affected consumers (from large industrial plants to very small family houses) and the way in what the forced load reduction has been accepted allow to better understanding consumer elasticity, what consumers of each type are prepared to accept and how they are willing to contribute for the overall objective. Non-technical losses are a major problem in Brazil, when compared with the EU, making the already accumulated knowledge concerning this subject a very important point to the EU partners' enrichment.

On the other side, EU countries, having recently more concerns in what respects to demand response and energy efficiency, due to high energy prices, have increased the knowledge concerning electricity consumption analysis, storage units' management and demand response opportunities. These are very relevant topics that can benefit Brazilian partners in their upcoming way to use demand response programs to increase energy efficiency and, in that way, reinforcing their economic competitiveness.

Apart from these differences, there is an obvious common need of ensuring sustainable electricity generation and increasing energy efficiency. In the last decade, we have seen a substantial growth of Distributed Energy Resources (DER) in Europe, with distributed and renewable based generation having already a relatively high importance in several countries. This has made European researchers to advance on DER management and control. As competitive markets have been consolidating their operation throughout Europe, market issues and simulation are also strong topics of European researchers, and Brazilian partners will benefit from this particular expertise.

Overall, this cooperation will reinforce both EU and Brazil partners research competences, making them more capable to contribute to their respective countries' economies competitiveness and for ensuring human life sustainability. Differences in culture, language, and habits are, from this point of view, no more a problem but a very valuable asset.

4. Conclusions

The paper presented ELECON, an international project that focuses on the establishment of a competent and fruitful network between EU and Brazilian researchers to contribute to the smart grid successful implementation. ELECON is an innovative scientific and exchange scheme aiming at advancing on electricity consumption analysis methods and on the way they are used to promote energy efficiency. ELECON focuses on the design and use of demand response (DR) and on the identification of non-technical losses, due to their crucial role in the sustainability of energy systems and relevance ensuring the correctness of the energy billing, respectively. It also addresses communications infrastructure and innovative decentralised control models, required to bring these concepts into reality.

The EU is in a good position to show its consolidated background in the energy field, to transfer knowledge to third party countries and rapidly advance towards effective real world changes in this area. Brazil is a very important player with interesting unique experiences in the energy field, so learning from them it is a great opportunity. The complementary expertise and high scientific level, supported by the exchange program of both ER and ESR, will bring high quality results with significant impact and lay the basis for long lasting collaboration.

5. Acknowledgements

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