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Distributed Energy Resources
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TEMPLATE FOR PROPOSAL UNDER DERRI

User-Project Proposal:

User-Project Acronym	MoDERN
User-Project Title	Modelling of Distributed Energy Resources Networks
Main-scientific field	Smart Grids
Specific-Discipline	Dynamic Modelling and Simulation of Distributed Generation Networks

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Position in Organization	Associate Professor

* 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	Higher Education Institute
Position in Organization	Post doctoral associate

Date of submission	30/01/2012
Re-submission	YES_______ NO__X_____
Proposed Host TA Facility	TA13 University of Strathclyde
Starting date (proposed)	15th July

Summary of proposed research (about ½ page)

Scope of the proposed project is the evaluation of a microgrid model built in the concept of the technical Virtual Power Plant (VPP) and Distribution Network Cell (DNC). The model is dynamic and the main target is to simulate dynamic phenomena such as transient/dynamic stability, voltage stability and short circuits for Dynamic Security Assessment (DSA) purposes. Each model will be able to communicate with other similar models using appropriate inputs and outputs in order to represent large areas of the power network.

Experimental measurements from the test facility will help in the determination of the model parameters as well as to evaluate the results from the simulations. For this purpose both steady state and dynamic measurements from the test facility are needed, in combination with the ability to fully control the various power sources. Moreover the available measurements at each node of the network will identify the best possible network reduction in order to simplify the model and enable it for large scale simulations of power systems.

State-of-the-Art (about 1 ½ page)

Traditionally the power flow in the distribution side of the network was unidirectional, from large power plants to medium and low voltage consumers. Nowadays the medium and low voltage distribution grid is transformed to an active network with bi-directional power flow. A large number of DG units and storage devices are connected or planned to be connected to the distribution side creating the need to reconsider the structure, the control operations and the protection principles, in order to retain a certain degree of reliability and stability in the power system and to counteract the intermittent behavior of renewable energy sources.

The integration of DG units creates a number of issues when faults occur concerning the dynamic/transient stability and short circuit capability of the system. The overall short circuit capability of the power system decreases and the trip currents of the circuit breakers need to be reconsidered or even updated in real time, depending on the type and number of DG units connected [1]. Moreover, storage devices, which can also act as controllable loads, need to be integrated in order to provide power during faults, balance the intermittency of renewable energy sources and thus enhance the dynamic stability of the system [2]. New control and power management strategies for both DG units and storage devices need to be implemented in order to achieve secure and reliable operation of the power system [3]. Fully controllable power sources such as Fuel Cells (FCs) and MicroTurbines (MTs) that are not intermittent can also be used to increase the stability of the system [4]. This way maximum DG unit penetration and utilization of the power system can be achieved.

Furthermore, the implementation of Phasor Measurement Units (PMUs), Automatic Meter Reading (AMR) systems and other Intelligent Electronic Devices (IEDs) improves significantly the monitoring and control functions of the power grid [5]. Several options, concerning the communication channel such as Wi-Fi, GPRS and Power Line Communication (PLC) are available. Real time measurements can provide valuable information for the state of the power system [6] and can also be used in the system modeling process. There are methods available in the literature concerning load modeling [7] and microgrid modeling [8] based on available measurements. This way the models can be updated online frequently providing a more accurate representation of the power system. In addition to measurements, IDE's can perform various automated control operations with signals from supervisory controllers, offering the opportunity for novel control strategies to be implemented.

Various approaches concerning dynamic microgrid modeling have been proposed in the literature with different degrees of detail, especially for power electronic interfaced units [9], [10]. Average Value Models for electronically interfaced units are a promising modeling approach considering large scale simulations, due to the fact that they can represent well dynamic phenomena in the order of a few kHz [11].

Another approach concerning microgrid modeling is the Virtual Power Plant (VPP). Technical VPPs are of significant importance for this study and are basically used to model the steady state as well as the dynamic behavior of a microgrid [12]. Technical VPPs are also referred to as Distribution Network Cells (DNCs). In this approach the microgrid is considered as a black or grey box and measurements are needed in order to determine the unknown parameters of the model using optimization techniques [13]. VPPs and DNCs are used in large scale simulations to represent the steady – state and dynamic behavior of microgrids in a black box approach which does not offer sufficient degree of detail concerning the individual behavior of each unit inside the VPP or DNC. The main disadvantage of these models is the lack of modularity and ability to integrate control operations, information flow and decision making abilities inside the VPP or DNC that the SG can offer.

References

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

Scope of this proposal is the evaluation and parameter estimation of a deterministic generalized dynamic model for the representation of a Medium and/or Low Voltage microgrid suitable for network segmentation and represent large networks with several microgrid models. The model will be more elaborate than the aforementioned VPPs and DNCs and will take properly into consideration the individual characteristics of all power sources, renewable or not, storage devices, loads and the information flow between all system units. Basic modeling principles will be used for each power source, describing its dynamic behavior. These models will be extended to include the suitable information, which will be available in the future Smart Grid (SG) by adding proper inputs and outputs for control and measurement signals that can be transmitted between power sources and/or supervisory controllers. A basis for the implementation of such models is provided in the IEC 61850-7 protocol and also in the literature.

The model is based on a step by step approach in order to create a dynamic, adaptive and modular model that can be used to extract valuable information in order to develop more sophisticated models in the concept of VPP ready to be used for large scale simulations. Measurements play a significant role and will be used in the modeling procedure in order to achieve the best possible network reduction but preserving also the individual characteristics of each power source. In addition available measurements will be used to evaluate the performance of the developed model. The controllers for the inverter interfaced units and conventional rotating machines will be also taken into consideration. It is important the proposed models to be portable and able to be integrated into existing software packages and real time simulators.

The final microgrid model will be used in order to:

- Simulate the dynamic behavior of microgrids regarding voltage stability, small signal and transient stability in grid – connected and islanded mode of operation and thus provide solutions to improve the dynamic behaviour of the system utilizing SG technologies.
- Study the impact of the intermittent nature of renewable energy sources and sudden load changes.
- Test and propose novel control strategies for the DG units and storage devices extending their operating limits without reducing reliability, in order to maximize DG unit penetration and utilization.
- Simulate worst case scenarios in real time to assess the dynamic stability of the system (Dynamic Security Assessment – DSA) utilizing also output from Distribution System State Estimation (DSSE) algorithms.
- Provide valuable information to promote automated decision making by supervisory controllers that can enhance the stability of the system or prevent unwanted situations.

The final model will be a real time tool that can execute multiple worst case scenario simulations for certain DG network topologies and operational states. This way valuable information about the system status can be used to make decisions and send proper control signals to the available units in order to enhance the operation and increase the security and reliability of the power system. The model will have a structure similar to a VPP with certain inputs and outputs in order to communicate valuable information between VPP's and/or with a supervisory controller. It is important that the model is portable and able to be implemented in various simulations platforms. Some key points of the model are the following:

- Time-varying, portable and easy to implement model
- Dynamic behavior and real-time performance;
- Flexibility and adaptability according to the location of loads, DG units, storage devices
- Utilization of measurements and data from Smart Meters, PMUs and metering devices in general as input data to determine modelling parameters as well as take control actions in order to meet preset goals
- Monitoring of the state and operations of the power system

For the purpose of the parameter estimation and evaluation of the model an extensive set of measurements from a microgrid test set up is needed. The Various operating conditions will be examined for different mix of power sources, storage devices and loads for both steady – state and dynamic conditions. Available measurements at each DG unit node will be used in order to achieve model simplification for each power source and determine the degree of the influence of each sinlge unit on the proposed model. For example if two synchronous generators are available in the microgrid they could be modeled using an equivalent generator with parameters derived from experimental measurements and possibly updated online when additional generators are connected or disconnected. The same applies for inverter interfaced units. One equivalent inverter interfaced source can be used to model the behavior of all the inverter interfaced units. Furthermore, measurements from the Point of Common Coupling (PCC) will be used in order to investigate the degree of reduction that can be achieved for the whole microgrid – VPP model. It is common in the literature that the voltage and frequency is used as inputs in the model and the real and reactive power as outputs.

The model will be evaluated by representing part of the network using a VPP and comparing the measurements with the simulation results. The part of the network modeled via the VPP will contain different types of power sources, either conventional or inverter interfaced, and also storage devices and loads. The parameters of the model can be fine tuned in order to determine the model operating region and ability to represent accurately the real installation behavior during disturbances.

The stability of the microgrid will be studied as well as the interaction and the applied control operations, which are adopted in order to increase the whole microgrid stability utilizing each power source and storage technology. The overall dynamic model will be evaluated using the measurements acquired from the test set – up for different operating conditions.

The test set-up should comprise of a fully controllable microgrid. The infrastructure should contain various DG sources including intermittent (wind generators and photovoltaic units), energy sources with controllable real power output, either conventional (combustion engines, steam/gas turbines) or modern power sources (fuel cells, microturbines) as well as storage devices such as batteries, flywheels or electrolyzers. All units should have the appropriate interface for interconnection and availability to operate in grid connected or islanded mode of operation, combined with the ability to connect and disconnect devices and change the network topology. Furthermore appropriate controllers that will implement different conventional (P – Q, P – f, etc.) and novel control strategies as well as a controllable power source, in order to test the microgrids behavior in the case of voltage dips at the Point of Common Coupling (PCC) are needed.

Appropriate metering devices should be installed in each network node, able to measure voltages, currents, real/reactive power output and frequency with fast sampling times in the order of a few ms at least. These information are valuable in both the modeling procedure and the design of the control strategies. A communication infrastructure that will be able to transmit the appropriate data and send proper control signals to the devices is necessary.

The proposed tests to be conducted in the test set up in the following order are presented:

- Grid – connected and islanded mode for steady – state and dynamic operation
- Load connection/disconnection
- DG units connection/disconnection and change in the operating point (steps and ramp changes in the power output)
- Voltage dips (50% remaining voltage for 500 – 1000 ms)
- Faults (3 – phase and 1 – phase short circuits)
- Test of novel control strategies such as, real/reactive power compensation of DG units in the case of the loss of a unit, changes in the set points of DG units according to certain control strategies implemented in a supervisory controller (voltage support in certain nodes)

It should be noted that the experimental measurement of faults should be carried out with extreme caution with appropriate protection devices properly regulated. Moreover the test of novel control strategies should be carefully designed to prevent equipment overloading. Proper simulation analysis should precede all the tests especially the two mentioned above in order to ensure that no operational limit of the test set up is surpassed.

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

The proposed work is a step towards the development of a more detailed Technical VPP model able to represent a segment of the network and its interactions with other VPPs using proper inputs and outputs. The control mechanisms inside each VPP as well as the information flow between the different sources will be also taken into account. This model will be appropriate for Dynamic Security Analysis of the power system. The available VPP models will be extended to include the control mechanisms of the various DG and storage units as well as the information flow inside the VPP from one VPP to another. The measurement and control signals and the inputs and outputs of the model will be investigated in order to propose the signals needed to be transmitted in the future smart grid.

Therefore, the model will be more precise than the existing VPPs and DNCs taking into consideration the individual behavior of each type of power source. The network reduction will aim at grouping similar power sources and loads and provide an interface for exchanging information between these entities in order to develop the overall microgrid model. Moreover the available DNCs in the literature are not targeted towards representing microgrids with high penetration of inverter interfaced units something that will be addressed in this proposal.

An other innovative approach is that the model will be based on real measurements not simulations something that will shed light to many practical problems that may arise in the process. A first approach to automate the procedure will be also made in order to identify possible restrictions from the hardware devices such as metering devices, controllers etc.

Furthermore, the available PMUs in the Smart Grid are a powerful monitoring tool and can provide valuable information for the network operating condition. For a given state of the network the proposed model will be able to perform multiple worst case scenario simulations of various types of faults, such as short circuits and voltage dips, and assess in real time the dynamic/transient and voltage stability of the system. The resulting model could be implemented in real time simulators giving a fast response for the system DSO to take control actions and lead to a more reliable and secure operation of the power system. This procedure can be executed repeatedly every time the network status changes and provide alarms in order to prevent marginal situations. Moreover automated control signals could be generated by local microgrid supervisory controllers in order to increase the stability and reliability of the power system. For example DG units can be controlled to provide reactive power when needed to support the voltage in certain nodes or a storage unit could be controlled to absorb or provide power when excess renewable power is available or when the available units reach their stability margins.

In addition the proposed model could be used in order to design control strategies that utilize the DG sources more effectively, thus maximizing the DG unit penetration without compromising security and reliability of the power system. Large scale simulations for different mix of Renewable Energy Sources and conventional can be studied and possible unwanted situations can be identified and avoided in real operating conditions. The use of rotating or power electronic interfaced units can also be studied and the impact of each technology will be better understood. The structure of the proposed model can be further developed to include in a systematic way all the available energy sources and technologies creating a basis for dynamic analysis of power systems in the concept of the IEC 61850-7 standard which provides a first approach towards creating a universal VPP for a small CHP unit.

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

A complete microgrid facility should be available in the proposed host TA infrastructure. The microgrid should be fully controllable and contain several different power sources, both renewable such as wind generators and photovoltaic, and conventional (steam/gas turbines, diesel engines). Modern power sources such as fuel cells and microturbines with fully controllable power output are also desirable. Moreover storage devices, such as batteries should be available. The microgrid should be able to operate in both grid – connected and islanded mode and the availability of a controlled power source that can simulate voltage dips is desirable.

The test facility should be also equipped with a high speed data acquisition system with a time step of at least a few ms. Measuring devices should be available at each network node providing the ability to monitor the power system operational status and record dynamic phenomena such as load connections/disconnections, faults etc. Moreover local controllers are necessary in order to implement and test various control strategies for the purpose of the study and send proper command signals to the DG units such as set reference signals, connect and disconnect units and loads. The control devices should be able to communicate with a central computer that will generate reference signals for each DG unit and decide for the appropriate control strategy. Finally suitable protection devices should be available for each unit in order to ensure that no operational limit is surpassed.

The university of Strathclyde test facility is suitable for the proposed study. The availability of real time simulators is also of great importance due to the ability to study more complex power networks with Hardware in the loop simulations. Moreover, previous research work concerning network reduction and dynamic phenomena such as transient, voltage and frequency stability of a microgrid resemble the proposed work. In addition previous work concerning improvement of the network stability using inverter interfaced units is also important. The experience of the technical and research staff could be of great assistance and ensure the best possible outcome of the experiment.

Synergy with ongoing research (about ½ page)

No other similar project is ongoing in the PSL.

Dissemination – Exploitation of results (about ½ page)

The completion of the test measurements will be accompanied by a report with the obtained data and initial results from the modeling procedure. Part of the project results will be presented in an international conference in the following months after the tests are over. The complete model will be published in an international peer reviewed journal when the study is finalized.

Furthermore the initial results will be made public through the Power System Laboratory webpage (power.ee.auth.gr) and they will be updated with the final results of the study as well.

Time schedule (about ½ page)

The target starting date of the proposed study is the 15th of July and the program is estimated to last at least one month.

The first week will aim at familiarizing with the microgrid installation and the available equipment. All the possible operating scenarios will be recorded and the final form of the experiments with all the details will be designed. Moreover the data sheets for each machine involved in the experiment will be recorded and valuable information that will be used in the simulation will be extracted.

In the second week an extensive set of steady – state measurements will be taken for various operating conditions and different mix of power sources. The results will be evaluated with the available models.

In the third and fourth week the dynamic experiments will take place. Various operating scenarios will be considered such as connection/disconnection of units and loads, voltage dips and faults. An initial evaluation of the dynamic model will be performed and the first results concerning the possible network reduction will be studied. By the end of the experiment a full test report will be presented.

The final model evaluation and parameter estimation will be carried out after the completion of the experiment and the resulting publications and announcements will be published afterwards.

Description of the proposing team (as long as needed)

Grigoris K. Papagiannis was born in Thessaloniki, Greece, on September 23, 1956. He received his Dipl. Eng. Degree and the Ph.D. degree from the Department of Electrical and Computer Engineering at the Aristotle University of Thessaloniki, in 1979 and 1998 respectively.

He is currently As. Professor at the Power Systems Laboratory of the Department of Electrical and Computer Engineering of the Aristotle University of Thessaloniki, Greece. His special interests are power systems modelling, computation of electromagnetic transients, distributed generation and powerline communications.

Panagiotis N. Papadopoulos was born in Komotini, Greece, on March 30, 1985. He received the Dipl. Eng. Degree from the Department of Electrical and Computer Engineering at the Aristotle University of Thessaloniki, in 2007. Since 2007 he has been postgraduate student at the same university. His research interests are in the field of power system modeling, simulation and transient analysis of distributed generation networks and smart grids.

Theofilos A. Papadopoulos was born in Thessaloniki, Greece, on March 10, 1980. He received his Dipl. Eng. Degree and Ph.D. from the Department of Electrical and Computer Engineering at the Aristotle University of Thessaloniki, in 2003 and 2008, respectively. He is currently a researcher at the Power Systems Laboratory of the Department of Electrical and Computer Engineering of the Aristotle University of Thessaloniki, Greece. His special interests are power systems modeling, powerline communications and computation of electromagnetic transients. Mr. Papadopoulos has received the Basil Papadias Award for the best student paper, presented at the IEEE PowerTech 07 Conference in Lausanne, Switzerland.

The Power Systems Laboratory (PSL) consists a legal entity of the Department of Electrical and Computer Engineering since 1980. It has been involved in more than 110 European, bi-lateral and national contract projects, mostly related to the research and development of power systems, renewable energy sources, electric power and consumption control, environmental impacts from power generation and applications of Information Technologies. It also cooperates closely with local energy authorities, energy market players and power producers. 16 PhD Theses have been concluded under the supervision of PSL members during the last 5 years, 4 of them on topics closely related to the field of this proposal.

The PSL laboratory equipment includes oscilloscopes, signal generators, power analyzers, electrical test instruments, data acquisition units, a complete set of LABVolt scale micromodels, including synchronous and asynchronous generators, overhead transmission lines, various transformers, power loads and DC and AC motors, capable of simulating the power system operation in steady state and transients. It also includes models of low-voltage installation protection and a full scale 20/0.4 kV substation with short overhead lines and cables for testing purposes. Two pilot installations including Medium and Low Voltage cables for PLC field test are also installed in the PSL. Moreover, a microgrid consisting of a PhotoVoltaic unit, a fuel cell, a battery storage is available in the PSL lab.

Following shareware and commercial software platforms are used in the PSL for educational & research purposes ATP-EMTP, MATLAB, ANSYS, COMSOL, NEPLAN, SINCAL, EMTP-RV, GTAP, ETAP Powerstation, EUROSTAG, POWERWORLD, as well as solvers like GAMS together with software developed by members of the PSL, especially in the field of this proposal.

The staff of the PSL consists of 3 Professors, 1 As. Professor, 3 Lecturers, 3 postdoctoral researchers, 14 postgraduate students and 5 members of administrative and technical staff. The staff of the PSL has authored or co-authored in many publications in peer reviewed scientific journals and international conferences, 66 of them in topics related to distributed generation, microgrids and smart grids. More info at http://power.ee.auth.gr.

1.1 Research group publications

1.1.1 Publications in scientific journals

1. G. Papagiannis, P. Dokopoulos: '**A Simplified Frequency Independent Modal Transformation for Overhead Line Switching Transients**', *European Transactions on Electric Power Systems. (ETEP)*, Vol. 5, No. 5, Sept.-Oct. 1995, pp. 307-314.
2. D.G. Triantafyllidis, G.K. Papagiannis, D.P. Labridis: **'Calculation of Overhead Transmission Line Impedances: A Finite Element Approach',** *IEEE Transactions on Power Delivery*, Vol. PWRD-14, No. 1, Jan. 1999, pp. 287-293**,** doi: 10.1109/61.736740.
3. G.K. Papagiannis, D.G. Triantafyllidis, D.P. Labridis: '**A One-Step Finite Element Formulation For The Modeling Of Single And Double-Circuit Transmission Lines',** *IEEE Transactions on Power Systems,* Vol. PWRS-15, No. 1, Feb. 2000, pp. 33-38, doi:10.1109/59.852098.
4. G. K. Papagiannis, D. A. Tsiamitros, D. P. Labridis, P. S. Dokopoulos: '**Direct Numerical**

Evaluation of the Earth Return Path Impedances of Underground Cables’, *IEE Proceedings on Generation, Transmission and Distribution*, vol. 152, No. 3, May 2005, pp. 321-328, doi:10.1049/ip-gtd:20045011.

5. D.A. Tsiamitros, G.K. Papagiannis, D.P. Labridis, P.S. Dokopoulos: **‘Earth Return Path Impedances Of Underground Cables For The Two-Layer Earth Case**’, *IEEE Transactions on Power Delivery*, vol. PWRD-20, No. 3, July 2005, pp. 2174-2181 doi:10.1109/TPWRD.2005.848737.
6. G.K. Papagiannis, D.A. Tsiamitros, D.P. Labridis, P.S. Dokopoulos, **‘A Systematic Approach To The Evaluation Of The Influence Of Multi-Layered Earth On Overhead Power Transmission Lines’,** *IEEE Transactions on Power Delivery*, vol. PWRD-20, No 4, Oct. 2005, pp. 2594-2601 doi: 10.1109/TPWRD.2005.855448.
7. A.S. Dagoumas, G.K. Papagiannis, P.S. Dokopoulos: ‘**An economic assessment of the Kyoto Protocol application**’**,** *Energy Policy*, Volume 34, Issue 1, January 2006, pp. 26-39, doi:10.1016/j.enpol.2004.05.012.
8. D.A. Tsiamitros, G.C. Christoforidis, G.K. Papagiannis, D.P. Labridis and P.S. Dokopoulos: ‘**Earth Conduction Effects in Systems of Overhead and Underground Conductors in Multi-Layered Soils**‘, *IEE Proceedings on Generation, Transmission and Distribution,* vol. 153, Nr. 3, May 2006, pp. 291 – 299.
9. A.S. Dagoumas, E. Kalaitzakis, G.K. Papagiannis, P.S. Dokopoulos: ‘**A post-Kyoto analysis of the Greek electric sector**’**,** *Energy Policy*, Vol. 35, Issue 3, March 2007, pp. 1551-1563, doi: 10.1016/j.enpol.2006.05.003
10. D.A. Tsiamitros, G.K. Papagiannis, P.S. Dokopoulos, **‘Homogenous Earth Approximation of Two-Layer Earth Structures. An Equivalent Resistivity Approach**’ , *IEEE Transactions on Power Delivery*, vol. PWRD-22, No 1, January 2007, pp. 658-666 doi: 10.1109/TPWRD.2006.881465.
11. N. Protogeros, A. Economides, G.K. Papagiannis, C. Syleos, ‘**Developing a Near-optimal Lowest-consumption Tunnel Lighting System Using Software Agents through Power Line Communications**’, *Journal of Computing and Information Technology* - CIT 15, 2007, No. 2, pp. 185–191, doi:10.2498/cit.1000811
12. G.K. Papagiannis, A.S. Dagoumas, N. Lettas, P.S. Dokopoulos: ‘**Economic and environmental impacts from the implementation of an intelligent demand side management system at the European level**’, *Energy Policy,* Vol. 36, Issue 1, January 2008, pp. 163-180, doi:10.1016/j.enpol.2007.09.005.
13. A.S. Dagoumas, I.P. Panapakidis, G.K. Papagiannis, P.S. Dokopoulos, ‘**Post-Kyoto energy consumption strategies for the Greek interconnected electric system**’ *Energy Policy,* Vol. 36, Issue 6, June 2008, pp. 1980-1999, doi:10.1016/j.enpol.2008.02.015.
14. T.A. Papadopoulos, G.K. Papagiannis, P.S. Dokopoulos, ‘**Low Voltage Distribution Line Performance Evaluation for PLC Signal Transmission**’, *IEEE Trans. on Power Delivery* Vol. PWRD-23, No. 4, Oct. 2008, pp. 1903-1910, doi: 10.1109/TPWRD.2007.916040.
15. D.A. Tsiamitros, G.K. Papagiannis, P.S. Dokopoulos: ‘**Earth Return Impedances of Conductor Arrangements in Multi-Layer Soils-Part I: Theoretical Model**’, *IEEE Trans. Power Delivery.,* Vol. PWRD-23, No. 4, pp. 2392-2400, Oct. 2008, doi: 10.1109/TPWRS.2008.923816
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1.1.2 Publications in conference proceedings

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2. G. Papagiannis, P. Dokopoulos: '**A simplified Real Frequency Independent Modal Transformation**', *Proceedings of the 21st E.M.T.P. European Users Group Meeting*, Crete Greece, June 1992, Pages 6.
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39. T. A. Papadopoulos, E. Topriska, G. K. Papagiannis, G. C. Christoforidis, "**Electrical Energy Consumption Analysis in Tertiary Buildings**", *3rd International Conference on Renewable Energy Sources & Energy Efficiency*, Nicosia, Cyprus, May 19-20, 2011.
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44. A. I. Chrysochos, T. A. Papadopoulos, G. K. Papagiannis, "**Improved Time-Domain Modeling of Underground Cables**", *46th International Universities Power Engineering Conference (UPEC)*, Soest, Germany, September 5 - 8, 2011.
45. P. N. Papadopoulos, M. D. Chatzisideris, T. A. Papadopoulos, A. G. Marinopoulos, G. K. Papagiannis, "**Integration of Smart Grid Technologies in a MicroGrid with PV and FC units**", *46th International Universities Power Engineering Conference (UPEC)*, Soest, Germany, September 5 - 8, 2011.

AWARDS

- Conference paper 23 was awarded with the *Basil Papadias* award for the best student paper, presented at the IEEE PowerTech 07 Conference, Lausanne, Switzerland.
- Conference paper 45 was awarded with the best oral presentation award, presented at the 46th International Universities Power Engineering Conference (UPEC), Soest, Germany.

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.