DERri
Distributed Energy Resources
Research Infrastructures

ANNEX 2: TEMPLATE FOR PROPOSAL UNDER DERRI

User-Project Proposal:

Use-Project Acronym	PV POWER
User-Project Title	Photovoltaics interaction with the grid and accurate MPPT tracking
Main-scientific field	Sustainable Dispersed Energy
Specific-Discipline	Power Quality

Lead User of the Proposing Team:

Name	Iakovakis Dimitris
Phone	00306937203762
E-mail	dimitris.iakovakis@yahoo.com
Nationality	Greek
Organization name, web site and address	Apollo Capital / Energy Bank
Activity type and legal status* of Organization	3
Position in Organization	Electrical Engineer

* 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	Kapetanaki Alexandra/ Angeliki Antonopoulou
Phone	+306970941800 /+306978657922
E-mail	akapetan@power.ece.ntua.gr / angelikiantonopoulou@gmail.com
Nationality	Greek / Greek
Organization name, web site and address	NTUA / Apollo Capital Group, www.apollocapitalgroup.com, G. Papandreou 106B, Zografou 15773
Activity type and legal status* of Organization	1 / 3
Position in Organization	Electrical Engineer Scientific Collaborator / Electrical Engineer

* 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	28/02/2012
Re-submission	YES_____ NO____√___
Proposed Host TA Facility	AIT - Austrian Institute of Technology
Starting date (proposed)	14th of March

DERri
Distributed Energy Resources
Research Infrastructures

Summary of proposed research

Our team consists of three members. Two of us have been working in the research and development department of "Bank of Energy", which is a subsidiary company of Apollo Capital Group; and the third is a research collaborator from the National Technical University of Athens.

Apollo Capital Group has acquired land plots in thousands of acres, at strategic locations with the highest solar radiation throughout our country, aiming to make a difference in the field of renewable energy sources and energy transformation that can help bring the world to lower carbon emissions and create a sustainable economy.

Photovoltaic units, solar-thermal and biomass power plants constitute our company's most ambitious project. Constructions and installations of photovoltaic units will begin this spring and thus, we are interested in widening our knowledge in their operation. We are focusing on their interaction with the grid and mostly, on the transient phenomena that occur during shortcuts and after sudden radiance fluctuations.

We are really glad that Der-ri project, through the access to specialized facilities, gives us the opportunity to not only study but also experience the operation of photovoltaic systems.

State-of-the-Art

- P. McNutt, J. Hambrick, M. Keesee, and D. Brown, Impact of SolarSmart Subdivisions on SMUD's Distribution System NREL/TP-550-46093, 2009.
- S. Cobben, B. Gaiddon, andH. Laukamp,WP4-Deliverable 4.3-Impact of Photovoltaic Generation on Power Quality in Urban Areas With High PV Population EIE/05/171/SI2.420208, 2008.
- Y. Ueda, K. Kurokawa, T. Tanabe, K. Kitamura, and H. Sugihara, "Analysis results of output power loss due to the grid voltage rise in grid-connected photovoltaic power generation systems," IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2744-2751, Jul. 2008.
- R. Tonkoski and L. A. C. Lopes, "Voltage regulation in radial distribution feeders with high penetration of photovoltaic," in IEEE Energy 2030 Conf. 2008, Atlanta, GA, 2008, pp. 1-7. K. De Brabandere, A.Woyte, R. Belmans, and J. Nijs, "Prevention of Inverter Voltage Tripping in High Density PV Grids," presented at the 19th EU-PVSEC, Paris, 2004.

- C. L.Masters, "Voltage rise: The big issue when connecting embedded generation to long 11 Kv overhead lines," Power Eng. J., vol. 16, pp. 5-12, 2002.

- D. N. Gaonkar, P. C. Rao, and R. N. Patel, "Hybrid method for voltage regulation of distribution system with maximum utilization of connected distributed generation source," in Proc. IEEE Power India Conf., 2006, p. 5.

- H. Rafa, O. Anaya-Lara, and J. R.McDonald, "Power factor control for inverter-interfaced microgeneration," in Proc. 43rd Int. Universities Power Engineering Conf., 2008 (UPEC 2008), 2008, pp. 1-5.

- J. C. Vasquez, R. A. Mastromauro, J. M. Guerrero, and M. Liserre, "Voltage support provided by a droop-controlled multifunctional inverter," IEEE Trans. Ind. Electron., vol. 56, no. 11, pp. 4510-4519, Nov. 2009.

- M. H. J. Bollen and A. Sannino, "Voltage control with inverter-based distributed generation," IEEE Trans. Power Delivery, vol. 20, no. 1, pp. 519-520, Jan. 2005.

- P. M. S. Carvalho, P. F. Correia, and L. A. F. Ferreira, "Distributed reactive power generation control for voltage rise mitigation in distribution networks," IEEE Trans. Power Syst., vol. 23, no. 2, pp. 766-772, May 2008.

- S. Toma, T. Senjyu, Y. Miyazato, A. Yona, T. Funabashi, A. Y. Saber, and K. Chul-Hwan, "Optimal coordinated voltage control in distribution system," in Proc. Power and Energy Society General Meeting-Conversion and Delivery of Electrical Energy in the 21st Century, 2008 IEEE, 2008, pp. 1-7.

- M. R. Salem, L. A. Talat, and H. M. Soliman, "Voltage control by tapchanging transformers for a radial distribution network," in Proc. Inst. Elect. Eng., Generation Transmission and Distribution, 1997, vol. 144, pp. 517-520.

- Y. Ueda, K. Kurokawa, T. Itou, K. Kitamura, K. Akanuma, M. Yokota, H. Sugihara, and A. Morimoto, "Advanced analysis of grid-connected PV system's performance and effect of batteries," Elect. Eng. Japan, vol. 164, pp. 247-258, 2008.

- Kulmala, K. Maki, S. Repo, and P. Jarventausta, "Including active voltage level management in planning of distribution networks with distributed generation," in Proc. 2009 IEEE PowerTech, Bucharest, 2009, pp. 1-6.

- W. Pruggler, F. Kupzog, B. Bletterie, and B. Helfried, "Active grid integration of

distributed generation utilizing existing infrastructuremore efficiently-An Austrian case study," in Proc. 5th Int.Conf. Eur. Electricity Market (EEM 2008), 2008, pp. 1-6.

- Interconnecting Inverter-based Micro-distributed Resources to Distribution Systems, C22.2 No. 257-06, CSA, 2006.

- Preferred Voltage Levels for AC Systems, 0 to 50 000 V, CAN3-C235-83, CSA, R2006.

- E. F. Mogos and X. Guillaud, "A voltage regulation system for distributed generation," in Proc. Power Systems Conf. Exposition, 2004 (IEEE PES), 2004, vol. 2, pp. 787-794.

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

The use of efficient, innovative and cost effective renewable energy systems seem to be a very promising research objective for scientists and especially engineers. Our company is still young in the energy domain and thus, it is essential that its scientific team, of the research and development department, is well trained and knowledgeable in the field.

It will be of great interest extending our knowledge and conducting some experiments in order to specify the interaction of the photovoltaic systems with the grid through the measurements below.

1. Measure transient phenomena after sudden irradiation fluctuations, using a PV simulator. This experiment can be held through a digital scope with high precision-accuracy and fast response. Through this experiment we can measure the steep variations of power and accurate tracking of MPPT.

2. Measure transients during shortcuts. All electrical systems are susceptible to short circuits and the abnormal current levels they create. Therefore, it's important to protect personnel and equipment by defining short-circuit currents during system upgrade and design. So there is a significant need of measuring single line to ground fault (of a single phase short circuit). Therefore, the short circuit analysis is an important limiting case, and is used to compute the coordination of fuses, circuit reclosers, circuit breakers, and other devices designed to recognize and isolate short circuits.

3. Study the ramp rates. This experiment includes set points of the power, which will be provided by the operator of the system and we will measure how fast the system responds to the demands. Thus the time delay is the requested magnitude. Moreover, another interesting subject is power curtailment and how this interacts with the grid. So, tests such as harmonic analysis, transient phenomena during power curtailment would be useful. Generally, each element of the power system must be examined for its sensitivity to harmonics as a basis for recommendations on the allowable levels. Voltage and current harmonics are of great importance because appear many effects within a power system such as:

    a) The possibility of amplification of harmonic levels resulting from series and parallel resonances
    b) A reduction in the efficiency of the generation, transmission and utilization of electric energy
    c) Ageing of the insulation of electrical plant components with consequence shortening of their useful life.
    d) Malfunctioning of the system or plant components.

    Among the possible external effects of harmonics are: a degradation in communication systems performance, excessive audible noise and harmonic – induced voltage and currents.

4. Tests, harmonized with standard EN50530 in order to measure the efficiency of the maximum power point tracking (MPPT) of inverters, which are used in grid connected photovoltaic systems (use of PV simulator). Moreover, tests associated with standard *IEC 61000 3-2 and 3-4 would be of great interest as they* contain limits for harmonic current emissions by equipment with input currents of 16A and below per phase.

5. Finally, we would like to study the methods which control the optimization charging and discharging of storage systems by predicting the solar irradiation and the load.

The points mentioned above, constitute our main focal point. However, since our company is also going to install biomass energy plants, we would be mostly interested in performing experiments and measurements on biomass power plants as well.

We do not know yet if there is any institution, participating in Der-ri project, with such facilities (an installed biomass plant); if there is, we are more than willing to discuss any possibility of conducting a research on its operation, after acceptance of our current application.

To sum up, the required facilities for our experiments should be the following: grid simulator, PV simulator, a power analyzer, a current transducer, an oscilloscope, cables, switchgear and probes.

Originality and Innovation of proposed research – Broader Impact

In our times, energy requirements constitute one of the key points of reference and research within the scientific society. The increasing energy demands, in combination with the reduction of natural recourses of gas and oil and the need to encounter the environmental pollution caused by carbon emissions, urges us to develop and try to maximize our energy efficiency from renewable sources.

Our company is licensed to install 100MW of photovoltaic units, 80MW of Biomass power plants and 5MW (for now) of solar-thermal power plants. A lot of those units are going to be installed in nearby fields and consequently they will be connected to common transmission lines.

Firstly, we have been examining the feasibility and the efficiency increase that could possibly derive from a combined and coordinated operation to a higher level of the power plants mentioned above.

Secondly, we are concerned about the possible effects that increasing energy penetration could have on the grid.

In Greece, so far, we have not been able to study a massive penetration of numerous photovoltaic units to the grid. Most photovoltaic installations are currently dispersed throughout the country. Our company's aim is to encounter any problem arising from our connection to the transmission lines and we also need to have answers and solutions ready for possible obstacles that could come up from our cooperation with the Public Power Corporation.

Proposed Host TA Infrastructure/Installation – Justification

The infrastructure that may better serve the scope of the proposed research is the AIT - Austrian Institute of Technology as it has the capability to actively support our proposed activities.

Moreover, the particular institute provides Qualification testing and conformity assessment of PV inverters and protection devices according to diverse national standards and recommendations and Performance and operational tests of distributed generators under different generation conditions as well.

Synergy with ongoing research

Currently, there is no synergy between our company and any research team we know on the project described above.

However, lately, we have been collaborating with Alexandra Kapetanaki, on theoretical basis, concerning our photovoltaics' and solar-thermal's projects. Alexandra Kapetanaki has gained great experience through her work in the NTUA and thanks to the substantial knowledge she has acquired through her dissertation. Her research concerns the interaction of the disperse generation with the grid, field our company is really interested in. Furthermore, she has not only theoretical but also practical skills which elucidate our R&D department's perspective.

Thus she has been a very useful scientific collaborator of our company, hoping that our cooperation will be extended in the future to her whole scientific team at the lab of the department of electric power in the NTUA.

Dissemination – Exploitation of results

The results of the study that we will perform in the infrastructure will be disseminated on the website and the journal of the Apollo Capital Group, http://www.apollocapitalgroup.com.

Furthermore, we will try to carry out a conference paper describing the experimental procedure, its results and its conclusions and hopefully we could also publish our study in a scientific journal.

Time schedule

An indicative starting date is on the 14th of March and we will need at least 2 weeks to conduct our experiments. The sequence of the experiments will be as it has been aforementioned in the detailed description of the proposed project.

More specifically about time, we could use

- 3-4 days for the first experiment,
- 3-4 days for the second one,
- 3 days for the third one,
- 2 days for the fourth
- 2 days for the last part

Description of the proposing team

Angeliki Antonopoulou:

Working Experience:

Working at the Energy Department of Apollo Capital Group. She is providing Technical support regarding applications that Apollo Capital Group had registered for the construction of Biomass power plants and photovoltaic installations. She is also promoting the approval of the applications to RAE (Regular Author for Energy). Lately, after the licenses were issued, she is also doing market research in order to find the most eligible technology and technical study for the power plants' construction. Apollo Capital Group has recently created a research and development department and Angeliki is a member of the team.

Education:

She studied Electrical and Computer Engineering of the National Technical University of Athens (NTUA). Her thesis focused on designing energy efficient buildings using all latest technologies and involved the development of a software system for this purpose. She graduated in October 2011 with a CGPA (including thesis grade) of 8.0/10.

Academic Honors and awards:

- 2009-2011: Scholarship for studies from Ialemos Kyprianidis' endowment through contest.
- During the 4 out of 6 years in High school I was the first prize person

Languages:

Greek (native), English (fluent), German (very good knowledge)

Iakovakis Dimitris

Education:

National Technical University of Athens, School of Electrical and Computer Engineering (E.C.E.), Department of Energy Engineering. (5-year studies - Masters Equivalent).

Working Experience:

August 2011 - today:

Consultant at the newly created Research and development department of Apollo Capital Group. Dealing with equipment and construction planning of Biomass facilities, Solar-thermal systems and Photovoltaics. Technical supervisor during the constructions of photovoltaics. Providing assistance to the license issuing team.

October 2010 - today:

Working on photovoltaic licenses and their approval by the Public Power Corporation and the Regular Author for Energy for the companies "DTEC Constructions", “Omega” and “Helvendo”.

October 2008 – October 2010:

Full time employment as a technical consultant in the Integrated Technology Services department of IBM. Work experience on Product and Software services of Enterprise Systems, such as storage servers (DS8000, DS6000, ESSS), Tape Libraries and zSeries.

Kapetanaki Alexandra:

Education:

She is Scientific Collaborator in NTUA and she has Diploma in Electrical Engineering and Computer Engineering (5 year cycle). She has specialized in the faculty of Energy of the Department of Electrical Engineering and Computer Engineering in the National Technical University of Athens (NTUA). The subject of her dissertation is associated with sustainable energy and adequate technology with title: “Research, construction and tests under normal circumstances on polycrystalline photovoltaic panel and Maximum Power Point Tracking (MPPT) regulator for connection in a battery system on low cost and adequate technology applications”.

Working Experience:

7/2010-8/2010:

Training practice in Public Power Corporation, department of management of production of Greek islands.

11/2006-5/2007:

Participation in the preparation of electrical-mechanical reports, specifications, plans and assistant supervisor during the construction of the building of Athens Stock Exchange, company Babis Vovos-International Construction (BVIC)

10/2005-1/2006:

Expertise in protection and administration of environmental management within the program of professionalism entitled «Organisation of programs of recycling and alerting the public», Center of professional expertisation «KEK GAIA AMKE»

Seminars:

She has attended a Technical seminar on microgrids products at SMA company and she has also studied electrical-mechanical planning and reports in low-voltage implementation with emphasis on renewable sources of energy at Schneider.

Academic awards:

She has been awarded the "1st Prize Award" for the "Best Power Engineering Diploma Dissertation" from IEEE Greece PES (Power & Energy Society) Chapter in the 13th Powered Conference.

Role at our Der-ri project

She will determine the exact procedure of the study. Her irreplaceable role to our team is due to the fact that she is the most experienced member of the project on both theoretical and practical matters. She will confirm the progress of the experiments and generally enhance our team's interoperability.