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Smart Grid - Demand Management as key resource for improvement and social contribution to 2020 strategy

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SUMMARY

The purpose of this paper is to explain to the Energy Sector the conclusions of the Smart Grid Communications emulation for 100.000 users, developed under the GAD project in Spain (Active Demand Management). Due to the current trend of enhancing the electrical network information and communication capabilities, the Smart Grid has raised an important opportunity of improvement thanks to Demand Response in the last mile. A new communications architecture to cover the different aspects of a Smart Grid and Demand Management has been designed in the GAD project. This architecture supports the automatic business procedures from the TSO (Transport & System Operator), DSO (Distribution System Operator) and Power Marketers, and considers protocols of recent introduction which still are now under stress test in the field, like PRIME, or the network automation like IEC61850.

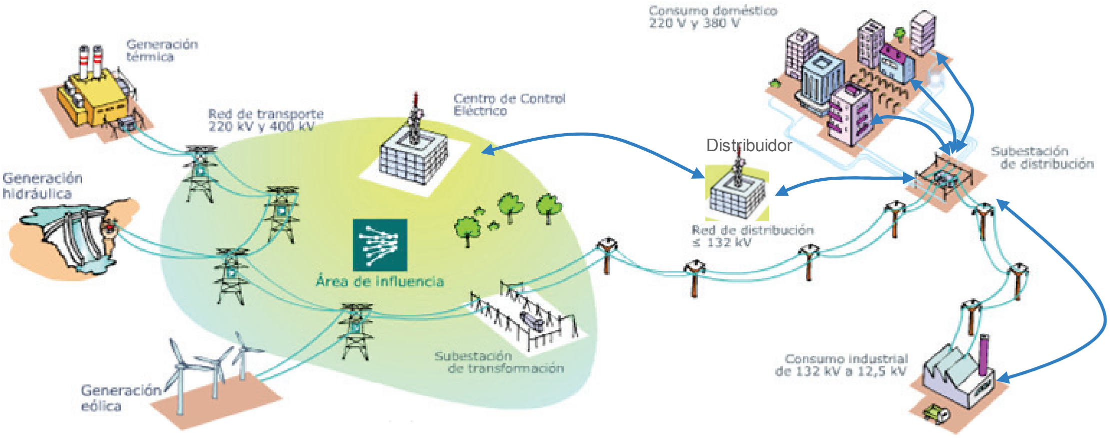

Figure 1. Overall situation to apply Smart Grids concepts.

The main objective is to flatten the national Demand Curve in an automatic and more efficient way, so that operation procedures and technical signals will be set up by the new Control Centres (TSO, DSO), also allowing the market pricing to be more flexible and managed via Power Marketers. In this scenario, regulators could rely on market operation to balance the system, in which advanced price signals could help the technical teams to prevent and avoid electrical network incidents.
Thanks to a more automated network, with a new generation of communications layer, the investment could be efficient, also thanks to the optimization of the generation mix. It's not only deployment of price and techniques in the net, but it is also social contribution to enhance consumption: the daily demand profile could be matched also with the residential demand, allowing users to really measure an manage their contribution to Energy Efficiency in the overall system, setting information about Carbon print at individual level and renewables integration
A new generation of systems and devices could now be deployed, studying profitable business models and allowing granular concepts from Information and Communication Technologies to interact also with the Energy Sector, keeping the current systems security & reliability. This means new age in

Control Centres for the TSO and DSOs, that could support new topographic information and visibility, together with higher resolution (e.g. lower than 1MW), and flexible configurations (user groups, Transformation Centres groups, Substations groups), that could lead to different User offers, taking into account consumer profiles and contributions, residential area infrastructure and investment needs, weather prediction and its impact on demand.

The main challenge, as far as we studied, is to deploy communication and telecontrol devices in a reliable, open standard and profitable way, adding the contribution to the business model of the different Smart Grid applications that could arise (e.g.- Electrical Vehicle, distributed or even residential generation integration, …).

For last mile user devices, there is a clear opportunity to merge the current user devices (business or leisure) with evolved applications, attractive and fancy, new web based applications ready to run.

Thanks to the CENIT GAD project, the Consortium has successfully proven the technical concept of the Active Demand Management, both in devices and simulation of a regional grid, with ability to jump into a National scale.

KEYWORDS

- √ Demand Management, Demand Response
- √ Demand Curve
- √ Predictive Maintenance
- √ Information and Communication Technologies
- √ Control Centres
- √ Communications Layer
- √ Energy Valued Applications

PAPER

MOTIVATION AND SCOPE

Due to 2020 strategy, there are a number of initiatives that have been successfully launched into the Energy Sector, especially due to CO_2 reduction and renewables integration. However, Energy Efficiency efforts are not enough, and nowadays the European Commission has raised the alarm, that we will hardly achieve 10% reduction by 2020.

Energy Efficiency requires combined efforts to achieve an overall target: improve the way in which we use and consume energy. We need to launch different initiatives to improve diverse factors as building isolation, industry / city waste recovering, but we think the main topic is to add more "intelligence" to the Energy Sector at all levels, from Control Centres to industrial or residential consumers:

- √ If a consumer has enough information of its contribution to the overall situation and current status of the electric grids, they could react supporting the net and help to improve daily situations or even contingency scenarios.
- √ On top of this, the current planned investments to deploy or improve the energy networks could be modified. This new on line information and added to the possibility to interact with the customers and Agents, will give some more operation life cycle to currently installed devices and platforms.

Probably the most important action to take, in order to improve the current Energy Efficiency landscape, is to flatten the Demand Curve, not only at national level, but acting at local level in the most saturated points of the Electric Grid.

GAD PROJECT SCENARIO

Thanks to the CENIT project GAD (meaning Active Demand Management) in Spain, we developed and deployed a Multisite Application, able to help in the support of the daily operations in a country. REE as TSO (Transport & System Operator) is able to monitor and manage the Transport Layer and demand prediction, IBERDROLA as DSO (Distribution System Operator) is able to operate the Distribution Layer, GTD act as Power Marketer, and all of them were interconnected through an environment emulation tool, developed by CEDETEL, under SIEMENS definition. This tool allows a bidirectional transit of energy and communications information among the named peers, and it is able to get real operation data from different devices in the field, or, by itself, simulate their behaviour in a real-time or accelerated mode, for a specific equivalent timeframe, to develop actions in case of contingency, possible incidents or investment scenarios. The structure is presented in Figure 2:

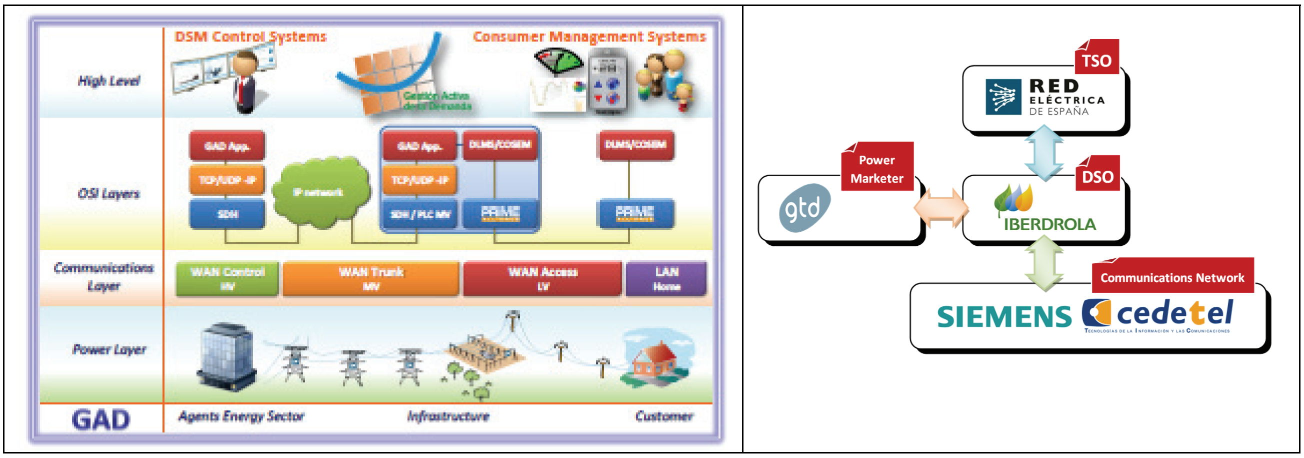

Figure 2. Overall Smart Grid Architecture and Agents, and interactive simulation structure

The technical partners in GAD developed the different devices (Power Stations, Control Centres, Power Meters and Home). Thanks to this new Application, these devices can be modelled in the tool, able to check their behaviour in a certain field set up, and make comparisons and audits between different topologies and solutions, protocols, or implementations from providers. Then, specific and customized Web Services were developed into the smart grid emulation tool to be able to establish real-time connections with the actual Utilities' demand management applications, in order to create a realistic and interactive emulation. These interconnections have allowed the creation of communication flows among the Utilities as they would be in a real deployment. Thus, the Utilities' applications have been tested under a production scenario, giving more consistency to their validation processes. In Figure 3, a representation of the Control segment into the emulation tool is presented, showing the specific modules in charge to represent and communicate with each Utility, and the interconnections among them and with the DSO's distribution network.

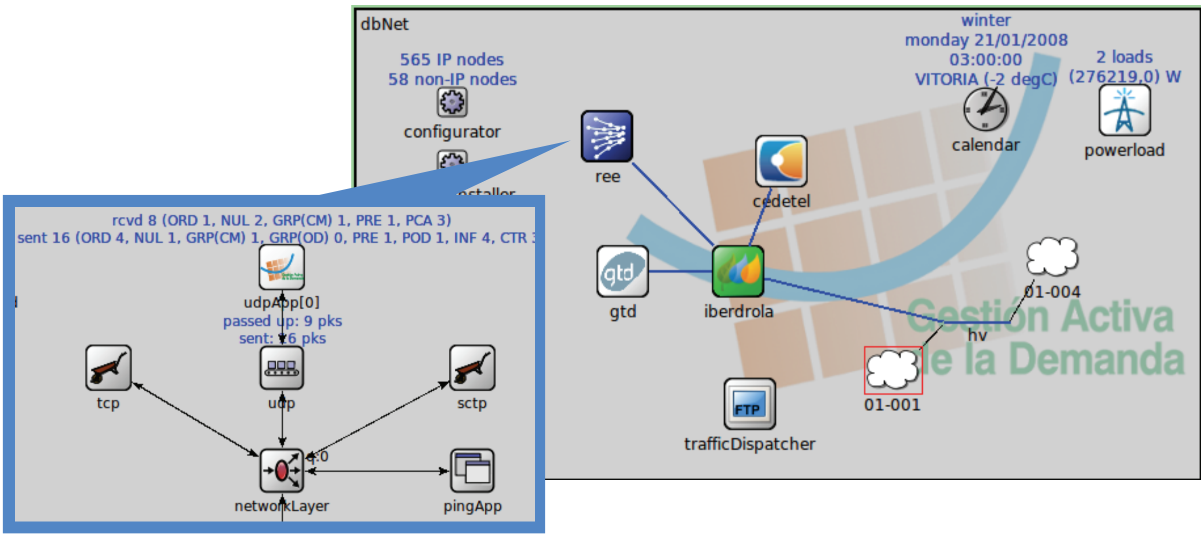

Figure 3. Emulation tool's representation of the real Utilities' interconnection.

To generate electric demand information, this tool supports the input of actual clients' consumptions data, but also provides the possibility to scale and emulate big populations through the use of user profiles representing different clients' habits. This gave us the possibility to build customized populations and study the contribution of 100.000 residential users to their regional electrical grid. We worked in an accelerated scenario, simulating in few hours one year time spans (with 15 minutes resolution), integrating real weather databases. We even reproduce contingency situations of the past year, acting TSO / DSO and PM, so that we could develop different strategies to prevent or solve already known situations, a way of learning for future grid management. In Figure 4, an example of the monitorization of the whole scenario's aggregated electric demand is shown, and the effect of the inter-day and weather variability can be observed. Then, Figure 5 and Figure 6 show how effectively a TSO/DSO intervention actually modifies the demand avoiding a contingency situation which would have arisen in any other case.

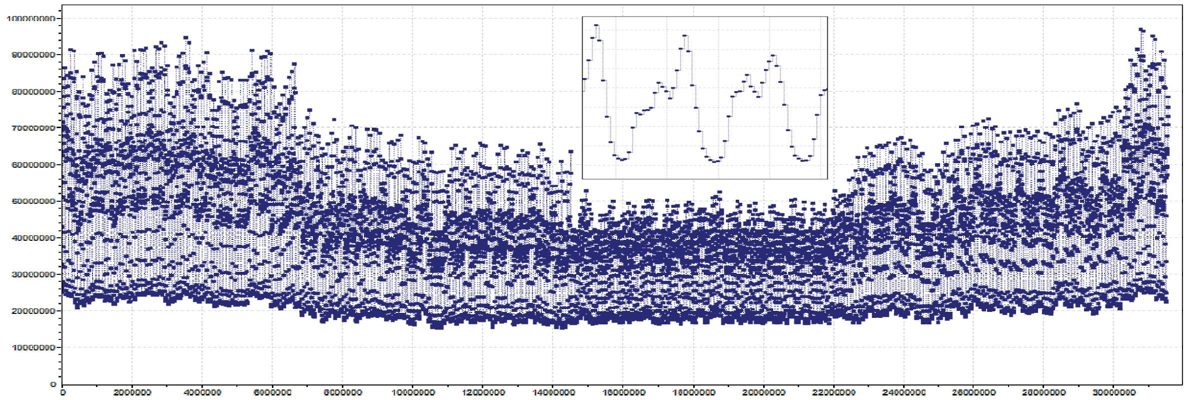

Figure 4. Simulated aggregated electric demand for a population of 100.000 residential users based on daily consumption profiles and weather information, from January 1 to December 31.

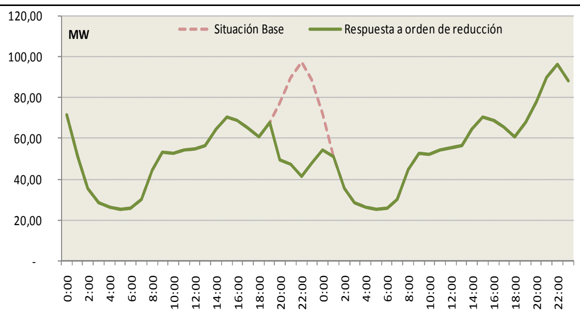

Fig. 5.- Demand Response to a TSO order in the simulated region, winter peak, 24hours.

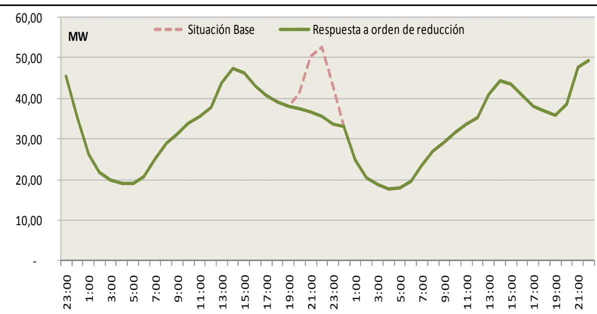

Fig. 6.- Demand Response to a TSO order in the simulated region, summer peak, 24hours.

We could demonstrate the high potential of a real communication orders flowing from the TSO to DSO, from Power Marketers to users via DSO, from DSO to their *facilities*. With this new communications architecture and developed applications, we could cover different aspects of a Smart Grid, and we stressed the Energy Demand Management due to project requirements.

This architecture supports the automatic business procedures from the TSO, DSO and Power Marketers, enabling new applications and models to be analysed and integrated. It considers protocols of recent introduction which still are now under stress test in the field, like PRIME or the network automation like IEC61850. Other protocols to reach last mile information, like Meters and More or G3 could be analysed against the same topology to discuss advantages and disadvantages at the last mile. It plays with current IPv4 implementations, also capable of IPv6, DLMS COSEM data models, any other protocols or new designs could be studied in the Application, to check viability and previous results to the field deployment. To illustrate, the next Figure shows the representation of a PRIME meter/load controller into the emulation tool, with its PRIME interface and GAD application receiving demand management commands from the Utilities.

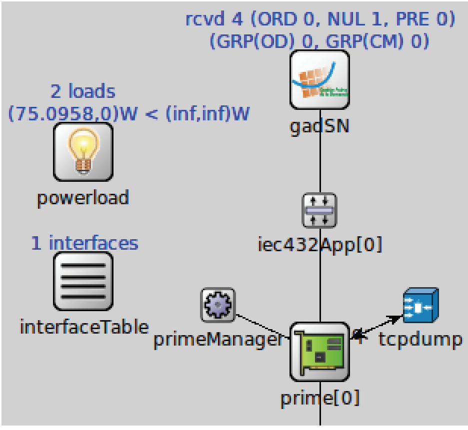

Figure 7. Representation of a meter/load controller into the emulation tool

RESULTS AND ANALYSIS

As we fixed as main objective to flatten the national Demand Curve in an automatic way, we developed new operation procedures and technical signals, together with new Control Centres (TSO, DSO). The information needs to be accurate between current Energy Control Systems (SCADAs) and this new Communications for the Control Centres, allowing last mile information to be available. This means a powerful information system, allowing the Agents to have a clear vision about their facilities and its behaviour, allowing them to study the real status of the network and helping them to plan more accurately, how / where / when to invest, in order to avoid incidents, maximize service and commitments. As an example, Transformation Stations (TS) could be prioritized according to a saturation ranking, study the users' profiles supported by this TS and offer them price signals or others, so that load could be modified with a certain criteria. This will enable the DSO to optimize the usage and life cycle of the different devices in that saturated TSs. Network development and deployment could be more rational, cost efficient and could be delayed in time, and optimized in topology.

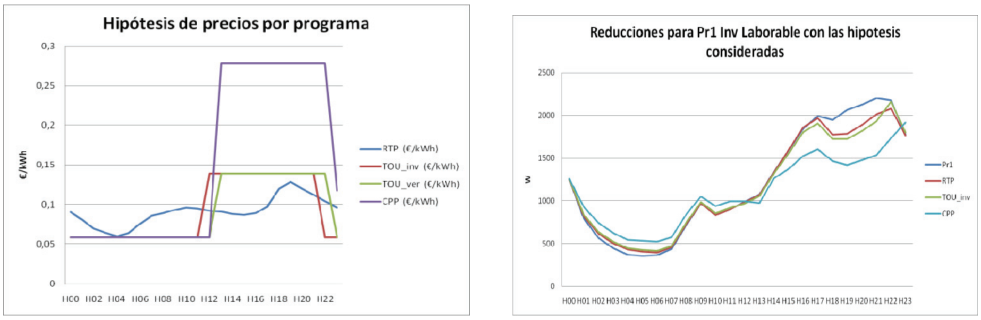

Figure 8: Some samples of demand response to different price signals.

Taking into account our current situation in Europe with regulated markets, and US experiences that achieve significant reductions of load in critical situations, we enabled market pricing policies and we demonstrated that we could achieve significant reductions using Demand Management. We think this could be a powerful tool in a scenario in which users' awareness and proactivity will allow technical management to be supported by a day-ahead forecasts, translating operational risks in price signals. We created the figure and some example policies of Power Marketers. In this scenario, regulators could relay in a market operation to balance the system, in which advanced price signals could help the technical teams to prevent electrical grid issues. In the simulation, we achieve results for a TOU (time of use tariff) scenario with to periods in a typical Winter day, as stated in Figure 9:

- √ Off-peak price 55% lower than peak price.
- √ 25% peak reduction with 0,2 kW per customer and shifting demand to off-peak.

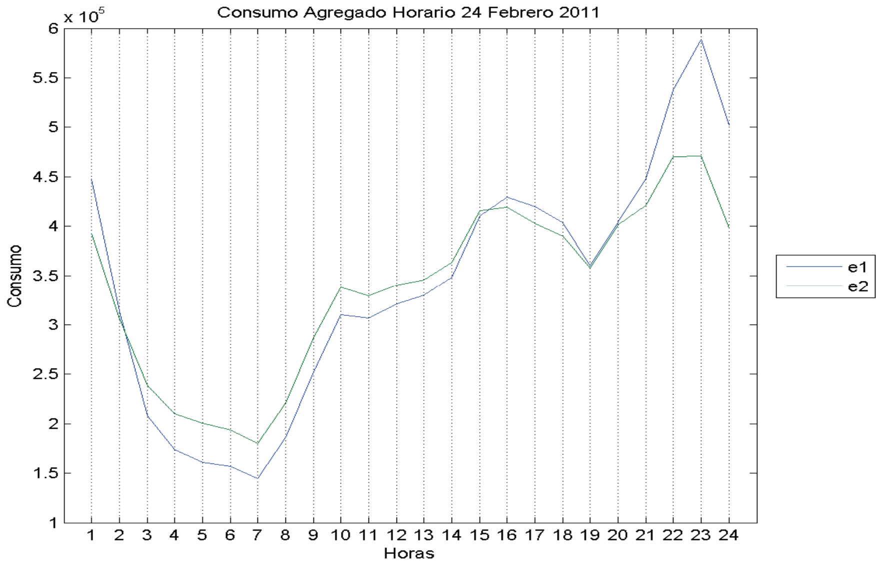

Figure 9: Demand Response to a TSO demand curtailment request, 24hours.

We also demonstrate that in this new scenario, significant savings at national level could be achieved, specially in gas / petrol imports, ordinary generation capacity needs and CO2 emissions.

There is the business model income, thanks to an automated network with a new generation of communications layer, the investment could be profitable: at national level, the mix generation can be optimized, the management and development of transport and distribution grids can be optimized, and operation and maintenance of the network would be more flexible and cost effective. But we think it's not only deployment of price and techniques in the net, we think the most important point would be the social contribution to enhance consumption: the daily generation profile could be matched also with the residential demand, allowing users to really measure their contribution to important parameters like Energy Efficiency in the overall system, Carbon print at individual level and a real optimization of renewables contribution.

We demonstrated in a living lab the usage and compatibility of this new generation of systems and devices, so that they could be now optimized, industrialized and deployed in regional and national levels, allowing granular concepts from Information and Communication Technologies to interact also with the Energy Sector. We think there are a couple of issues that needs to be worked on:

- √ studying profitable business models taking into account regulated market, and Agents current costs ¿(it would be easier to play optimizing TSO / DSO current procedures)?.
- √ keeping the current systems reliability. This is a must, we need to ensure a robust deployment in pilots to ensure current parameters are still on their tags (e.g. TIEPIs).

This means a stress test in regional living pilots of new developments in Control Centres (TSO and DSO, even Power Marketers), supporting new topographic visibility, together with higher resolution (e.g. lower than 1MW, able to provide detailed information at Power Stations, Transformation Stations and even Meters level). We will enable different flexible configurations, for instance, groups could be defined with a certain criteria, to provide better service or attractive offers: user groups, Transformation Stations groups, Power Stations groups. In this case, we will have to take into account consumer profiles and contributions, residential area infrastructure and investment needs, weather prediction and impact on generation / demand balance.

The main challenge as far as we studied, is to deploy communication and remote control devices in a reliable, open standard and profitable way, adding the contribution to the business model of the different Smart Grid applications that could arise (e.g.- Electrical Vehicle, distributed or even residential generation integration, …). In our opinion, this is the real challenge, and we think the deployment needs to have an incentive. With clear policies and investment support, Energy Efficiency initiatives like this one could have a positive outcome, following the example of CO_2 and renewables integration. The introduction level is broader than users' initiatives, an industrial area, Town Hall or even islands would be the ideal scenarios to perform a pilot. In these scenarios, storage could be also studied to avoid risks and dimensions, so that new technology could support the load peaks, levering the risk of load management, so that risk in contingency operation and maintenance is lowered.

For the last mile user devices, there is a clear opportunity to merge the current user devices (business or leisure) with evolved applications, attractive and fancy, new web based applications ready to run. The new tablets that have been deployed in the past two years would be a fancy tool to provide user information, ensuring communication from the grid needs, final customers and social networks. Figure 10 shows the different modules of the new Smart Grid tool, that allows both, real data collection from the field to perform daily operations, or work in a emulation, to plan or prevent actions.

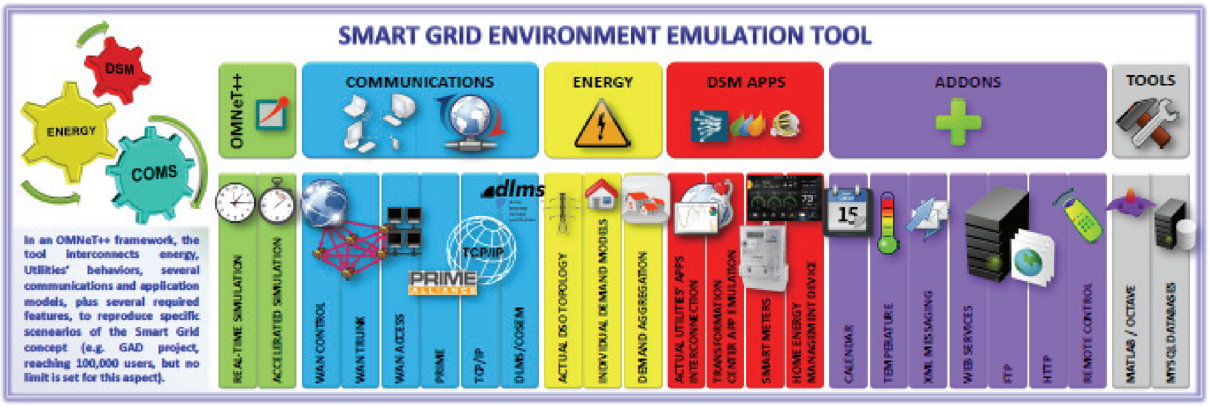

Figure 10: Smart Grid Environment. New tool to collect real or emulated data

CONCLUSIONS:

Thanks to the CENIT GAD project, the Consortium has proven the technical concept of the Smart Grid, and stressed one of the different applications it may support, the Active Demand Management. This has been checked both in physical devices, as well as in a simulation of a regional grid, with ability to jump into a National scale. This is now the next opportunity: to find out a real living environment to perform a pilot and demonstrate the technical and economical viability at macro level with real citizens, scenarios and needs.

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CEDETEL is the research organization chosen by SIEMENS to design the architecture of the WAN network of the GAD Project. Iberdrola leads the Integration Phase. Siemens has defined Smart Grids as a strategic topic in Energy Sector. All of them are part of the communications WP (Work Package) of the GAD Project.

For more info, please refer to the project home page: http://www.proyectogad.es/