DERri
Distributed Energy Resources
Research Infrastructures

TEMPLATE FOR PROPOSAL UNDER DERRI

User-Project Proposal:

User-Project Acronym	**MICROEFIRED**
User-Project Title	Research for the Development of a Low Voltage Microgrid for the Integration of Distributed Resources Under the Criteria of Improving Energy Efficiency and to Facilitate Demand Response
Main-scientific field	Smart-grids
Specific-Discipline	Control systems

Lead User of the Proposing Team:

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* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

Additional Users in the Proposing Team:

Name	
Phone	
E-mail	
Nationality	
Organization name, web site and address	
Activity type and legal status* of Organization	
Position in Organization	

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

(Repeat for all Users)

Date of submission	18-06-2012
Re-submission	YES_____ NO___X____
Proposed Host TA Facility	Open
Starting date (proposed)	18-06-2012

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Summary of proposed research

A microgrid is basically a network of small-scale distribution and low voltage. As such, it has the same elements as a conventional network, generators, loads and control systems, adding further the possibility of including energy storage devices. However, although conceptually these devices have the same functions as in a large-scale network, its operations and especially their control and protection systems must be adapted to operate properly according to the operating philosophy of microgrids.

In this project, we propose to establish the basis of a microgrid, of the implementation with commercial devices and the definition of the control system of the different components. The network management raises two premises of control, improving the energy efficiency of the systems involved and to provide the necessary tools to facilitate demand response within the electrical system.

As a result of the research, a control system to manage different types of microgrids is expected to be defined. This system will support both configurations: electrically isolated or other self-sufficiency facilities.

State-of-the-Art

Nowadays in developed countries the electrical markets are freeing. On the other hand, the legislation requires maintaining quality levels of power supply [1].

Year after year there is an increase in demand; as a consequence, the load levels in electrical networks are closer to technical limits. This increases the possibility of stability problems [2].

And it is necessary to remember that the electricity is the only industrial product that must be consumed at the same time it is manufactured.

Our challenge is to ensure a reliable and quality electricity supply to modern digital society that respects the environment.

Energy efficiency refers to using less energy to provide the same or improved level of service to the energy consumer in an economically efficient way; it includes using less energy at any time, including during peak periods [3]. In contrast, **demand response** entails customers changing their normal consumption patterns in response to changes in the price of energy over time or to incentive payments designed to induce lower electricity use when prices are high or system reliability is in jeopardy [4]. Because most demand response programs in effect today are event driven, customers tend to assume that demand response events occur for limited periods that are called by the grid operator; but critical peak pricing (CPP) and real-time pricing (RTP) are growing in prevalence and impact. Many demand response programs are designed primarily to curtail or shift load for short periods of time; however, those programs that educate customers about energy use with time of use (TOU) rates, dynamic rates, and energy use feedback can also produce measurable reductions in customers' total energy use and cost [5-8].

While energy efficiency is an increasingly prominent component of efforts to supply affordable, reliable, secure, and clean electric power, demand response is becoming a valuable tool in utility and regional resource plans.

There are significant differences in how energy efficiency and demand response are evaluated, what organizations offer to them, how they are delivered to customers, and how they are rewarded in the marketplace. Reducing these differences and coordinating energy efficiency and demand response could be beneficial. Better coordination of energy efficiency and demand response programs at the provider level could bring about cost efficiencies and more rational allocation of resources for both program providers and customers. Coordination could help customers, as most customers do not understand or care about the difference between energy efficiency and demand response and would be receptive to an integrated, packaged approach to managing their energy usage. Greater customer willingness could also increase demand response market penetration and capture energy savings and customer bill-reduction opportunities that might otherwise be lost.

Besides, **micro-grids** are small electrical distribution systems that connect multiple customers to multiple distributed sources of generation and storage [9, 10]. This new concept of distributed generation means a novel approach to the management of electricity systems that, conversely to the traditional configuration based on large generation plants, resides on the

connection of small modular generation units to the medium and low voltage grids. Distributed generators, together with the energy storage devices, constitute a solution to the randomness of renewable energy sources. A micro-grid should be [11-18]:

- Reliable and repair itself: it provides the security and quality of supply that required twenty-one century digital society.
- Accessible for all network users: it allows active participation of consumers though demand management; it ensures the connection of generations and distributed storage.
- Economic: it optimizes assets and energy efficiency utilization, it ensures competition and regulation, it enables new products, services and markets.
- Technological innovation: sensors, monitoring, meters, digital control, power electronics, computing, communications.

To take advantage the potential, the use of distributed generation in distribution network, generation elements, storage and loads must be considered as integral parts of the network. Each of these elements must be able to respond autonomously to perceived changes in the network such as voltage, current and frequency regarding the optimal operating point. Micro-grid apparatus should be able to act so that distributed generation resources continue to supply power to the greatest number of charges.

To give greater flexibility to system we propose **in this project** the implementation of relationship and functioning model such as peer-to-peer and plug-to-play for each distributed generation apparatus, implying that a generator could connect to a network without make changes in engineering of network itself or in its control system. If a centralized control does not exist, this implies that every component controls its reactive power contribution to the network based on the local voltage. Moreover, system operation should not be altered although some of its elements are lost.

So that, the **project aims** to implement in the **control system** of the micro-grid all those functionalities to facilitate the integration of different apparatus that can participate as demand response resources within the system and taking into account energy efficiency strategies. Identification, design and implantation of management applications will be carry out for effective integration of all actors in program. Furthermore, tools will be providing for settlements agreements.

References

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Detailed Description of proposed project : Objectives – Expected Outcome – Fundamental Scientific and Technical value and interest

The project focuses on the establishment of the basis of the design and implementation of the interconnection network and the control of the components of the micro-grid. The components of the micro-grid are available in the research working groups of the same Institute on which this project is going to be developed (Institute for energy engineering). The different components of the micro-grid are currently available. Now, it is required to advance in their integration and control functioning together in a micro-grid.

The present project tries to be a check of some of the steps forward in the field of electrical engineering aimed at the efficient control of micro-grids and integrate the skills to provide the effective integration of demand response and energy efficiency strategies.

Moreover, the political actions aimed to reduce climate change effects propose reductions in CO2 emissions while encourage the use of renewable energies like biomass, solar, hydrogen fuel cells, some of which are efficient small-scale, attainable with the development of this project.

The **objectives** of the **project** are:

1. Define the basis of the design and implementation of the micro-grid. For this, available apparatus at the Institute for Energy Engineering will be used. High nominal power apparatus are not needed, as the fundamental objective of the project is to provide a system in which implement the proposed control.
2. Define a management system that enables the micro-grid control. This system should be able to obtain electrical magnitudes, to store dates and to execute the necessary control measures for the micro-grid management.
3. Define the Implementation of the micro-grid control to improve the energy efficiency of the installations.

The **innovation** in this project consists of the **rules to use in the control** of the components of a micro-grid. Two main criteria are proposed:

1. Improvement of energy efficiency in the installations that constitute the micro-grid.
2. To provide the integration of different distributed resources acting as a demand response resource.

This development raises a control system that provides different software and hardware applications. The control system is based on a web platform that allows control resources, the development of the control of the installations and also provide a common space for the integration of the various agents in a demand response program.

One of the fundamental characteristics of the proposed control system is the possibility of communicating with facilities which are far away from each other, and gathering all the information in a central sever. TCP-IP Ethernet communication is used, which permits an easy

and fast access to the system.

Thus, in the architecture of the control system, the system components are located in two different sites: one is inside the controlled components of the micro-grid, where electrical measurements are taken and control actions are performed. The other one is the control center, where data is stored and a main server manages all the other different applications.

The **tasks** to be developed for the project are:

- Task 1. Definition of the conceptual design of the system. In this tasks the choice of equipment to be controlled is included. Choice of control systems for each of them. Purchase necessary control equipments and server that will serve as the control center for the management of the micro-grid.
- Task 2. Definition of control algorithms to operate as a mechanism for a demand response. Development of software for system operation. Verification of the system viability by means of specific tests.
- Task 3. Definition of the implementation of web viewer.
- Task 4. Definition of the control algorithms designed. Specificaiton of the software for the management of the micro-grid.
- Task 5. Definition of the operational testing. Proposal for improvements. Feedback in the proposed control techniques. Improvement of the development implemented.

So that, through this research will obtain the development of microgrids control system with the aims of improved control of energy efficiency and mechanisms to participate in programs of demand response.

So that, the project **aims** to implement **the control system of the micro-grid** all those functionalities to facilitate the integration of different apparatus that can participate as demand response resources within the system and taking into account energy efficiency strategies. Identification, design and implantation of management applications will be carry out for effective integration of all actors in program. Furthermore, tools will be providing for settlements agreements.

The project focuses on the design and implementation of the interconnection network and the control of the components of the micro-grid. The components of the micro-grid are available in the research working groups of the same Institute on which this project is going to be developed (Institute for Energy Engineering). The different components of the micro-grid are currently available. Now, it is required to advance in their integration and the control of functioning together in a micro-grid.

Originality and Innovation of proposed research – Broader impact

The **innovation** of this project is to **coordinate energy efficiency and demand response**, as there are many research of one or the other but not the combination of both. An additional improvement is the **integration of geographical information** on the electrical data in this type of systems because of the usual geographical dispersion of the different components of the micro-grid.

Through this research the development of a micro-grid control system will be obtained with the control objectives of improving energy efficiency and mechanisms to participate in programs of demand response.

Plan for *dissemination and exploitation* of project results, wich will be assessed in the evaluation on the proposal and on project monitoring:

The *results* produced will be *published* in national media and publishing internationally.

The impact on scientific and industrial sector will broadcast conferences, seminars or other means.

This presentation provided a minimum of 3 publications at conferences and developing a thesis project that will be used for further data analysis applications.

In *collaboration* with the *company* Active Energy Demand SL is planned to implement the results in facilities in operation which are working together for the duration of the project.

Proposed Host TA Infrastructure/Installation – Justification (about one page).

The candidate do not focus this project in one concrete TA infrastructure. Any of them offer advantages for the development of the project. The main aspect to be performed during the project is the definition of the facilities to be implemented in the IIE (Spain) and for that it is necessary to know other similar facilities dedicated to similar aspect as can be found in the DERri infrastructures.

Synergy with ongoing research

It is important to indicate that the project focuses on the design and implementation of the interconnection network and the control of the components of the micro-grid. The **components** of the micro-grid (biomass plant, solar power plant, hidrogen fuel cell, etc.) **are available** in the research working groups of the same **Energy Engineering Institute** (IIE) on which this project is going to be implemented. At the present time, it is required to advance in their integration and the control of functioning together in a micro-grid.

Nowadays exists different groups focused on the different components of the micogrid (biomass plant, solar power plant, etc.) and it is necessary to develep the grid for integration all of them.

Dissemination – Exploitation of results (about ½ page)

Through this research the development of a micro-grid control system will be obtained with the control objectives of improving energy efficiency and mechanisms to participate in programs of demand response.

Plan for *dissemination and exploitation* of project results, wich will be assessed in the evaluation on the proposal and on project monitoring:

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Time schedule

Two month. Starting date: 10-12-2012.

It is important to indicate that the project focuses on the definition of the interconnection network and the control of the components of the micro-grid. The **components** of the micro-grid (biomass plant, solar power plant, hidrogen fuel cell, etc.) **are available** in the research working groups of the same **Institute** on which this project is going to be developed (IIE). At the present time, it is required to advance in their integration and the control of functioning together in a micro-grid.

The tasks to be developed for the project are:

Task 1

Definitioin of the microgrid for the implementation of control. Completing the conceptual design of the system. In this tasks the choice of equipment to be controlled is included. Choice of control systems for each of them. Purchase necessary control equipments and server that will serve as the control center for the management of the micro-grid.

Task 2

Definition of control algorithms for efficient management of the micro-grid. Definition of control algorithms to operate as a mechanism for a demand response. Development of software for system operation. Verification of the system viability by means of specific tests:

- Measure the power consumed in different distributed apparatus.This measurement is made with a power recorder connected directly to the PLC power.
- Interaction with the installations, by means of disconnecting a load across the outputs of PLC and the use of contactors.

Task 3

Definition of the proposed control system. Implementation of the control algorithms designed.

Task 4

Definition of the operational testing. Proposal for improvements. Feedback in the proposed control techniques. Improvement of the development implemented.

Task cronology:

- Task 1 and Task 2 will be carried out during the first month.
- Task 3 and Task 4 will be performed during the second month.

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Description of the proposing team

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