DERri
Distributed Energy Resources
Research Infrastructures

ANNEX 2: TEMPLATE FOR PROPOSAL UNDER DERRI

User-Project Proposal:

Use-Project Acronym	EMC-PV-M
User-Project Title	ElectroMagnetic Compatibility of PV inverters and electronic Meters
Main-scientific field	Power Quality and metering
Specific-Discipline	Electromagnetic Compatibility

Lead User of the Proposing Team:

Name	Rogakos Vasilis
Phone	+30 210 3492143
E-mail	v.rogkakos@dei.com.gr
Nationality	Greek
Organization name, web site and address	Public Power Corporation http://www.dei.gr/ecHome.aspx?lang=2 30 Chalkokondili street,10432, Athens, Greece
Activity type and legal status* of Organization	Large private enterprise (5)
Position in Organization	Head of Tele-metering Operation in PPC / Distribution / Network Department

* 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	Panos Kotsampopoulos
Phone	+30 2107721499
E-mail	kotsa@power.ece.ntua.gr
Nationality	Greek
Organization name, web site and address	National Technical University of Athens, www.ntua.gr Heroon Polytechniou 9, 15780 Zografou,Athens, Greece
Activity type and legal status* of Organization	Higher Education Institution (1)
Position in Organization	Phd student

* 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)

Date of submission	2nd March 2012
Re-submission	YES_____ NO_____
Proposed Host TA Facility	Fraunhofer IWES-TA6
Starting date (proposed)	End of March

DERri
Distributed Energy Resources
Research Infrastructures

Summary of proposed research (about ½ page)

Electronic-smart meters are increasingly being installed in European electricity networks. However, due to a gap in standardization of both immunity and emissions (range 2-150kHz), EMC problems have been reported. Specifically, the malfunction of electronic meters when used in combination with PV inverters has been observed in different countries. Therefore, in-order to prevent these problems from enlarging, limits need to be defined on immunity and emissions, as well as laboratory set-ups to perform suitable tests.

PPC and NTUA are working together in this demanding EMC issue. As the DERri consortium includes members with expertise in this topic, the proposed Transnational Access project can significantly aid in providing thorough practical and theoretic understanding, and in the development of an immunity test set-up in Greece. Future cooperation with the host-institute is desired in-order to share experiences in European level and provide input to standardization bodies.

State-of-the-Art (about 1 ½ page)

The European union strongly promotes the use of smart-electronic meters in electricity networks [9]. However, reports on malfunction of electronic meters when connected with PV inverters or other devices have been reported in different European Countries [2], [3]. EN 50470 part 1 and part 3 standard for electricity meters doesn't cover the frequency range of 2-150kHz. In addition emission levels for PV inverters haven't yet been defined in this frequency range, while the switching frequency of PV inverters is commonly within this range. Therefore a gap in standardization exists that can cause increasingly EMC problems and possibly delay the large deployment of electronic-smart meters.

For this reason limits need to be defined for both emission and immunity in this frequency range. European and international standardization bodies [7], [8], [1] and also European smart meter manufacturers [4] are taking into serious consideration this important issue.

In addition, laboratory set-ups that perform these specific tests need to be designed and implemented. Important progress in this direction has been reported in Germany where laboratory tests and limits have been proposed [1], [2].

References

[1] "Leitfaden Zuverlässigkeit Messbeständigkeit von Elektrizitatzahlern und Zusatzeinrichtungen", VDE FNN, November 2011

[2] 24th European Photovoltaic Solar Energy Conference and Exhibition, 21th to 25th September 2009, Hamburg, Germany: "Results of the OPTINOS Project – Deficits and Uncertainties in Photovoltaic Inverter Test Procedures", J. KIRCHHOF, G. KLEIN, Fraunhofer IWES

[3] "Noise" and standards for electricity meters, EN-50470-1 & EN 50470-3, Swedish Board for Accreditation and Conformity Assessment (Swedac), 2010

[4] EMC workshop, ESMIG, Brusssels, April 2011

[5] "Review of the Measuring Instruments Directive 2004/22/EC", EU reactions to PC, 2010

[6] 20th CIRED Conference, Prague, 8 – 11/09: “Measurements of interaction between equipment in the frequency range 9 to 95 kHz”. S. K. RÖNNBERG, M. WAHLBERG, M. H. J. BOLLEN, A. LARSSON, C. M. LUNDMARK
[7] CENELEC SC 205A “Study Report on Electromagnetic Interference between Electrical Equipment / Systems in the Frequency Range below 150 kHz”, SC205A/Sec0260/R, April 2010
[8] IEC Smart Grid Standardization Roadmap, June 2010, p. 102&3
[9] Measuring Instrument Directive (MID) 2004/22/EC, European parliament
[10] EN50470, “Electricity metering equipment (a.c.). General requirements, tests and test conditions. Metering equipment. (class indexes A, B and C)”
[11] IEC 61000-4, “Electromagnetic Compatibility, Testing and Measurement Techniques Package”

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

The malfunction of electronic meters when used in operation with PV inverters has been observed in different countries. In several occasions the energy measurement of the electronic meter proved to be less than the real energy production. This can be a serious problem as in various countries the use of electronic meters and PV inverters is increasing.

PPC and NTUA are working together in-order to thoroughly address this EMC issue. The important experience already gained in European level can significantly assist this research activity. Therefore the proposed Transnational Access project has the following **main objectives**:

1) Gaining thorough practical and theoretical understanding as well as latest information.
- Update on standardization activities in this field
- Proposed limits for immunity and emissions in the studied frequency range

2) Obtaining important experience on a unique laboratory set-up, as well as on laboratory procedures, equipment, potential problems, solutions, challenges etc…

3) PPC and NTUA are planning to develop a laboratory set-up in Greece in-order to perform immunity tests on electronic meters concerning the operation combined with PV inverters. The proposed Transnational-Access project can significantly aid in this procedure.

4) Long-term cooperation with the host-institution on exchanging experience on EMC issues. Input to standardization organizations could be provided.

A highly important step for fulfilling the above objectives is the performance of the following tests in the host-laboratory:

Tests performed:
a) Immunity:“indirect feed” where a matching transformer is used in-order to feed the disturbance current into the electronic meter (references[1],[2])
b) Immunity:“direct feed” where a decoupling resistor is used in-order to feed the disturbance current into the electronic meter (reference [1])
c) Immunity: other possible methods on testing immunity of electronic meters available in the host infrastructure (if possible)
d) Emissions: PV inverters emissions by forming an Artificial Mains Network (AMN) with low

differential-mode impedance (reference [2])

Two electronic meters need to be tested for immunity: one that operates satisfactory at the proposed limits (reference [1]) and one that measures incorrectly.

For the immunity tests (*a* and *b*) the main equipment that is needed is written below: Two electronic meters, signal generator, amplifier, matching transformer (for *a),* precise voltage source, resistive load, bypass capacitors. Especially for test (*b*) decoupling resistors and transformers are needed. The main measurements that will be performed by a power analyzer are: reference energy measurement, voltage and current (frequency spectrum).

For the emissions tests (*d*) the main equipment that is needed is written below: PV inverter, low impedance Artificial Mains Network (AMN) formed by specific resistors, inductors and capacitors (as described in reference [2]). The main measurements that will be performed by a power analyzer are voltage and current measurements (frequency spectrum).

It is highlighted that the main focus of this proposal is on testing procedures for the **immunity** of electronic meters when used with PV inverters!

In addition, demonstration of immunity problems of electronic meters when combined with other devices (e.g. heat pumps) would also be interesting if possible.

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

The advantages of electronic meters and smart meters (in the smart-grid concept) compared to electromechanical, led the European union in strongly promoting their use. More and more electronic-smart meters are installed across Europe. However a gap in standardization has contributed to the malfunction of meters when used with PV inverters and some other devices in several countries. This situation is expected to become worse as more electronic meters are installed and in addition PV and DER penetration increases. If these issues aren't solved on time the large-scale use of electronic-smart meters could face problems.

Therefore this work will aid in avoiding similar EMC problems in Greece in the future. Currently few suitable laboratory set-ups exist world-wide. The development of the planned immunity set-up in Greece can provide useful experience to European Standardization bodies. Sharing experience with the host-institute will promote the cooperation in European level and contribute to the solution of this important and urgent task.

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

The EMC laboratory of Fraunhofer IWES (TA6) is the ideal laboratory for performing such experiments. IWES has thoroughly and effectively worked on the specific EMC issue and provides a unique laboratory environment to deal with these recently faced problems [2]. It is one of the very few places in the world where these experiments can be held.

Synergy with ongoing research (about ½ page)

Dissemination – Exploitation of results (about ½ page)

Common publications with the host-institute in scientific conferences will be performed. The results will be published in the website/newsletter of PPC or Greek journals. After the development of an immunity set-up in Greece, the experience gained could be provided to standardization bodies.

Time schedule (about ½ page)

March 2012:

26th: Theoretic background, standardization activities, description of the laboratory equipment, preparation .

27th: Performance of immunity tests on electronic meters (indirect feed)

28th: Performance of immunity tests on electronic meters (direct feed)

29th: Performance of emission tests on PV inverters

30th: Problems-faced, solutions, challenges. Advices for the development of an immunity set-up in Greece

Description of the proposing team (as long as needed)

1) PPC is Greek largest electricity generator, the sole owner of transmission assets and currently the sole distributor of electricity in the country. As of December 2007, PPC had an installed generating capacity of 12,760 MW in the 97 privately-owned power stations. Electricity is transported via 11,400 km of high voltage lines and distributed to consumers via a 207,300 km – long distribution network. PPC is providing electricity to approximately 7.4 million customers.

Vasilis Rogakos received the diploma and Phd from the School of Electrical Engineers of National Technical University of Athens. He has worked on project management and development of IT solutions and ERP systems for DIS S.A and Printec S.A. He has been an Engineer in PPC/ Distribution / Network Department since 2000 and he is currently the head of Tele-metering Operation in PPC / Distribution / Network Department.

2) The **National Technical University of Athens** (NTUA) is the oldest and among the most prestigious educational institutions in the field of technology in Greece. The School of Electrical and Computer Engineering of NTUA offers various degrees of research and experimental training for students in the electric energy systems domain: Power System Analysis, Power Generation, Power System Control and Stability, Transmission and Distribution Networks, Power System Protection, Renewable Energy Sources, SCADA and Digital Techniques in Power Systems etc. NTUA has participated in more than 40 research,

development and demonstration projects, most of which are collaborative EU funded projects.

Panos Kotsampopoulos received the Diploma in Electrical and Computer Engineering from the National Technical University of Athens (NTUA) in 2010. He is currently a Phd Student at the Electric Power Division of NTUA in the area of Distributed Energy Resources. His research interests include Real-Time and Hardware-In-Loop simulation, Electromagnetic Compatibility, microgrids, wind turbines and rural electrification.

PPC and NTUA are collaborating in this EMC issue and make this proposal to the Transnational Access of DERri. Vasilis Rogakos will have a supervisory role in the activities.

Panos Kotsampopoulos is the technical responsible of this work and of developing an immunity laboratory set-up in Greece. His wide experience in laboratory work and knowledge of EMC issues make him an important part of the team of this proposal.

Publications and presentations:

- T. Strasser, M Stifter, W. Hribernik, E. Lambert, P. Kotsampopoulos, P. Crolla, C. Tornelli, "Improving the Portability and Exchangeability of Model Data for Smart Grids focusing on Real-Time Simulations – Definition of a Common Reference Model", CIGRE Session 44 Paris, France, August 2012 (abstract accepted, paper submitted)

- B. Kleftakis, P. Kotsampopoulos, "PHIL simulation and voltage increase due to the PV production in Low Voltage grids", 5th conference of electrical and computer engineering students of Greece, April 2012, Xanthi, Greece (paper submitted)

- K. Latoufis, G. Messinis, P. Kotsampopoulos, N. Hatziargyriou "Axial flux permanent magnet generator design for low cost manufacturing of small wind turbines", Wind Engineering (paper submitted)

- P. Kotsampopoulos, "Real-Time simulation and microgrids", DERlab's PhD and Young Researcher Seminar: Distributed and Renewable Generation, Glasgow, United Kingdom, April 2011

- P. Kotsampopoulos, G. Messinis, T. Gkravas, K. Latoufis, N. Hatziargyriou, "Design, Construction, Simulation and Performance of Axial Flux Small Wind Turbines", EWEA, March 2011, Brussels, Belgium

- K. Latoufis, P. Kotsampopoulos, "Design, construction and simulation of a small scale axial flux wind turbine for appropriate technology applications", International Workshop on Small Scale Wind Energy for Developing Countries, November 2010, Pokhara, Nepal

- P. Kotsampopoulos, K. Latoufis, "Design, construction and simulation of an axial flux small wind turbine", 4th conference of electrical and computer engineering students of Greece, November 2010, Patras, Greece

- P. Kotsampopoulos, "Design, construction and simulation of an axial flux small wind turbine", presented at PowerEd students event, IEEE Greece PES Chapter, November 2010, Patras, Greece