TEMPLATE FOR PROPOSAL UNDER DERRI

User-Project Proposal:

User-Project Acronym	DGIV
User-Project Title	Distributed Generation Integration and Validation
Main-scientific field	Distributed generation penetration
Specific-Discipline	Network behavior under large DER penetration

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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)

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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)

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Activity type and legal status* of Organization	CENER, National Renewable Energies Center of Spain (3)
Position in Organization	Distributed Generation Area Responsible

Date of submission	30/03/2013
Re-submission	YES_______ NO_____
Proposed Host TA Facility	ICCS-NTUA, CRES , USTRAT, Fraunhofer IWES, RSE
Starting date (proposed)	01/05/2013

Summary of proposed research (about ½ page)

Prepare a ½ page summary describing the relevance and the scope of the proposed work, and the expected outcome(s)

The current recommended research is a prolongation of the DEIAgrid project with ID 20120630-06 and will be in partial fulfillment of the requirements for a Doctoral Thesis under the title: *The potential integration of distributed generation in a low voltage autonomous power system*.

In the abovementioned project, its purpose was to investigate the effects of Static Synchronous Compensator (STATCOM) on voltage stability of a low voltage (LV) distribution system. Generally, the STATCOM is a shunt device that regulates the system voltage and mitigates voltage sags by absorbing or generating reactive power.

Thus, it was simulated an Average Model of STATCOM that the IGBT Voltage-Source Converters are represented by equivalent controlled voltage sources generating the AC voltage into the low voltage network grid with PWM switching frequencies being neglected. Moreover, the integration and control of energy storage system (ESS) such as a Supercapacitor was investigated throughout that work. The STATCOM DC nominal bus voltage was at 400 V. In more details, a Supercapacitor rated at 400 V with a capacity of 0.5 F and equivalent series resistance (ESR) of 0.1 Ohms was simulated to match the DC voltage requirement and aided to enhance distribution system reliability by maintaining the STATCOM DC voltage constant under different load demand profiles. In continuation, there were executed power hardware-in-the-loop experiments (PHIL) utilizing a resistive and reactive load of 78 and 32.36 Ohms respectively as hardware under test (HuT).

The present proposal is an expansion of the previous one with step forward objectives since PHIL topology is very flexible on the software side (i.e. RTDS) and various hardware-in-the-loop tests can be performed as outlined beneath: 1) to emulate the behaviour of single or multiple connected generators to LV grids, i.e. a diesel generator that is naturally working with droop control to be connected to network with feeders and various load profiles, 2) to investigate on the integration of different energy systems such as fuel cells and batteries into the distribution network, 3) execute simulations on PQ power control with various types of loads penetrated into a well-defined LV network system. As far as the hardware equipment is concerned, it could be utilised as HuT a PV inverter, controllable loads (Labview or PLC based), a wind

turbine or battery inverter in connected mode.

Nevertheless, not only PHIL simulations but also tests that should verify an AC micro-grid setup could be executed, like focusing on the connection of PVs and the way their inverter react to grid frequency oscillations. Additionally, the validation of the real equipment of energy storage devices such as supercapacitors, batteries and/or fuel cell during their charging and discharging cycles would be interesting to carry out.

Thereafter, suggestions will be outlined that provide a means for determining different potential schemes and capacity scenarios in order to meet the targets of EU energy policy, in terms of reliability, availability and power security. Subjects like voltage and frequency stability of the network nodes will be analyzed. The viability and contribution of the above scenarios to the electricity energy mix will be determined. In this way, it is possible to define the requirements needed to promote the alternative applications of dispersed generation in order to be compared to the conventional one, as well as to foresee the integration of renewable energies and energy storage systems into the grid, energy demand increase and the achieving of Kyoto protocol commitments.

The extention in mind after the completion of this project will be to demonstrate a distributed generation pack (DGP) like a micro-grid infrastruture with conventional generators or renewable energy based technologies, FACT devices and energy storage devices that can be integrated into the low-voltage networks.

Consequently, the main objective will be to develop a ´´energy map´´ by sizing and allocating the distributed generation. The estimation of the distributed penetration figure into the network requires the accomplishment of steady state and dynamic analysis configurations in order to check the dynamic behavior and fault ride through capability of the system under normal operation and against several disturbances in the grid. PSS/E is the simulation tool that will be used to execute this work. The main issues being addressed will be the total system losses, fault level at the addition and nearby buses, whereas among the most critical perturbations that mainly rise high of interest is a three phase fault application at the connection points of embedded generation.

Moreover, a micro-grid infrastructure entity with all its power generator systems, energy storage elements and STATCOM devices its will be simulated in the PSS/E software tool as an isolated entity and connected to the main grid. Besides, storage batteries, ultra capacitors, flywheels, constitute backup energy storage devices that must be included in micro-grids to ensure uninterrupted power supply. They should be connected to the DC bus of the micro-grid and provided with ride-through capabilities during system changes. The ´´smart´´ coexistence of central and decentralized generation with low carbon generation profile and efficient demand response need also to be verified under realistic conditions. Therefore, a hardware-in-the loop structure is the best service tool to examine the generation plants integration and interconnection of micro-grids infrastructures focusing on control centers, power and communication interfaces.

State-of-the-Art (about 1 ½ page)

Describe in brief (in about 1½ pages) the current knowledge on the subject, citing recent relevant references. Identify any knowledge gaps and their relevance.

In a conventional large electric power system, the central generators feed the interconnected transmission system through their step-up transformers and the power being extracted from this high voltage network passes through a series of bulk supply transformers to the distribution network to ultimately reach the clients´ demand.

Over the last decade there has been an increasing interest in the generation connection to the distribution network, the so-called embedded or dispersed generation. Both names are synonymous and are used to represent small-scale electricity generation **(1), (2)**.

There is no any universally approved definition of what constitutes the embedded generation and the way it differs from central or conventional generation. Among the working groups that tried to award some common attributes are CIGRE **(3)** (The International Conference on Large High Voltage Electric Systems), CIRED (The International Conference on Electricity Distribution Networks), the IEEE and IEA **(4)**. The first two defined distributed generation (DG) as the generation of units, normally connected to the distribution voltage level, with a maximum capacity of 50-100 MW and that are neither centrally planned nor dispatched **(3)**. Moreover, the IEEE considers DG as the generation from facilities enough smaller than the central power plants, thus the interconnection at any point near the power system is feasible. On the other hand, IEA does not take into account the power capacity level but considers that DG supplies power directly to the customer´s site. In general speaking, all the reviews seem to converge at least to the small-scale generation statement and the most preferable specification concerns that distributed energy resources (DERs) are ordinarily applied to the distribution system voltages of 230/415 V up to 145 kV **(5)**.

But which are the technical considerations for the connection of dispersed technology? The question of power quality and DG is not outspoken. On the one hand dispersed generation unit can positively affect the power quality. However, a contrary effect could be noted. The DG units may influence the system frequency, while regularly are not equipped with a load-frequency control, they will hamper on the efforts of the transmission grid operator or the regulatory body to sustain system frequency **(6).** In addition, embedded generation can prove to have a healing effect on the voltage profile, especially on rather low voltage levels **(7).** On the other hand, sudden and extreme increases of voltage figures in radial networks constitute a major connection issue of the distributed generation. Besides, voltage fluctuations result from bi-directional power flows and complex reactive power management. Variations in voltage level can generally be divided into slow and rapid changes-flicker **(7), (8).** The former results from power deviations e.g. in case of wind turbines because of variations in wind speed, and the latter occurs due to start/stop activity of a device.

Moreover, distributed generators have regularly difficulties in predicting their power output, especially when we are talking about heat driven electrical energy production or renewable energies. In case they are unable to meet the power portfolio, balance-power injections to be roughly equal to withdrawals, they are penalized **(5).**

One more difficulty could be detected on the fact that bi-directional flows require for diverge protection schemes at both voltage levels, as increased share of distributed generation may introduce power flows from the low voltage into the medium-voltage grid. Furthermore **(1)**, when some market participants may want to change to ''remote'' mode, they should fulfill the characteristics for such operation mode and in case they want to be reconnected, the dispersed units need to be capable to synchronize again.

In this context, testing the distributed generation penetration in accordance with distinct voltage connection level-low or medium voltage, real time simulations need to be formulated for the better validation of the equipment. Real –time digital simulators assist with feasibility studies, design new strategies and test controllers for a great deal of applications such as converters, power grid distributed energy sources, energy storage systems, FACT devices etc.

What is worthy to mention is that the majority of embedded plants occupy rotating machines, with induction and synchronous generators increasing the fault level of the distribution system. One way to limit this effect could be the appearance of impedance as induced by a transformer or a reactor but at the expense of higher losses and bigger voltage variations at the generator side **(9).**

With the integration of dispersed generation in the grid is necessary to estimate the expected disturbances beginning with those in the point of common coupling (PCC) due to a particular DG installation. Dedicated interconnection lines are part of the grid, thus disturbance limits can be also applied in the CP point with more lenient attribute than for the PCC **(8), (9).** Specifically, these limits are defined in order to ensure that the resulted faults will not affect other users of the network. The majority of reports comply with the IEC 61000 standards, that planning levels are utilized as disturbance limits **(10), (11).**

Harmonic distortion is a product of power electronics use in variable speed wind turbines, photovoltaic panels, micro turbines, etc. A group of different IEC standards is applied to identify the acceptable disturbance limits with IEC 61000-2-2 and IEC 61000-3-6 being the most prevalent **(8), (11).**

Apart from the power quality issues, additional considerations involve steady state thermal obligations, network congestion and short circuit capacity. Over currents and overloads may incur with the penetration of high amount of DG not only at the connection point but also and in the area around it **(12).** Moreover, the outputs of grid components need to be capable to deal with the power of the dispersed unit.

Attention should also be paid to avoid exceeding the fault level of the network, because embedded generation induce and arise the fault currents and fault power in the grid **(7).**

Ultimately, distribution generation units need to comply with ancillary service issues that involve reactive power compensation and voltage control. Voltage and reactive power are linked to a chicken-and-egg situation: Reactive power intake induces voltage dips in the system with generating plants or capacitor banks take part in this compensation. Voltage Source Converters, such as a STATCOM regulate the voltage in a power system by compensating the reactive power. In this way, the system's load ability is increased **(13)**. In addition, storage batteries, ultra capacitors, flywheels, constitute backup energy storage devices that must be included in micro-grids to ensure uninterrupted power supply. They should be connected to the DC bus of the micro-grid and provided with ride-through capabilities during system changes**.**

References

List relevant References

1) Jenkins N., Allan R., Crossley P., Kirschen D. and Strbac G.: ´´Embedded generation´´. Power and Energy Series 31, IEE, 2000.

2) Chowdhury S., Chowdhury S.P. and Crossley P.: ´´Microgrids and Active Distribution Networks´´, Renewable Energy Series 6, IET, 2009.

3) CIRED, "Dispersed generation, Preliminary report of CIRED working group WG04", June, 1999.

4) IEA 2002, *Distributed Generation in Liberalised Electricity Markets*, http://www.iea.org/textbase/nppdf/free/2000/distributed2002.pdf Date accessed: 19/01/2006.

5) Purchala, Belmas R., KULeuven, et.al, Imperial Cpllege London. ´´Distributed generation and the grid integration issues´´.

6) Dondi, P., Bayoumi, D., Haederli, C., Julian, D., Suter, M., 2002. Network integration of distributed power generation. Journal of Power Sources 106, 1–9.

7) Papathanassiou S. and Hatziargyriou N., ´´Technical requirements for the connection of dispersed generation to the grid´´. Electric Power Systems Research 77 (2007) 24-34. Available at www.sciencedirect.com

8) Th. Boutsika, S. Papathanassiou, N. Drossos, Calculation of the fault level contribution of distributed generation according to IEC Standard 60909, in: Proceedings of CIGRE Symposium Power Systems with Dispersed Generation, Athens. April 2005.

9) R.B. Alderfer, M.M. Eldridge, T.J. Starrs, "Making Connections: Case Studies of Interconnection Barriers and their Impact on Distributed Power Projects". NREL Report SR-200-28053, July 2000.

10) Marko Stefan and Darul´a Ivan: ´´Large scale integration of renewable electricity production into the grids´´. Journal of Electrical Engineering, Vol. 58, NO. 1, 2007, 58-60.

11) Ropenus, S.; Skytte, K., ´´Regulatory review and barriers for the electricity supply system for distributed generation in EU-15, ´´ Future Power Systems, 2005 International Conference on vol., no. pp. 6 pp.-, 16-18 Nov. 2005.

12) European Norm EN 50160, "Voltage characteristics of electricity supplied by public distribution systems". CENELEC, 1999.

13) Zhengping Xi and et.al.: ''Improving Distribution System Performance with Integrated STATCOM and Supercapacitor Energy Storage System''. Proceedings of the IEEE, vol.76, pp.1390-1395, 2008.

Detailed Description of proposed project : Objectives – Expected Outcome – Fundamental Scientific and Technical value and interest (2-3 pages)

Provide a detailed description of the objectives of the proposed activity, the way these objectives will be fulfilled through the proposed work, as well as indications on the expected outcome and the fundamental scientific and technical value and interest of the proposal. Specify the type of TA infrastructure (distributed generation simulator; domotic house; etc.) and the test setup. With the understanding that these aspects will be discussed with the TA infrastructure after approval of the proposal and specified in the Agreement to be signed between the TA infrastructure and the User team, indicate the number of tests to be carried out and their sequence, the response quantities to be measured through the instrumentation, etc. Describe any special requirements for equipment, standards, safety measures, etc. Point out any shortcomings, uncertainties and risks for the fulfillment of the project objectives, as well as the means to mitigate relevant risks.

First objective of the project will be to examine grid integration and micro-grid interactions over hardware –in-the-loop simulations that may test energy units such as: distributed generators, energy storage systems and converters like PV converters with regard to their maximum power point (MPP) tracking behavior. For instance PV connection on one phase and a variable load on another phase in a rural distribution network could be the simulation set up. In that case, an irradiation sensor will provide the power input to the simulated PVs in order to reach realistic conditions. Steady state and dynamic simulations, such as solar irradiation drop or short circuit faults may be performed.

Secondly, tests can be conducted goaling to analyzing the energy transfer in an islanded AC microgrid with different distributed generators, such as the PV panels simulated as current sources. The experiments that concern the above expected outcomes could be the measurement of the micro-grid battery inverter's droop curves, checking the battery inverter's active power droop control by changing the frequency droop curve and finally testing the PV inverter how it reacts with grid frequency variation. However, the above mentioned experiments need to be decided in agreement with the host facility.

Consequently, the equipment behavior will be validated against voltage and frequency stability, dynamic voltage support and control centers behavior. In this display, compatibility and suitability tests of power systems will be performed as well as real-time visualization will be managed via control simulation interfaces in the host infrastructure. Additionally, at the end it will be viable the implemetation and development of a methodology that characterizes the energy supply devices and system analysis for decentralised grid services.

On the other hand, the primary objective of my Doctoral thesis fulfillment will be to investigate the basic issues of distributed generation penetration either in interconnected low voltage grids or in island grid modes and the current research proposal will constitute part of this thesis while goals to evaluate and verify a micro-grid or a local grid configuration.

Since the major work of the Doctoral thesis will be focused to investigate dispersed generation integration into the electrical grids, it is necessary analyzing the grid in an integrated environment that will be reinforced via PSS/E software tool in CENER premises. The analysis of the grid will be accomplished via steady state and dynamic simulations in PSS/E software that will incorporate the variable potential scenarios. In more details, the spesific objectives for this part of research investigation will be the following: 1) confirm that the proposed schemes of penetration comply with the grid requirements and identify the influences of dispersed introduction on the distribution system, 2) apply recommendations concerning improvements for the existing grid and possible solutions to advance the penetration level, 3) point out different aspects on distributed generation integration according to the network, operation and control among countries, 4) implement a static analysis of the distribution grid, involving power flow study, short circuit and contingencies analysis, 5) ensure N-1 security constraints and examine if the system can withstand a generator or line outage, 6) implement a dynamic analysis in order to check the transient and long term stability of the system under time domain and finally, 7) analyze whether and to what extent the accommodation of the new distributed units affect the power quality and reliability of the network.

Conclusively, the upper goal of the given research proposal will be to compare the resulting PSS/E simulations of the outlined objectives above with the real network simulations developed on hardware-in – loop (hil) environment and/or with the outcomes of the written above executed experiments that shall verify and validate the distributed generation technologies and energy storage systems.

The expected conclusions drawn through the micro-grid tests and PSS/E simulations could be the comparison of dynamic performance among different energy sources and choose which best fits in our grid studies. Finally, since test series will follow specific current standards and application requisites, the results could to a greater extent grow the grid connection guidelines.

Originality and Innovation of proposed research – Broader Impact (1-2 pages)

Demonstrate the originality and innovation of the proposed work and the impact the expected results will have on current and future research or practice, public safety, European standardization, competitiveness, integration and cohesion and on sustainable growth.

Worldwide demand for energy is growing at an alarming rate. An average growth rate of 1.8% per year for the period 2000-2030 for primary energy worldwide is predicted. The continuous growth in this load demand has led to the depletion of fossil fuel reserve. Therefore, governments have switched their interest to more efficient and cost effective energy solutions, such as the renewable energy sources **.**Global warming and environmental policies are the driving force to look for cleaner energy solutions. According to the Kyoto protocol EU, UK and many other countries have adopted new strategies in order to reduce greenhouse emissions.

It is expected that embedded generation will support this scheme by producing cleaner and more efficient energy. Besides, distributed generation has gained a significant interest the last decade. The factors that have contributed to this are numbered as the following: new acquirements regarding the distributed energy resources technologies, limitations on the transmission lines, increased demand, the electricity market liberalization and major concerns about the climate change. Dispersed technology can offer flexibility in reliability necessities. A variety of industries, such as chemical, petroleum, metal etc. may criticize the grid supplied electricity too low and may want to invest in distributed generation to enhance this level of reliability. For instance, fuel cells and backup systems could possibly supply with protection against power interruptions. One of the most vital examples is the CHP (combined heat and power) plants which utilize the waste heat for industrial, commercial or domestic applications. Additionally, they are located close to the heat loads to minimize the transport losses and thus the capital investment. The introduction of these kinds of systems allows a better management of the resources, the electricity and an optimum planning of the power generation system favouring the reduction or even elimination of inefficient and expensive plants.

Nevertheless and in spite of the governmental support, there are no specific studies about the potential of dispersed technology penetration and the similtaneous real time distribution grid simulations in low voltage power systems as a whole and therefore, the incentives and proposals are more qualitative than quantitative.

Active electrical distribution power systems require steady state and disturbances assessment studies like power quality, system reliability, ride-fault through capability, contribution to the ancillary services etc. The ancillary services concerning voltage and frequency regulation, supply reserves, load following are becoming critical for the secure and reliable operation of the power systems.

The core of such active networks is depicted by the power converters and with serious impacts on the power quality parameters. In the current project the upper goal is to propose the potential and suitable areas for integration of distributed electrical generation in active distribution networks, able to function in either connected or isolated mode and research their control performance and the interaction of the devices connected to these grids. We will analyse the power system by performing static and dynamic studies for present and future configurations. This will not only allow us to size and locate the distributed generation systems, but also will let us optimize the low voltage network, and likely introduce energy storage.

Moreover, the transition to active power systems requires dynamic and flexible tools for simulation and testing. Real time distribution grid simulations and especially PHIL modeling will permit us test and validate the electrical properties of system devices such as converters, wind energy generators, hybrid and energy storage systems. This kind of testing gives the opportunity to analyze the behavior of the hardware equipment in real time as the current and voltage measurement signals of the generation unit are fed back. The extension in mind will be to develop the equipment (technology) and methodology to manage a micro-grid or generally a low voltage distribution system into the laboratory under specific boundaries and examine their impact on the general electrical grid, as well as the necessary operation procedures for right intercommunication between both systems.

We will also analyse the technical constraints that influence in the feasibility of the different integration schemes determining the barriers and circumstances to favour the feasibility of some applications and in which degree and also the share of distributed generation in the total fleet.

Following this manner, the proper authorities could promote new policies to support and favor the special regime market, by proposing objectives more ambitious.

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

Specify the type of TA infrastructure (e.g. distributed generation simulator; domotic house; etc.) and if possible which one of the 13 TA Infrastructures in DERri may better serve the scope of the proposed research. Justifications should be provided on the grounds of the test set-up, testing method, equipment, past experience in relevant subject, etc. State whether the TA User team intends to deliver to the premises of the TA Infrastructure parts or components to be tested at the TA User's expense and responsibility, or to cover the whole or part of the construction/adaptation cost of the specimens to be tested.

Since the current proposal is a prolongation of the DEIAgrid project that was implemented in the ICCS-NTUA Energy Systems Laboratory, this TA infrastructure will favorably serve better the scope of this research work and can host the proposed investigation for real time simulations and experimental testing for grid integration studies.

Dispersed energy technologies and the electrical generation status are continuously modifying, which imposes new challenges in terms of intelligent communication technologies, voltage and power quality in transmission and distribution networks. According to this grown awareness and increased technical know-how, laboratories are more equipped and switch their research interest towards this investigation field.

ICCS-NTUA offers a great deal of research lines from test and evaluation methods for wind turbines and components to control, energy management, grid operation and integration of decentralized energy converters and storage systems. A main component of the Energy Systems Laboratory is a micro-grid installation that comprises of two PV generators, a small Wind Turbine, battery energy storage, controllable loads and a controlled interconnection to the local LV grid. The battery unit, the PV generators and the Wind Turbine are connected to the AC grid via fast-acting DC/AC power converters. The converters are suitably controlled to permit the operation of the system either interconnected to the LV network (grid-tied), or in stand-alone (island) mode, with a seamless transfer from the one mode to the other, e.g. at 10 kV which is a distribution voltage value for the island grid being investigated in my Doctoral Thesis.

Moreover, a PHIL simulation focusing on DER devices and micro-grids is developed in NTUA. The Real Time Digital Simulator RTDS used contains several processing cards that work in parallel as well as various analog and digital inputs and outputs. Dedicated software is utilized to design the electric circuit, control parameters in real time, monitor simulation variables etc.

Synergy with ongoing research (about ½ page)

Provide information on any concurrent research project with the same or similar subject with the one proposed. Describe the synergy (if any) that will be sought between the existing and the proposed project.

The proposed research not only will be an extension of the DEIAgrid project within the DERri Transnational Access supported by the 7th Framework programme of the European Commission but also will be of partial fulfillment of my Doctoral Thesis regarding the potential distributed generation penetration into low voltage power grids and the interaction of micro-grid installation onto the central networks. The system behavior will be examined with embedded generation introduction in terms of power quality, voltage and frequency stability whereas the system equipment will be validated with real time distribution network simulation in medium and low voltage power networks.

Many projects study wind energy penetration and the impacts of distributed generation into electrical grids whereas others deal with the validation of wind and photovoltaic converters within micro-grid or centralized installations.

However, this research study aims to achieve both investigation approaches.

Dissemination – Exploitation of results (about ½ page)

Describe the means through which the results to be obtained from the proposed project will be diffused and made broadly known.

The transfer of the acquired knowledge will be done in the present and future time frame under different capacity scenarios for potential penetration and validation of the system equipment. The companies and sectors which could be beneficiary of the results belong to the energy sectors, and it will be useful to define market plans and strategies. Also this project could favour the definition of R&D and environmental policies by governmental organizations.

DIFFUSION PLAN

Related to the dissemination of results, we foresee the following scenarios:

1. Technical workshops. The results shall be presented in technical workshops related to distributed generation, micro-grids, PSS/E and harware-in –the- loop applications.
2. Direct Contact with companies and institutions to transfer the information to industrial sector and governmental organizations. The contacts of CENER with many private companies as well as administrative organisations ensure the results transfer trough seminars and infodays.
3. Full papers in technical journals. Our purpose is publishing articles in international journals and others in national conferences or energy journals.
4. Congress and conferences participation.

Time schedule (about ½ page)

Provide an indicative time-schedule for the proposed work and a target starting date.

Tasks Proposed starting date: **01/05/2013**	1st Week	2nd Week	3rd Week	4th Week
Model setting & familiarity	**|X|X|X|X|X|**			
Test grid interface & integration of system equipment		**|X|X|X|X|X|**	**|X|X|X|X|X|**	**|X|X|X|X|X|**
Model validation & analyze results				**|X|X|X|X|X|**
Report documentation			**|X|X|X|X|X|**	**|X|X|X|X|X|**

Description of the proposing team (as long as needed)

Give a short description of each member (organization and persons) of the proposing team including publications, experience in test campaigns and role in the proposed project.

Mónica Aguado Alonso, Phd. in Electrical Engineer, Public University of Navarre (UPNA), Spain, 2000. Qualification: Apto "Cum Laude".

She received the first Grant Foundation Fuentes Dutor (Industrial Engineers Professional Association), "Analysis lightning discharge risk in Navarra", 1999-2000 and the Second Grant Foundation Fuentes Dutor, (Industrial Engineers Professional Association), Overvoltage analysis due to lightning discharges in low, medium voltage installations and wind mills", 2000-2001

She has more than sixteen years of research experience developed in electric power systems area as associate professor of the electrical engineering department of UPNA since 1996 to date.

In 2003 she was engaged by CENER (National Renewable Energy Centre) to develop the Renewable Energies Grid Integration Department. She has working experience in the field of energy grid integration and renewable energies, wind and photovoltaic energy, energy storage systems (hydrogen production from renewable energies and application as energy carrier in Fuel Cells, electrochemical systems as flow and advanced batteries, electric vehicles, etc.).

She participates in international organizations as member and expert evaluator for the European Commission (6FP and 7FP) and national organisms since 2004 and as reviewer of technical papers for international conferences and journals.

Actually is the Director of the Energy Storage Area at the Renewable Energies Grid Integration Department - CENER (Spanish National Renewable Energy Centre) and associate Professor in the Electrical Engineering Department of Public University of Navarre

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She has participated in several projects. Some of them are the following: “**Zinc-Bromine Flow Batteries. Technology and Value Chain**”. CENER for S2M; “**Conceptual engineering of a zinc-bromine flow battery of 1 kW power**”. CENER for S2M; “**Design, development and implementation of micro grid in Navarre”.** CENER for Navarra Government; “**Prospects for integration of Hydrogen, Energy Storage Systems and Electric Vehicles in the Spanish Energy Sector**”. CENER; “**Study and Characterization of the Wind Power-Hydrogen Plant in Sotavento**”. CENER and Gas Natural-Unión Fenosa; Cenit “**Solutions for the Production of Hydrogen as Energy Carrier and Reconversion Systems Associated** (**SPHERA**)”. CENER for Acciona Energía S.A; Cenit “**Off-shore Wind Farms Technologies** (**EOLIA**). CENER for Acciona Energía S.A; “**REVE Project**. Wind Power Management with Electric Vehicles”. CENER for AEE (Asociación Empresarios Eólicos); “**Energy Storage Systems. Technology and Market**”. CENER for Grupo Ormazabal; Consejería de vivienda y ordenación del territorio, Junta de Andalucía, “**Definition and analysis of a residential building with hydrogen integration**”; Cooperation Navarre-Aquitaine, “**Hydrostock**”; “**Energy systems for microgrids**”. Collaboration CENER-NAREC (UK); “**Hydrogen Generation with Wind Power**”. CENER for Enhol.; **Obtaining ENAC Accreditation for voltage dips simulations**”. CENER; “**Obtaining ENAC Accreditation for voltage dips field test**”. CENER; “**Efficiency analysis of industrial areas**”. CENER for Navarre Government; Scientific research and Technological Development project: “**Conversion of WindFact model developed in Matlab/Simulink to PSCAD software**”. CENER for confidential enterprise; “**Development of validation procedure of simulation models for WindFact**”. CENER for confidential enterprise; “**Analysis of the necessary characteristics of the electrical grid for the wind energy penetration in Dominican Republic**”. CENER for DominicanRepublic Government; European Project VI Frame Programme, “**Grid Architecture for Wind Power Production with Energy Storage through Load Shifting in Refrigerated Warehouses-NightWind**”. CENER; Intelligent Energy – Europe (IEE)-ALTENER 2004, ”**Regional Markets of RES-Fuel Cell Systems for Households-RES-FC Market**”. CENER; “**State of art of distributed generation**”. CENER for Navarre Government

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Her main responsibilities were: Evaluation of concentration rates of pollutants and comparison of concentrations with meteorological parameters and file organization in electronic form of environmental data relating to the quality of ambient air.
During her postgraduate studies she participated in several projects related to Power Systems Engineering, Wind Energy, Marine Energy, and Solar Energy and on Technologies for Sustainable Energy.

From 2/2010 until 09/2010 was employed by ***Electeco Energy Management S.A.*** as an Energy Consultant. Her main duties were focused on: 1) Completion of environmental research, 2) Assessment of energy consumption and efficiency of building constructions, 3) Ability to carry out energy surveys, 4) Contact with companies and industrial companies for proposals and recommendations for energy savings, 5) Preparation of economic and technical study for the establishment of autonomous or connected photovoltaic system, and 6) Understanding of lighting operation and system design

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