

# Annual Activity Report 2014



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## About the Centre

### FOSS Research Centre for Sustainable Energy

FOSS Research Centre for Sustainable Energy was created in order to play a key role in research and technological development activities in the field of sustainable energy within Cyprus and at international level with the aim of contributing to the achievement of the relevant energy and environment objectives set out by Europe. In particular, FOSS strives to become a centre of excellence in energy that will act as a structure where world-standard R&D work can be performed, in terms of measurable scientific production (including training) and/or technological innovation. In FOSS significant research expertise from the University of Cyprus as well as from industry has been assembled that spans a host of fields: Electrical, Mechanical, Civil, Environmental, Chemical Engineering, Physics, Chemistry, Economics, Finance, Computer Science as well as Architecture.



#### Thematic Areas

- Renewable energy sources (RES) with an emphasis on solar energy
- Distributed generation and microgrids
- Smart electricity networks
- Nearly Zero Energy Buildings (NZEB)
- Enabling technologies including energy storage and ICT

#### Application Areas and Research Projects

- Energy efficiency and energy saving
- Demand Side Management
- Energy in Smart cities
- Electric mobility
- Integrated services
- Energy Policy and Energy economics
- Education and awareness work on sustainable energy matters

### Impact

FOSS aims to be established as a regional research and innovation (R&I) hub of excellence which will generate novel ideas, provide a strong stimulus for interdisciplinary co-operation and be an internationally respected, state-of-the-art training and education centre. The Centre of Excellence will generate an effective research and innovation culture in Cyprus and the surrounding region, promoting effective cooperation between academia, industry and business sectors, as well as contributing to the transfer of knowledge from advanced European clusters to the region. The Centre will create a test-bed and “living lab” in the areas of energy and sustainability and will be a major driver to facilitate commercialization of innovation in energy-related fields in Cyprus, Europe and the Middle East/North Africa (MENA) region.

## Message from the Director

Today there is a continuously growing global demand for energy to power technological and economic development, which is both unsustainable and negatively affecting the environment and the climate. It is thus becoming increasingly important to attain sustainable, secure and competitive energy resources and attitudes that promote growth within a more resource-efficient and greener economy. To this end, at global and European level, strategic priorities and action plans are now focusing on growth, which has as key elements knowledge, innovation and sustainability.



FOSS Research Centre for Sustainable Energy was created precisely to address this challenge and contribute to the transformation of societies and economies into more energy-conscious ones. FOSS in Greek means 'light', this inexhaustible source of energy that can provide sustainability. In order to achieve its objectives, FOSS has brought together significant research expertise from across disciplines within the University of Cyprus, but also through targeted international collaborations for more effective research efforts in tackling sustainable energy issues. Moreover, the necessary critical mass of researchers and academics has been created in order to make a real contribution and have an impact in Cyprus, Europe but also beyond. Since 2014, FOSS has been officially established and approved by the parliament of Cyprus. The facilities, structure and framework of operation and procedures have been set up and the foundations for a successful endeavour have been established.

FOSS is already gathering momentum, participating in and coordinating a number of relevant research projects involving European and regional partners, as well as employing its first new PhD students and post-doctoral fellows. FOSS' vision is to become the ground where novel ideas will be conceived, grown, exploited further and transferred to society through active cooperation between academia, industry and other key stakeholders, both at a local and international level. Through its activities and collaborations, FOSS strives to become an active player in the field in Europe and a hub of transferring knowhow and expertise to the Mediterranean and MENA region. This is the beginning of what promises to be a long and exciting journey for academic and scientific excellence in a field of crucial importance for our country and the world at large.

I would like to thank all my colleagues who contributed to this effort and who share the vision for a successful and sustainable Centre of Excellence.

Dr. George E. Georghiou

## Message from the Chairman

FOSS is with us to shed lasting light, with the full meaning of the word, to all the energy related activities of our Cypriot community. The sustainable future of our country is a responsibility that we undertake to fully support with commitment that will further strengthen the competitiveness of the Cypriot economy based on improved energy supplies that offer higher security and continuity.



We need in this process a vision to develop a strategy for the future of our society that is in line with the aspirations of Europe for successfully manifesting the already declared Energy Union and the five identified interrelated *dimensions* designed to bring greater energy security, sustainability and competitiveness:

- Energy security, solidarity and trust
- A fully integrated European energy market
- Energy efficiency contributing to moderation of demand
- Decarbonising the economy, and
- Research, Innovation and Competitiveness.

We will make every effort to understand this process with realism and optimism aiming to translate it into real day to day actions for the Cypriot Community. FOSS will take a lead in this process and will support the Cypriot community, to play a positive role in this direction: the University of Cyprus, related Ministries and other Governmental services, Municipalities and Communities, CERA, TSOC, DSO / EAC, the industry and Cypriot society at large!

Research and innovation interlinked with education will be pivotal in our efforts for transforming our society into a knowledge based society of promise and hope. We endeavour to make FOSS the home of the new generation of engineers who want to build the future on sound knowledge substantiated through state of the art research with strong European links to centres of excellence that will give breadth and depth to our work. Sustainable technologies will be the core of our work but always linked to the current technologies that serve today the Cypriot economy, substantiated with a documented strategy for optimal evolution into the targeted sustainable future.

We have walked the first year in small but firm steps, creating the interlinked environment for future successes. You will find in this report the most important aspects of the work done in this short period of time and we look forward to the future with optimism for positively capturing the opportunities that are ahead of us.

Dr Venizelos Efthymiou

Date

## Committees

### Board

Prof. Andreas Alexandrou, University of Cyprus

Dr. Venizelos Efthymiou, University of Cyprus  
(Chairman)

Prof. Costas Georghiades, Texas A&M University

Dr. George E. Georghiou, University of Cyprus  
(Director)

Prof. Nikos Hadjiargyriou, National Technical University of Athens

Prof. Christoforos Hadjicostis, University of Cyprus

Dr. Ioannis Krikides, University of Cyprus

Mr. Marios Tsiakkis, Secretary-General of Cyprus Chamber of Commerce and Industry



### Academic Committee

Dr. Charalambos A. Charalambous, Department of Electrical and Computer Engineering

Prof. Charalambos D. Charalambous, Department of Electrical and Computer Engineering

Dr. George E. Georghiou, Department of Electrical and Computer Engineering

Dr. Demokritos Gregoriadis, Department of Mechanical and Manufacturing Engineering

Dr. Andreas Kyprianou, Department of Mechanical and Manufacturing Engineering

Dr. Marina Neophytou, Department of Civil and Environmental Engineering

Prof. Panos Papanastasiou, Department of Civil and Environmental Engineering

Dr. Marios C. Phocas, Department of Architecture

Dr. Panayiota Pyla, Department of Architecture

## Members

Dr. Charalambos A. Charalambous, Department of Electrical and Computer Engineering

Prof. Charalambos D. Charalambous, Department of Electrical and Computer Engineering

Dr. George E. Georghiou, Department of Electrical and Computer Engineering

Dr. Demokritos Gregoriadis, Department of Mechanical and Manufacturing Engineering

Dr. Christos Hadjichristos, Department of Electrical and Computer Engineering

Dr. Stavros Kassinos, Department of Mechanical and Manufacturing Engineering

Dr. Andreas Kyprianou, Department of Mechanical and Manufacturing Engineering

Dr. Alexandros Arsalis, Department of Mechanical and Manufacturing Engineering

Dr. Aimilios Michael, Department of Architecture

Dr. Marina Neophytou, Department of Civil and Environmental Engineering

Prof. Panos Papanastasiou, Department of Civil and Environmental Engineering

Dr. Marios C. Phocas, Department of Architecture

Dr. Panayiota Pyla, Department of Architecture

Dr. Andreas Savvides, Department of Architecture

## Memberships

### **European Distributed Energy Resources Laboratories (DERlab)**

DERlab is the association of leading laboratories and research institutes in the field of distributed energy resources equipment and systems. The association develops joint requirements and quality criteria for the connection and operation of distributed energy resources (DER) and strongly supports the consistent development of DER technologies. DERlab offers testing and consulting services for distributed generation (DG) to support the transition towards more decentralised power systems. The various activities in research, pre-standardisation can be found at: <http://www.der-lab.net/>



### **European Energy Research Alliance (EERA) Joint Programme for Smart Grids**

The European Energy Research Alliance (EERA) contributes to coordinate a massive public research effort to develop more efficient and cheaper low carbon energy technologies. Wind turbines and solar panels, building a “smart” electricity grid, harnessing energy from the oceans and underground heat sources, as well as finding new ways to store and use energy instead of wasting it. EERA is the public research pillar of the EU Strategic Energy Technology Plan (SET-Plan). This tightly focused strategy aims at accelerating the development and market uptake of key low carbon technologies. The Joint Programme on Smart Grids was officially launched at the SET Plan Conference in Madrid (3-4 June 2010). The Joint Programme, coordinated by RSE and ENEA from Italy by means of an extended cross-disciplinary cooperation involving many Research and Development (R&D) participants with different and complementary expertise and facilities, aims at addressing in a medium- to long-term research perspective, one of the most critical areas directly relating to the effective acceleration of smart grid development and deployment. More details can be found at: <http://www.eera-set.eu/eera-joint-programmes-jps/smart-grids/>

### **The Association of European Renewable Energy Research Centres (EUREC)**

EUREC, is the leading association representing research centres and university departments active in the area of renewable energy. EUREC was founded in 1991 as European Economic Interest Grouping (E.E.I.G.) with the goal of improving the quality and scope of European research and development in renewable energy technologies. The purpose of the association is to promote and support the development of innovative technologies and human resources to enable a prompt transition to a sustainable energy system. EUREC is the voice of renewable energy research in Europe, representing European Research Centres active in renewable energy. More details can be found at: <http://www.eurec.be/en/>

## Collaboration Agreements

### Texas A&M University at Qatar Collaborates with University of Cyprus Research Centre for Sustainable Energy (FOSS)

Texas A&M University at Qatar has signed an agreement with the Research Centre for Sustainable Energy (FOSS) at the University of Cyprus. The agreement seeks to expand research endeavors in

the sustainable energy arena and was signed at the University's Engineering building on 27 January 2014. It will encourage the enrollment of qualified students in new academic programs, explore opportunities to exchange faculty for joint teaching and research programs and explore avenues for strengthening relationship and furthering excellence in education in both Qatar and Cyprus.

The agreement formed part of the official visit of the President of the Republic of Cyprus to the State of Qatar and the Qatar-Cyprus business forum, that took place on the 27<sup>th</sup> and 28<sup>th</sup> January 2014.



### NATIONAL TECHNICAL UNIVERSITY OF ATHENS

FOSS has signed a cooperation agreement with Smart RUE, one of the Research Groups of the Institute of Communication and Computer Systems (ICCS). Smart RUE belongs to the Electric Energy Systems Laboratory (EESL) of the School of Electrical and Computer Engineering of the National Technical University of Athens. The agreement foresees undertaking research on mutually agreed areas in the field of energy. It includes joint participation in research programs, exchange of knowledge and know-how, as well as targeted exchanges of academic staff and students. The two centres are highly regarded for their respective activities and this cooperation will push them a step forward in the challenging field of energy.



## Alfa Mediterranean Enterprises Ltd

The aim of this collaboration is to investigate solar energy issues and better ways of integrating concentrated solar power to the network.

Alfa Mediterranean is to install, for the first time in Cyprus, an innovative system that allows production of electricity from concentrated solar power in an attempt to reach the targets set by



the European Union regarding the share of renewable sources of energy in the electricity mix by 2020. The system proposed by Alpha Mediterranean (Lloyd system) has the unique feature of combining concentrated solar power with storage. The concentrated solar power system consists of towers, which have solar receivers and heat storage tanks, heliostats and steam generators. The company won the “NER300” competition for innovative renewable energy technology by the European Commission and has received funding of €60.2 million.

## Corinex open BPL Competence Centre for Smart Metering

The University of Cyprus, through FOSS Research Centre, has opened a BPL Competence Centre with the support of industry technology leader Corinex Communications. The Centre is equipped with the latest in Corinex BPL-to-the-meter technology, with facilities for testing and validating BPL communications performance on LV and MV lines and free samples from leading meter vendors.

The main target is to enrich the Corinex BPL concentrator and SmartGrid solution with new algorithms researched and developed by the University, and then validate them with Corinex customers. The University also plans to introduce a new learning subject specialization: Energy Sustainability and Smart Grids, which include BPL and its applications in the Energy sector.



## Distribution System Operator/Electricity Authority of Cyprus

For more than 10 years the DSO / EAC carried out collaborative work with the University of Cyprus and the predecessor of FOSS (PV Technology Laboratory).

In particular some of the topics of collaboration are outlined below:

- EMF leading to long term commitment for carrying out certified low frequency measurements near the exposed grid of the DSO / EAC in support of the internal work of the DSO / EAC or for informing responsibly the general public wherever they raised interest to know the level of the EMF in the vicinity of their premises substantiated with the requirements of international standards and the European recommendations.
- The DSO / EAC was facing a real problem of bad quality underground cables leading to premature failure of terminations and joints. The joint work undertaken by the DSO with FOSS was an attempt to make partial discharge readings more reliable by removing noise from other sources, leading to more consistency between actual recordings of partial discharge activity and subsequent failure of the affected equipment / cables.
- The national grid rules specify quite clearly the required quality that is expected from the interconnected grid and for this reason the DSO / EAC is obliged to take all necessary actions to fulfill the dictated obligations. In order to fulfill these obligations, the DSO / EAC has asked FOSS to assist in this work. FOSS is providing the required measurements and documented analysis with substantiated recommendations for alleviating the declared problem.
- Specialized studies that emanated in the following have been assigned to FOSS:
  - ✓ Thermal analysis tool for the design of enclosed substations for correctly sizing the substation and the associated ventilation systems;
  - ✓ Cost evaluation of thermal losses of transformers, of the Network and of Future Networks with increasing penetration of RES,
  - ✓ Code of practice for the protection of RES installations from overvoltages and lightning.



## Initiatives

### Mediterranean Technology Platform for Smart Grids

FOSS Research Centre, through the PV-NET project “Promoting photovoltaic technology through net metering optimization” (co-financed by the European Regional Development Fund through the MED Programme) took the initiative to establish the Mediterranean



Technology Platform for Smart Grids (MedTP4SG). The coordinator of the PV-NET project Dr. George E Georghiou, the Deputy Director of the Energy Service in Cyprus Constantinos Xichilos, and the Head of European Commission Representation in Cyprus Georgios Markopouliotis addressed the event dedicated to the establishment of the MedTP4SG. The Platform is now up and running with the full support of FOSS and is expected to address regional issues related to smart grids and aims to

work in close cooperation with the European Technology Platform for Electricity Networks of the Future (ETP SmartGrids) for addressing the main priorities of the Energy Union.

### Cyprus Technology Platform for Smart Grids (CyTP4SG)

FOSS is a founding member of Cyprus Technology Platform for Smart Grids (CyTP4SG) and an active member of the Steering Committee. The Cyprus Technology Platform for Smart Grids (CyTP4SG) offers strategic guidance for its stakeholders on the development of technologies related to Smart Grids that will address the future needs of electricity networks in Cyprus. The stakeholders include: the regulator of Cyprus CERA; the TSO of Cyprus, the DSO of Cyprus, the manufacturers, industrialists and traders of Cyprus represented by KEBE and OEB, the RES producers of Cyprus represented by ΣΕΑΠΕΚ, the Research Centre for Sustainable Energy FOSS of the University of Cyprus and the Cyprus Energy Agency. The strategic guidance is developed through mobilisation of the expertise resident in the above stakeholders of Cyprus and close cooperation with the ETP SG, the work groups that are functioning under its



auspices and the Mediterranean Forum of national technology smart grid platforms in the region. Cooperation, sharing of information, bilateral exchange of expertise and knowhow, development of an effective platform for dissemination of results, common research efforts on projects of common interest and targeted workshops discussing current problems of the industry are means through which we aim to build the momentum for the evolution of the electrical grid in support of the energy strategy of Cyprus, the Mediterranean and Europe.

## Services to the Community

### Education

#### Teaching

Members of FOSS provide teaching to students of the University of Cyprus, at undergraduate and postgraduate level. Also, for masters projects, students receive guidance from the faculty of FOSS Research Centre for Sustainable Energy.



#### School visits



Over 250 schools have visited FOSS's PV Technology facilities to learn more about photovoltaic technology. Children have the opportunity to be exposed to the latest technologies through experiments. The presentation covers the outdoor and indoor infrastructure and tests carried out on a daily basis. At the outdoor facility the students understand the operation of both a grid-connected and stand-alone PV system. At the indoor infrastructure they see the equipment (climatic chamber and sun simulators) required for the indoor simulation of PV cells and modules.

## **Government, Local / Regional Authorities and Industrial Services**

One of FOSS 's prime objectives is to provide constant support to the various government departments, municipalities / communities and the local industry. Attempts will be continuous for building trust and be in a position to positively intervene in the day to day issues that are worrying the government, local communities and the local industry to offer services for valued solutions whenever the need arises.

As covered in other areas of this report, FOSS is already cooperating on these issues signing MoU wherever needed and responding to requests for support on specific issues. FOSS can be the catalyst for informed solutions to all energy related problems that the Cypriot community is facing and we will gladly take this role since we consider it to be one of the prime objectives for the establishment of universities and more specifically for the creation of the research centre FOSS and giving it the multi-discipline character and content that is currently enjoying.

Examples include: Intertek/UK Network Rail, Helios Project, ELEMKO SA/AEGEK-IMPREGILO-ANSALDO and Electricity Authority Cyprus.

## Public Awareness

### 1. Events

#### Local Energy Day

On the 11<sup>th</sup> June 2014, a Local Energy Day was organized by FOSS and the SmartPV Consortium in Nicosia, within the framework of the EUSEW (23–27 June 2014) entitled “Beyond grid parity: Smart net metering for promoting PV technology and the importance of developing dynamic tariffs to support demand side management in an attempt to optimize PV penetration.” The event attracted all the major stakeholders as well as the public’s interest and it covered all the key themes and current developments in Cyprus in the field of net metering, subsidy schemes and grid integration. Fruitful discussions between presenters, participating partners and audience followed the presentations of the event.

#### Uptake of Solar PV energy through net metering - EU Sustainable Energy Week

EU Sustainable Energy Week (EUSEW) – 23 to 27 June 2014 – is the premier event for public authorities, energy agencies, private companies, NGOs and industry associations engaged in helping to meet the EU's energy and climate goals. It features activities dedicated to energy efficiency and renewable energy solutions in Europe and around the world. As part of the European Week for Sustainable Energy 2014 (EUSEW 2014), a workshop organized by FOSS, through the program PV-Net, was held in Brussels on June 25, 2014. The workshop was on “Uptake of Solar PV energy through net metering” and the speakers presented the latest developments in photovoltaic technology, their supporting systems and infrastructure to be developed for the smooth operation of the unified power grid.



## 2. Articles to the Media for Public Awareness

### **FOSS publishes articles in Newspapers to inform the public and has regular articles in the monthly Newsletter of the Technical Chamber of Cyprus (ETEK)**

The latest article was about Smart meters and the benefits for the consumers by M. Patsalides, N. Philippou, V. Efthymiou, and G. E. Georghiou, FOSS Research Centre for Sustainable Energy, PV Technology and was published in many newspapers of the island (26/10/2014).

On the other hand, the latest article in the monthly Newsletter of the Technical Chamber of Cyprus (ETEK), was about PV status and energy policies in Cyprus by the team M. Hadjipanayi, I. Koumparou, N. Philippou, V. Paraskeva, A. Phinikarides, G. Makrides, V. Efthymiou, and G. E. Georghiou, FOSS Research Centre for Sustainable Energy, PV Technology, Department of Electrical and Computer Engineering, University of Cyprus, as well as an article about the research project Smart PV, which involves 300 consumers who will benefit by their participation (11/12/2014).

## Publications

### Book Chapters

F. Gonzalez-Longatt, J.M. Roldan, J.L. Rueda, Charalambos A. Charalambous, and B. S. Rajpurohit, "Implementation of Simplified Models of Local Controller for Multi-terminal HVDC Systems in DigSILENT Power Factory", in "Power Factory Applications for Power System Analysis", Publisher: Springer, 2014, pp: 447-472.

F. Gonzalez-Longatt, J.L. Rueda, Charalambos A. Charalambous, and P. De Oliveira, " Estimation of Equivalent Model for Clusters of Induction Generators based on PMU Measurements" in "Power Factory Applications for Power System Analysis", Publisher: Springer, 2014, pp: 473-489.

A. Nikolaidis, F. Gonzalez-Longatt and Charalambos A. Charalambous, "Indices to Assess the Integration of Renewable Energy Resources on Standard Test Networks through DigSILENT's Programming Language (DPL)" in "Power Factory Applications for Power System Analysis", Publisher: Springer, 2014, pp: 135-156.

### Journals

C. A. Charalambous, N. Kokkinos, N. Christofides, "External Lightning Protection and Grounding in Large Scale Photovoltaic Applications", Electromagnetic Compatibility, IEEE Transactions on, vol.56, no.2, pp.427,434, April 2014.

G. Makrides, B. Zinsser, M. Schubert, G. E. Georghiou, "Performance loss rates of different photovoltaic technologies," Solar Energy, vol. 100, pp. 28-42, May 2014.

C. A. Charalambous, Z.D. Wang, P. Jarman and J.P Sturgess; 'A Time Domain Finite Element Technique for Quantifying the Effect of Sustained Ferroresonance on Power Transformer Core Bolts', Electric Power Applications, IET (formerly IEE Proceedings), Volume 8, Issue 6, July 2014, p. 221 – 231.

A. Lazari and C. A. Charalambous, "Probabilistic Total Ownership Cost of Power Transformers Serving Large-Scale Wind Plants in Liberalized Electricity Markets", IEEE Transactions on Power Delivery, DOI: 10.1109/TPWRD.2014.2365832, Accepted October 2014. (In Press)

C.A. Charalambous and Aylott, P., "Dynamic Stray Current Evaluations on Cut-and-Cover Sections of DC Metro Systems", Vehicular Technology, IEEE Transactions on, vol.63, no.8, pp.3530, 3538, Oct. 2014.

A. Arsalis, A. Alexandrou, "Thermoeconomic modeling and exergy analysis of a decentralized liquefied natural gas-fueled combined-cooling heating-and-power plant", Journal of Natural Gas Science and Engineering, vol. 21, pp. 209-220, Nov. 2014.

- A. *Lazari* and C. A. Charalambous, "Life-Cycle Loss Evaluations of Power Transformers Serving Large Photovoltaic Plants in Vertically Integrated and Decentralised Systems". IET Generation Transmission and Distribution (formerly IEE Proceedings), Accepted November 18<sup>th</sup>, 2014. (In Press)
- A. Phinikarides, G. Makrides, M. Schubert, G. E. Georghiou, "Analysis of photovoltaic system performance time series: seasonality and performance loss Renewable Energy," Renewable Energy, vol. 43, pp. 143-152, Dec 2014.
- A. Phinikarides, G. Makrides, M. Schubert, G. E. Georghiou, "Review of photovoltaic degradation rate methodologies," Renewable and Sustainable Energy Reviews, vol. 43, pp. 143-152, Dec 2014.
- A. Nikolaidis, A. Milidonis and C. A. Charalambous, "Impact of Fuel-Dependent Electricity Retail Charges on the Savings Value of Net-Metered PV Applications in Vertically Integrated Systems". Energy Policy, DOI:10.1016/j.enpol.2015.01.010, JEPO7939, Accepted December 2014 (In Press).
- Arsalis, A., and A.N. Alexandrou. Effect of collector tilt angle on the performance of a residential solar-heating-and-cooling system. Journal of Advanced Thermal Science Research. 1:44–50. 2014. doi:10.15377/2409-5826.2014.01.02.2
- Arsalis, A., and A.N. Alexandrou. Thermoeconomic modeling and exergy analysis of a decentralized liquefied natural gas-fueled combined-cooling-heating-and-power plant. Journal of Natural Gas Science and Engineering. 21:209–220. 2014. [Top 25 Hottest Articles (October to December 2014) doi:10.1016/j.jngse.2014.08.009
- Charalambous, C.A.; Cotton, I.; Aylott, P.; Kokkinos, N.D., "A Holistic Stray Current Assessment of Bored Tunnel Sections of DC Transit Systems," Power Delivery, IEEE Transactions on , vol.28, no.2, pp.1048,1056, April 2013.
- Charalambous, C.A.; Milidonis, A.; *Lazari, A.; Nikolaidis, A.I.*, "Loss Evaluation and Total Ownership Cost of Power Transformers—Part I: A Comprehensive Method," Power Delivery, IEEE Transactions on, vol.28, no.3, pp.1870 - 1880, July 2013.
- Charalambous, C.A.; Milidonis, A.; *Hirodantis, S.; Lazari, A.*, "Loss Evaluation and Total Ownership Cost of Power Transformers—Part II: Application of Method and Numerical Results," Power Delivery, IEEE Transactions on, vol.28, no.3, pp.1881 - 1889, July 2013.
- Charalambous, C.A.; Cotton, I.; Aylott, P., "Modeling for Preliminary Stray Current Design Assessments: The Effect of Cross Track Regeneration Supply," Power Delivery, IEEE Transactions on, vol.28, no.3, pp.1899, 1908, July 2013.
- A. *Lazari* and C. A. Charalambous, "Integrating Greenhouse Gas Emissions Costs in Lifecycle Loss Evaluations: A Case Study for Transmission Lines," Journal of Conference Papers in Energy, vol. 2013, Article ID 682130, 6 pages, 2013. doi:10.1155/2013/682130, July 2013.

A. Nikolaidis, F.G. Longatt and C.A. Charalambous, "Indices to Assess the Integration of Renewable Energy Resources on Transmission Systems," *Journal of Conference Papers in Energy*, vol. 2013, Article ID 324562, 8 pages, 2013. doi:10.1155/2013/324562, July 2013.

M. Patsalides, A. Stavrou, V. Efthymiou, G. E. Georghiou, "Thevenin Equivalent Circuit for the Study of High Photovoltaic Penetration in Distribution Grids", 4th IEEE PES Innovative Smart Grid Technologies Europe (ISGT Europe), pp. 1-5, 2013.

M. Patsalides, A. Stavrou, V. Efthymiou, G. E. Georghiou, "Towards the Establishment of Maximum PV Generation Limits due to Power Quality Constraints", *International Journal of Electrical Power and Energy Systems*, pp. 1-14, Feb. 2012.

G. Makrides, B. Zinsser, A. Phikarides, M. Schubert, G. E. Georghiou, "Temperature and thermal annealing effects on different photovoltaic technologies", *Renewable Energy*, vol. 43, pp. 407-417, Jul. 2012.

M. Patsalides, A. Stavrou, V. Efthymiou, G. E. Georghiou, "Assessing the Power Quality Behaviour of High Photovoltaic (PV) Penetration Levels inside the Distribution Network", 3rd IEEE, International Symposium on Power Electronics for Distributed Generation Systems, pp. 1-8, 2012.

C. A. Charalambous, Z.D. Wang, P. Jarman and J.P Sturgess; "Facilitating an Electromagnetic Finite Element Analysis of a Power Transformer Experiencing Ferroresonance, in Frequency Domain", *Generation, Transmission & Distribution, IET (formerly IEE Proceedings)*, Volume: 5 Issue: 6, page(s): 640 – 649, June 2011.

G. Makrides, B. Zinsser, M. Schubert, G. E. Georghiou, *Progress in Photovoltaics: Research and Applications*, "Energy yield prediction errors and uncertainties of different photovoltaic models", 2011.

### **Conference Papers**

M. Patsalides, G.E. Georghiou, A. Stavrou and V. Efthimiou, "Evaluation of Voltage Regulation Schemes for Photovoltaic Systems using a Simplified Grid Equivalent," in 9th Mediterranean Conference on Power Generation, Transmission, Distribution and Energy Conversion, MEDPOWER, 2014.

M. Patsalides, G.E. Georghiou, A. Stavrou and V. Efthimiou, "New voltage regulation scheme for photovoltaic systems based on Thevenin's Theorem," *IEEE International Energy Conference (ENERGYCON) 2014*, vol., no., pp.132,138, 13-16 May 2014.

N. Philippou, M. Hadjipanayi, G. Makrides, V. Efthymiou and G. E. Georghiou, "Effective dynamic tariffs for price-based demand side management with grid-connected PV systems", in MedPower Conference, 2014, pp 1 - 6.

M. Norton, V. Paraskeva, R. Galleano, G. Makrides, R. P. Kenny and G. E. Georghiou, "High quality measurements of the solar spectrum for simulation of multi-junction photovoltaic cell yields", in 29th European Photovoltaic Solar Energy Conference, 2014, pp 1 - 6.

G. Makrides, J. Bratcher, J. Pratt and G. E. Georghiou, "Outdoor performance and reliability evaluation of different crystalline silicon photovoltaic modules with innovative packaging components", in 29th European Photovoltaic Solar Energy Conference, 2014, pp 1 - 6.

A. Kyprianou, A. Phinikarides, G. Makrides and G. E. Georghiou, "Robust principal component analysis for computing the degradation rates of different photovoltaic systems", in 29th European Photovoltaic Solar Energy Conference, 2014, pp 1 - 6.

A. Phinikarides, N. Philippou, G. Makrides and G. E. Georghiou, "Performance loss rates of different photovoltaic technologies after eight years of operation under warm climate conditions", in 29th European Photovoltaic Solar Energy Conference, 2014, pp 1 - 6.

A. Phinikarides, G. Makrides, N. Kindyni and G. E. Georghiou, "Comparison of trend extraction methods for calculating performance loss rates of different photovoltaic technologies", in 40th IEEE Photovoltaic Specialists Conference, 2014, pp 1 - 6.

## Projects

### **Renewable energy management for small and medium scale distributed generators in rural environment (GREEN+) (FOSS Partner)**

A NER300 funded project with coordinator the Electricity Authority of Cyprus (EAC) and FOSS as a partner in the national consortium. The mountainous and densely forested areas in Cyprus face challenges while trying to maintain a balance between reliable electricity supply and minimal impact on the sensitive local environment. The erection of transmission overhead lines and substations has been effectively brought to a halt in this area due to both protests from local communities as well as restrictions imposed by the Department of Forestry which seeks to maintain a minimum level of interference to the local environment. As a result, the EAC seems to be running out of options when it comes to network reinforcements and particularly additional installations necessary to keep up with increasing electricity demand especially during the most populated seasons (Principal Investigator for FOSS: George E. Georghiou).

Budget: €46,000,000 (Euros)

#### Main Outcomes:

- The main outcome of the project is to analyse and seek to radically address and give solutions to the issues of maintaining and balancing between reliable electricity supply and minimal environmental impact. In this way sustainable growth in the area will be promoted in addition to the much needed local economy boost.

Dates: 2014 – 2018

Partners: Electricity Authority Cyprus, University of Cyprus FOSS.

## Smart net metering for promotion and cost-efficient grid-integration of PV technology in Cyprus, SmartPV

The project “Smart net metering for promotion and cost-efficient grid-integration of PV technology in Cyprus” is co-financed by the EU through the LIFE+ Programme. It is an international project with FOSS as the coordinator ([www.smartpvproject.eu](http://www.smartpvproject.eu)). The project is in line with the general and specific objectives of LIFE+ environment, policy, and governance particularly as regards to contribution in implementation, updating and developing environmental policy.

The SmartPV project aims to thoroughly investigate net metering schemes for cost-effective and higher grid penetration of PV in Cyprus with the target of achieving a win-win scenario for both consumers and energy utilities. The project also focuses on consumer behavioural changes resulting from the pilot implementation of smart meters and net metering and on transferring know-how generated to mainland Europe and the region (Principal Investigator for FOSS: George E. Georghiou).



Weblink: <http://www.smartpvproject.eu/>

Budget: €1,219,838 (Euros)

Main Outcomes:

- development and validation of a cost optimum scheme for higher RES penetration in the energy mix of Cyprus;
- provision of market-driven incentives to consumers who become local producers (prosumers) thus alleviating the need for costly Feed-in-tariff (FIT) schemes to be in place;
- facilitate the implementation of and have a real contribution to environment policies adopted in Cyprus as set by the EU;
- usage of gained knowledge on optimization of net metering in Cyprus for the development of metering schemes & policies in other EU countries.

Dates: 2013 – 2017

Partners: FOSS University of Cyprus, Electricity Authority of Cyprus, Cyprus Energy Regulatory Agency, Department of Environment, Deloitte

## Promotion of PV energy through net metering optimization, PV-NET

The project aims to develop and enhance the energy policy for the promotion of renewable energies in Mediterranean countries, targeting the best and most cost efficient use of PV technology. It is an international project with FOSS as the coordinator. The focus is on the optimization of smart energy management systems in order to create alternative economic and sustainable measures through harmonization and reassessment of existing support schemes including government subsidies and grants. It further paves the way for more efficient RES exploitation in the Mediterranean. The project is co-financed by the European Regional Development Fund through the transnational cooperation programme MED. This is an innovative technology project which can contribute to the goals of the EU strategy on “Climate change and energy” and was approved under the priority Axis 2: Environmental protection and promotion of a sustainable territorial development (Principal Investigator for FOSS: George E. Georghiou).

Weblink: <http://www.pvnetmetering.eu/>

Budget: €1,279,526 (Euros)

Main Outcomes: The general outcome of the project is to drive energy policy in the Mediterranean region that will act to protect the environment and at the same time promote sustainable development in the region. Specifically, the main outcomes of the project include:

- a collection of studies for each country involved concerning the optimal net metering policies for connecting PV to the grid in residential, commercial, public and industrial buildings;
- a metering optimization tool that can be used by public authorities and electricity utilities to investigate the impact of proposed strategies in order to optimize the grid connection methods for a particular set of circumstances using net metering. The method and tool will be distributed to public authorities in the Mediterranean region for wider implementation;
- a set of guidelines resulting from the knowledge generated through the project execution, to be distributed to public authorities in the energy sector;
- the promotion of the tangible benefits of PV systems through high-profile demonstration and media campaigns targeting the citizens of each partner country;

Dates: 2013 – 2015

Partners: FOSS University of Cyprus, Andalusian Institute of Technology, Aristotle University of Thessaloniki, University of Maribor, Algarve Regional Energy and Environment Agency, Cyprus Energy Agency, Rhonalpennergie-Environment

## **Novel transient photovoltaic (PV) system models for the study of the power quality and fault behaviour under increasing penetration levels, NOVARIPOS**

Modelling PV systems by assessing in detail the transient behaviour of PV systems. In this framework, an accurate PV system model will be developed, simulated and experimentally validated. The PV system model will be verified by exposing the experimental setup to environmental and load variations and by comparing experimental with simulation results. Intentional islanding will be studied also to observe the dynamics of PV systems under fault conditions and make the required modifications for the improvement of the proposed model. The validated PV system model and its reduced representation will be used to study the power quality and fault response of the electricity grid, considering different PV penetration scenarios. Successful simulation, validation and demonstration of results can be considered as important steps in the development and exploitation of such new energy technologies. Collaboration with the local electricity authority will establish applicable guidelines for the installation of PV systems inside the electricity network to ensure that the quality of supplied energy is maintained at the desirable levels set by international standards. New knowledge gained from this work will finally enable the secure exploitation of PV technology without the concern of serious or unpredictable impacts to utility and its users. (Principal Investigator for FOSS: Andreas Kyprianou).

Budget: €70,000 (Euros)

Main Outcomes:

- development of an accurate and flexible model to represent the transient behaviour of a complete PV system structure;
- development of an experimental PV system setup which will be monitored by a state-of-art data acquisition system;
- creation of policies that will help the successful deployment/exploitation of PV technology;
- determination of technical requirements for PV systems to allow high PV penetration levels.

Dates: 2013 – 2015

Partners: University of Cyprus

## **Reliable assessment of degradation in new thin-film photovoltaic technologies, PV-DEGRADATION**

A national applied research project funded by EU development funds and the RPF. The objective of the project is to develop a protocol for evaluating degradation of thin-film and crystalline silicon PV by combining performance monitoring from systems, individual modules, and indoor characterization. At the University of Cyprus we monitor and assess the performance of PV systems operating in the field. Measurements are collected from both grid-connected systems and from current-voltage (IV) characterization of modules on the plane of the array. Indoor characterization is performed using electroluminescence, dark IV and testing at Standard Test Conditions (STC) using a solar simulator. PV-Degradation is a project that aims to analyse these measurements in order to formulate a robust protocol for the accurate determination of degradation. The protocol will be benchmarked in different regions and validated through round-robin procedures. (Principal Investigator for FOSS: George E. Georghiou).

Weblink: <http://www.pvtechnology.ucy.ac.cy/projects/pvdegradation/>

Budget: €174,426 (Euros)

Main Outcomes: The general outcome of the project is to enable those interested in photovoltaic energy production to be able to accurately measure the degradation of thin-film and crystalline silicon PV modules. This will allow them to select the technology with the best performance-to-cost ratio and the longest projected lifespan.

- Collection of high-quality, high-resolution PV operational and IV measurements from PV systems and modules installed in the field for the monitoring of their performance.
- Collection of high-resolution environmental and spectral data for evaluating the spectral performance of new thin-film PV technologies.
- Investigation of degradation in new thin-film technologies by the constant monitoring and testing of newly installed thin-film modules
- The development of a protocol for the determination of degradation on thin-film PV modules that will allow the standardization of the methodology proposed.

Dates: 2013 – 2015

Partners: University of Cyprus FOSS, Austrian Institute of Technology (AIT), Institut für Photovoltaik (ipv) University of Stuttgart, University of Barcelona and Cyprus Energy Regulatory Authority.

## Reviewing and Optimising L.V. Earthing Policy and Practice (EARTHOPT)

Thorough evaluation of current EAC earthing practice, from generation down to distribution level. Benchmarking theoretical approaches and methodologies to practical tests and field measurements, covering aspects related to fault level calculations (as per network topologies and type of faults) and external source impedance measurements. Assist E.A.C in specific short and large scale laboratory and field testing related to the specific scope of work. (Principal Investigator for FOSS: Charalambos. A. Charalambous)

### Main Outcomes:

- To perform a thorough literature survey covering the international practice of various utilities in earthing policy and application methods at distribution level.
- To evaluate the current EAC earthing practice, from Generation down to Distribution level.
- To benchmark any theoretical approaches and methodologies to practical tests and field measurements. These should cover aspects related to fault level calculations (as per network topologies and type of faults) and external source impedance measurements.
- To actively participate and assist in any E.A.C short or large scale laboratory and field tastings related to the specific scope of work.
- A detailed report and a technical earthing guidance memorandum for E.A.C and its clients have been produced.

Budget: ~€24,000 (Euros)

Weblink: <http://psm.ucy.ac.cy/research-projects/>

Dates: Nov. 2013 - May 2014

Partners: University of Cyprus, Electricity Authority of Cyprus

## Life Cycle Loss Evaluation of Power Transformers Serving Large Scale Renewable Energy Plants (EVLOCOST)

This project had firstly developed a comprehensive loss evaluation method of power transformers serving large scale solar applications. The fact that these transformers are obliged to serve an intermittent energy source calls for a suitable method to evaluate their life-cycle losses and total ownership costs. These transformers may be owned by Independent Photovoltaic Power producers or by Regulated Utilities. Thus, the method developed during the course of the project concurrently responds to the current efforts to address the concept of loss evaluation both in vertically-integrated and decentralized energy systems that are experiencing a high penetration of solar energy. A second dimension of the project relates to a probabilistic, life-cycle loss evaluation method to evaluate the Total Ownership Cost of power transformers that are obliged to exclusively serve large wind plants. The method introduced, responds to the ongoing efforts of developing risk and cost-based decision making processes in today's competitive and dynamic energy markets. Therefore, capitalizing the losses and consequently the ownership cost of transformers, serving intermittent wind energy sources, entails a probabilistic approach that integrates the financial and technical characteristics as well as the uncertainties of wind energy generation. (Principal Investigator for FOSS: Charalambos. A. Charalambous)

Budget: ~€24,000 (Euros)

Main Outcomes:

Please visit the following two websites for project deliverables:

<http://psm.ncy.ac.cy/loss-evaluation-method-for-power-transformers-serving-large-pv-plants/>

<http://psm.ncy.ac.cy/probabilistic-loss-evaluation-method-for-transformers-serving-large-wind-plants/>

Dates: Nov. 2012 - Nov. 2014

Partners: University of Cyprus, Electricity Authority of Cyprus

## MUREE Tempus IV

The project addresses the Jordan national priority for joint project of curricula reform, specifically modernisation of undergraduate curricula in renewable energy with emphasis on 3 cycle structure, ECTS and degree recognition. The project aims to develop and implement a new national undergraduate degree programme in renewable energy in Jordanian universities according to EU practices. It will foster significant development in the professional human capacity of Jordanian universities and allow strong partnership with EU partners. This proposal is highly supported the Higher Education Accreditation Commission in Jordan. The wider objective of MUREE is to develop, integrate, accredit and evaluate a quality bachelor degree programme in Renewable Energy in Jordan with an appropriate laboratory component jointly taught by universities in Jordan, in accordance with the Bologna process. (Principal Investigator for FOSS: George E. Georghiou).

This objective will be achieved through the following activities:

- Short visits for the staff of Jordanian universities to EU partner institutions, and vice versa, to develop the study plan and curricula, select and prepare the content of 4 traditional and 2 eLearning courses in renewable energy, 2 traditional and 4 internet labs, with appropriate VLE delivery system;
- Series of seminars and workshops, both in Europe and Jordan to prepare, run and evaluate teaching material of the renewable energy bachelor programme, its associated practical work and online content, competencies and VLE;
- Training visits for younger and female Jordanian staff to EU universities to upgrade their knowledge;
- Short visits by senior staff of Jordanian universities to EU partner institutions to observe the experience of EU institutions which have adopted the Bologna system and to hold seminars in Jordan to promote it.
- Inject entrepreneurial spirit into the university culture in Jordan through networking between universities and enterprises in Europe and Jordan.

Weblink: <http://muree.psut.edu.jo/Home.aspx>

Budget: 1,325,766.38 (euros)

Dates: 2012 to 2015

Partners: University of Cyprus FOSS, Princess Sumaya University for Technology (PSUT), The University of Jordan, Jordan University of Science and Technology, Mutah University, Hashemite University, Technical University of Berlin, National University for Distance Learning, Sapienza University of Rome, Graz University of Technology, IGFoton Ingenieros S.L. Company, Naim Energy Technologies.

### **Power Quality Measurements in Cyprus grid network**

The Power Quality Measurements project is a collaboration of Electricity Authority of Cyprus and University of Cyprus. The main aim of the project is to perform power quality measurements inside the distribution network of Electricity Authority of Cyprus and reveal the existence of possible power quality issues in order to take a proactive stance or undertake the appropriate measures (Principal Investigator for FOSS: George E. Georghiou).

Budget: €150,000 (Euros)

Main outcomes:

- to measure the power quality at different locations within the distribution network of Cyprus and
- analyse the power quality at different locations within the distribution network of Cyprus.

Dates: 2010 – 2015

Partners: University of Cyprus FOSS, Electricity Authority Cyprus.

### **Spatial mapping of the electricity network using GIS**

This project funded by the Electricity Authority of Cyprus (EAC) and FOSS as a partner aims the development of the digital spatial mapping of the electrical network of Cyprus. With the use of ArcGIS all LV, MV and HV power lines and substations are mapped including their technical specifications (Principal Investigator for FOSS: George E. Georghiou).

Budget: €633,250 (Euros)

Main Outcomes:

The main outcomes of the project include the digital geospatial mapping of:

- Cables (underground and overhead power lines)
- MV and HV substations

Dates: 2010 – 2015

Partners: University of Cyprus FOSS, Electricity Authority Cyprus.

## Advanced Photovoltaic Research and Testing for Improved Technologies, PV-UPGRADE

PV-UPGRADE is an infrastructure upgrade project funded by EU structural funds and Cyprus Research Promotion Foundation (RPF). The project proposes to study the real outdoor performance of a number of crystalline, thin-film and concentrator PV (CPV) systems. Outdoor testing of a variety of PV technologies at the state-of-the-art University of Cyprus (UCY) PV park is already producing valuable information. However, a full performance analysis requires standardized laboratory tests against control modules to quantify the output degradation that occurs due to long-term environmental exposure. A key project objective is therefore to upgrade the existing UCY infrastructure to include high-quality facilities for indoor testing to IEC standards 61215 for crystalline PV, 61646 for thin-film PV, and 62108 for CPV. The main activities of the project are: upgrading the current infrastructure in collaboration with the experienced partner institutions; creating a fully-trained, multidisciplinary team of researchers to staff the laboratory and maintain a critical mass of personnel, ensuring continuity of operation; obtaining long-term outdoor performance data from the PV systems at the site; performing standardized tests upon these PV modules and their controls; developing advanced indoor test and rating methodologies for new PV technologies in collaboration with other research institutions (Principal Investigator for FOSS: George E. Georghiou).

Weblink: <http://www.pvtechnology.ucy.ac.cy/projects/pvupgrade/>

Budget: €395,840 (Euros)

Main Outcomes:

- develop and implement a world-class facility in Cyprus for testing PV technologies to appropriate IEC standards and to implement a quality management system according to ISO 17025:2005;
- enhance the understanding of the performance and reliability of PV systems under environmental conditions found in Cyprus, with general implications for the various technologies;
- improve the existing testing and rating methodologies for CPV technologies;
- exploit the urgent need for high quality laboratories in this field;
- contribute to the field of energy research by providing wide access to such an infrastructure, both to Cypriot and EU researchers.

Dates: 2009 – 2013

Partners: University of Cyprus FOSS, Institut für Photovoltaik (ipv) University of Stuttgart, Centre for Renewable Energy Systems Technology (CREST), Austrian Institute of Technology (AIT) and Centre for Renewable Energy Sources (CRES).

## **Multi approach for high efficiency integrated and intelligent concentrating PV modules (systems), APOLLON**

The APOLLON project concerns the optimisation and development of Point focus and Mirror Based Spectra Splitting photovoltaic concentrating (CPV) systems (multi-approach). The different technology paths followed with due focalisation on the recognised critical issues related to each system component in order to increase CPV efficiency, assure reliability, reduce cost and environmental impact. Multi-junction (MJ) solar cells were manufactured by using new materials and deposition technologies allowing reaching and even surpassing the MJ solar cell efficiency target set on the European Strategic Research Agenda on Concentration Photovoltaics. Optimisation of Fresnel and Prismatic lens along with the development of new non-imaging, high concentration, cell self-protecting stable optics allow getting high optical efficiency and wide acceptance angles. New concepts were applied for Mirror based spectra splitting systems which allow eliminating the cooling needs. Both the optimised and the new technologies were properly tested to get reliable a long life time CPV systems. (Principal Investigator for FOSS: George E. Georghiou).

Budget: €11,800,000 (Euros)

Weblink: [http://www.pvtechnology.ucy.ac.cy/pdf/APOLLON\\_final\\_report.pdf](http://www.pvtechnology.ucy.ac.cy/pdf/APOLLON_final_report.pdf)

Main Outcomes:

- The main outcome of the APOLLON project was to develop High concentration Point Focus and Dense Array systems (MBS) based on monolithic and discrete MJ technology with a final target cost of 2 €/W.
- In order to answer to the industrial need to speed up the pre-qualification phase of the CPV systems, without risking to hinder the path toward more attractive solutions, which require longer developing time, the APOLLON Project has been divided in two developing phases.
- In the first one, an optimisation of the existing CPV technologies, from the cell component up to the system level, has been implemented.

Dates: 2008 – 2013

Partners: University of Cyprus FOSS, AIXTRON, CNRS, CPOWER, CRP, ENE, ENEA, ECN, JRC, NAREC.