Scholarship Application Template

PhD SCHOLARSHIP APPLICATION DATA

Business Division Business Area	DEMA Smart Grids and Storage
Scholarship location Province/Building	Bizkaia, Edificio 700

SCHOLARSHIP DESCRIPTION

Title: New decentralised control architectures for a future digitalised electrical grid

Brief description of scholarship:

The European ELECTRA project (www.electrairp.eu) in which TECNALIA has participated, derived from the European Energy Research Alliance's Joint Programme for Smart Grids (EERA JP SG), has proposed a new control architecture model for the electrical grid of the future as an alternative to the current centralised structure dominated by the transport operators. This new concept divides the electrical grid (distribution and transport) into a cell structure called "Web-of-Cells" (WoC). Each cell is managed by a Cell System Operator responsible for its operation, frequency and voltage control and the management of the resources inside the cell. In this way, the stability of the entire system is achieved as an added effect through this local accountability.

Through the resolution of local problems with local resources, the transfer of energy from one end of the system to the other is avoided, mitigating losses and congestions, significantly reducing the effort associated with communication and information processing (delimited to each individual cell), and managing reserves far more efficiently.

This is the conceptual framework behind this doctorate thesis, which has the main purpose of developing new grid control strategies based on a Web-of-Cells structure, sustained on a high observability of its structure and the flexibility of its resources. The new frequency and voltage control schemes will be evaluated in a laboratory environment, reaching a TRL4.

The doctoral student will reinforce the research line of the TECNALIA Smart Grids area on the integration of distributed resources into the grid and the management/operation of this grid.

Scholarship description:

To reach the scenario set out in the 2030 strategy marked by the European Union, the electrical sector must face an in-depth transformation based on three facilitator vectors, known as the 3 D's: Decarbonisation, Decentralisation and Digitalisation.

The decarbonisation of the grid, based on a greater use of renewable sources (wind and solar power), is going to introduce more variability and intermittency into generation, highly dependent on meteorological factors. On the other hand, the decentralisation of the grid, resulting from the geographical dispersion of new generation and storage resources, along with the increased

participation of the final consumer, is going to generate more uncertainty related to the distribution of the energy flows in the grid.

This scenario of greater complexity of the electrical grid, with the incorporation of a higher number of renewable storage and generation distributed resources connected at all voltage levels, and the increased volume of information that is being obtained as a result of the deployment of digital infrastructures, makes the development of new, more decentralised ways of management and operation necessary, in which digitalisation is going to play an essential role in the development of the grid.

The European Energy Research Alliance's Joint Programme for Smart Grids (EERA JP SG) brings together the main European research centres and universities in terms of Smart Electrical Grids. They have been working on the ELECTRA project, which has defined a new grid control architecture model called Web-of-Cells (WoC). Under the "divide and rule" approach, the WoC concept represents the electrical grid as a set of cells with the ability to resolve the voltage and frequency problems (generation-demand balance) individually in real time, in such a way that each cell operates stably, ensuring that the entire grid maintains global stability and security ("bottom-up" approach) in a more efficient way.

As can be seen in Figure 1, each cell is a group of loads, distributed generation, storage units, conventional generators, etc., interconnected within some well defined electrical and geographical limits; each cell is connected to the neighbouring cells via one or several tie-lines.

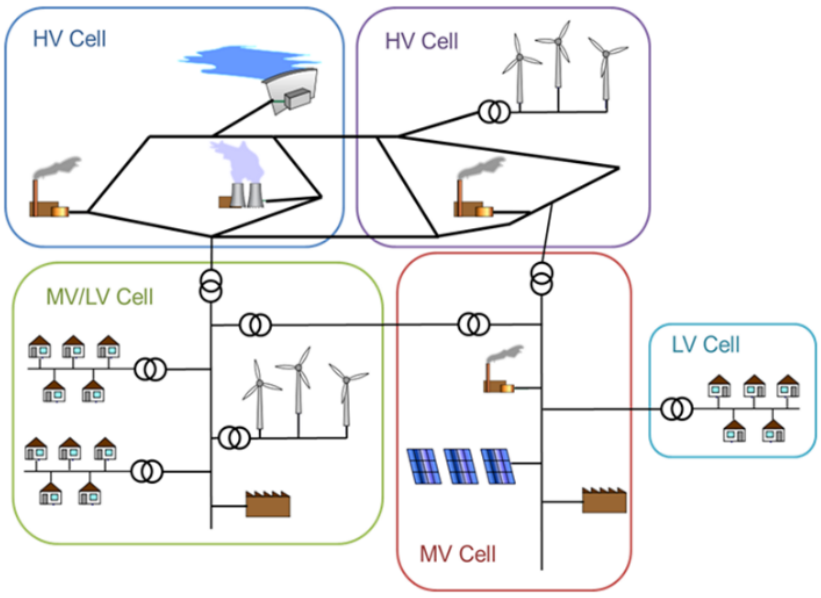

Figure 1. Graphic representation of the Web-of-Cells concept.

This new operation concept introduces important advantages with respect to the traditional centralised management model. On one hand, local resolution of local problems, in which generation or consumption needs are satisfied by the resources existing in the cell, without the needs to import energy from points that are far away in the grid, which leads to a reduction of losses and possible congestions. On the other hand, the amount of information that each cell must obtain and process is reduced significantly, which minimises the data traffic between the

distributed resources in the grid and the control centre. Less data traffic implies a reduced sending time, fewer information losses, less errors/uncertainty in the information aggregation and disaggregation processes and less response time for more efficient management of reserves.

However, WoC is still in a theoretical definition phase, still a long way off the necessary maturity for its real implementation. Basic aspects, such as the control models for each type of cell (generator, consumer, mixed), the static or dynamic nature of the structure of the cells, concept scalability problems, integration and control hierarchy, conflicts between control functions with different objectives, etc. still need to be addressed.

This doctoral thesis falls within this context, with the main objective of developing new grid control strategies within the Web-of-Cells concept, supported by a high degree of grid observability and availability of flexible resources. The specific tasks to be performed by the doctorate candidate are:

- State of the Art: analysis of alternative electrical grid control architectures (cell, fractal, etc.) and further study of the Web-of-Cells concept.
- Research into the optimum specification of the cell within a grid cell structure (size, dimensioning of the necessary resources, static/dynamic nature, etc.), as well as the viability of collaboration mechanisms between cells.
- Development of advanced voltage/frequency control schemes on a representative grid model, following corrective schemes (in light of a grid event) and proactive schemes (anticipation of a grid event based on generation and load predictions).
- Benchmarking compared to the current centralised system (reference). Definition of metrics and KPIs.
- Validation of the control schemes in a laboratory environment on pure simulation and Hardware-in-the-Loop platforms. Different future grid scenarios will be reproduced to evaluate the efficiency of the grid management and potential limitations.

Therefore, this proposed doctorate scholarship will be co-directed by the **Department for Electrical Engineering at the UPV/EHU,** more specifically the **Electrical Energy Systems Research Group (GISEL)**, which will offer its knowledge on modelling, analysis and simulation of electrical systems, and the **Smart Grids and Storage Area** in the **TECNALIA** Energy and Environment Division, with extensive experience in the management and operation of electrical grids with a high integration of distributed and renewable generation.

It may be rounded off with a **stay** at a European research centre or university that is working on the WoC concept, such as AIT (Austria), DTU (Denmark) or SINTEF (Norway).

PhD candidate profile /requirements:

The PhD candidate shall meet the following requirements:

- Degree and specialisation: Master's or equivalent degree in Engineering required to enter the PhD programme. Electrics, electronics and automation or similar specialisation.

- Languages: English is essential. Advanced level (speaking and writing skills).
- IT skills (please specify programmes and level of use): advanced knowledge of power and control electric systems simulation programmes such as (Power Factory/PSS®E, Simulink/SimPowerSystems) and of programming languages (Matlab, Python).

The following will be a plus:

- Teamworking skills.
- Autonomy and initiative to put forward new ideas and implement them.

Further information and applications: http://bit.ly/2JTzULq