



# FOSS

Research Centre for  
Sustainable Energy

## Annual Activity Report 2015



University of Cyprus  
Research Centre for  
Sustainable Energy

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## About the Centre

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

FOSS Research Centre for Sustainable Energy has been created to contribute to the energy transformation for a sustainable energy future in Cyprus, Europe and beyond and in the past two years substantial momentum has been gained towards this direction. In the first year of operation, the facilities, structure and running framework have been set up in order to lay solid foundations for critical work ahead. Since the beginning of its operation, but particularly this past year, significant funding has been attracted via competitive research grants: national, European as well as industrial.

To start with, FOSS researchers are currently participating in a number of projects concerning academic training, researcher mobility and course development in energy efficiency, innovation and renewable energy resources and which involve partners from Europe, the MENA region, Latin America and Asia. Furthermore, FOSS has secured European funding for projects focusing on innovative research including research in performance monitoring systems for improved reliability of PV, in grid integration of renewables and utilization of storage technologies. Most importantly, from the beginning of 2016, FOSS researchers will be engaged in a twinning project, which is a leading coordination and support activity of Horizon 2020. The project, titled “Stimulating scientific excellence through twinning in the quest for sustainable energy” (TwinPV; Coordinator: FOSS), is all about gaining strategic partners for collaboration, in this case the Austrian Institute for Technology (AIT) and the Technical University of Denmark (DTU). Both organizations are leaders in the field of PV technology and grid integration and through TwinPV, best practice and knowhow transfer as well as facility sharing will be enabled, leading to important capacity building in PV grid integration at FOSS.

FOSS also places great importance in generating and strengthening networking ties at both European and international level. In the past year, FOSS has made important strides in securing vital networking collaborations as well as reaching out to industry with academia-industry initiatives for developing its innovation and R&D portfolio. At local level, FOSS has developed important links with municipalities and key energy actors in Cyprus including the Municipality of Nicosia and Aglantzia, the Distribution System Operator (DSO), the Energy Regulatory Authority, the Department of Energy and the Department of Environment in Cyprus. FOSS is now focusing on employing scientifically excellent researchers to engage in the research work envisaged. Already a strong team has been set up comprising of PhD students, postdoctoral fellows and technical engineers. At the same time, students from various universities conduct short- and long- term internships at FOSS, in this way diversifying the FOSS team and enhancing networking with other universities and research groups. Through dedication and hard work we here at FOSS will strive to create the critical mass of researchers and academics necessary to push the research centre to go even further to achieve its goals and vision as well as provide significant impetus in the path for long-term sustainability for FOSS.

Dr. George E. Georghiou



## Message from the Chairman

**Growing stronger** are the two words that reflect the activities of FOSS within 2015. In content, in numbers, in collaborations, in partnerships, in publications, in projects, in awards, providing convincing evidence that the establishment of FOSS was a prudent decision much needed by the Cyprus economy. We strongly believe that this is just the beginning that has the potential to flourish into a living centre with knowledge and solutions in support of the sustainable economy of Cyprus, the Mediterranean and Europe. For this to happen though we need here in Cyprus and the university to see fundamental changes as to how we address research and innovation activities and how we create a supportive environment on which to build a sustainable process!



It is only natural that FOSS is active in the realm of the Energy Union of Europe aiming to play a role in the energy transition that is currently happening. We are trying to grow in a resilient Energy Union with an ambitious climate policy at its core to give EU consumers - households and businesses - secure, sustainable, competitive and affordable energy. We have identified a long term strategy for maturing within this vision set out by the Energy Union for:

- Member States seeing that they depend on each other to deliver secure energy to their citizens, based on true solidarity and trust;
- A sustainable, low-carbon and climate-friendly economy that is designed to last;
- Strong, innovative and competitive European companies that develop the industrial products and technology needed to deliver energy efficiency and low carbon technologies inside and outside Europe;
- A European labour force with the skills to build and manage the energy system of tomorrow;
- Citizens at its core, where citizens take ownership of the energy transition, benefit from new technologies to reduce their bills, participate actively in the market, and where vulnerable consumers are protected.

It is true to say that the world has never experienced such dramatic calls for transition as of today. We are called to face such radical and quick changes, in providing sustainable energy for all. We should address this knowing that this is the first driver for social and economic development. At the same time we know that these are real challenges in the troublesome world that we are living in today. What is happening around us is a real revolution and the awareness of the ongoing changes and the ability to positively influence them, is our drive for playing a positive role at the heart of this change. For achieving such a strategic result, the condition is knowledge development and sharing, through a network for knowledge transfer, involving all stakeholders in Europe and most specifically the Mediterranean Area where we want to play an active leading role.

We at FOSS have learned to walk in firm steps, creating the interlinked environment for future successes. You will find in this report the most important aspects of the work done in the second year of our existence and we reiterate that we look forward to the future with optimism for positively capturing the opportunities that are ahead of us!

Dr Venizelos Efthymiou

## 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

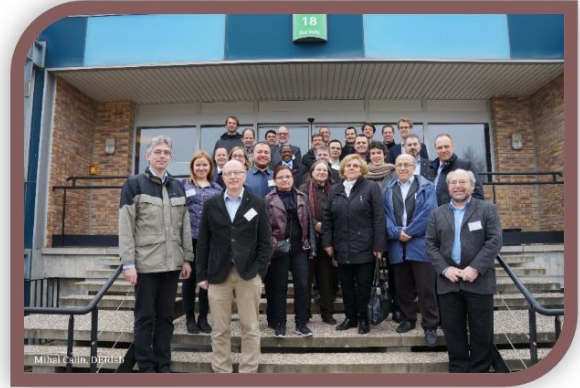
Dr. Charalambos A. Charalambous, Department of Electrical and Computer Engineering  
Prof. Charalambos D. Charalambous, Department of Electrical and Computer Engineering  
Dr. George E. Georghiou, Department of Electrical and Computer Engineering  
Dr. Demokritos Gregoriadis, Department of Mechanical and Manufacturing Engineering  
Dr. Christos Hadjichristos, Department of Architecture  
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://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/>



## International Energy Agency

The International Energy Agency (IEA) Photovoltaic Power Systems Task 13 workgroup aims to improve the operation, reliability, electrical and economic outputs of photovoltaic (PV) systems. The workgroup focuses to provide reliable information to the PV industry with respect to the different PV applications and system locations (e.g. different countries, regions, and climates), technical issues such as adapting



test methods and lifetime assessments and optimization of PV systems economic and institutional issues such as the comparison of investment costs and energy costs. FOSS members have been invited to participate as observers contributing to the activities of this initiative. Dr. George Makrides is participating in this task on behalf of FOSS Research Centre for Sustainable Energy and has already attended the 12th IEA PVPS Task 13 Expert Meeting in Leoben, Austria, on the 17th -19th March 2015.

## Collaboration Agreements

### Innovation and Entrepreneurship Centre of Deloitte

On the 8<sup>th</sup> October 2015 FOSS Research Centre for Sustainable Energy, University of Cyprus and Deloitte's Innovation and Entrepreneurship Centre signed a Memorandum of Understanding at the facilities of the University of Cyprus (PV Technology Lab) in Nicosia. The aim of the memorandum is to strengthen the framework of cooperation between the two organisations in the field of research and to promote further international cooperation with the ultimate objective to design optimum energy policies for better penetration of the renewable energy sources in the energy mix of Cyprus, with emphasis on the solar-energy based technologies.

The memorandum includes the exchange of information and know-how, the joint undertaking of research projects and studies, the submission of research proposals mainly through the European Union financing tools, the implementation of funded projects, but also the joint organization of events, workshops and meetings with the participation of all relevant stakeholders, aiming to encourage dialogue, awareness and the exchange of knowledge and expertise.



### Alfa Mediterranean Enterprises Ltd

FOSS and Alfa Mediterranean Enterprises Ltd aim through this collaboration to support research and innovation in the area of concentrated solar power (CSP) with thermal storage making the complete system supportive to the electricity grid since it can be dispatched according to the requirements of the energy mix.

Alfa Mediterranean owns and operates EOSOLAR, a fully licensed operator of the very successful Australian patented technologies of Lloyd Energy Systems, making complete CSP systems through a fully automated system with heliostats, 24 m towers with graphite tanks at the top to store the harnessed thermal energy and state of the art steam engines to deliver the electrical energy that operators desire to meet the active load profiles. FOSS as the technical and research advisors to EOSOLAR



are active in all phases of the projects that EOSOLAR is engaged in making the working relation very fruitful for both entities.

EOSOLAR is to install, for the first time in Cyprus, an innovative system that allows production of electricity from CSP assisting Cyprus to reach the targets set by the European Union regarding the share of renewable sources of energy in the electricity mix by 2020. The project is in the final stages of being licensed and it is the result of the successful bid to the “NER300” competition for innovative renewable energy technology to the European Commission. The EOSOLAR project has secured funding of €60.2 million through this process and it is going ahead as planned aiming to complete the ambitious objectives of the consortium within the time frame set out by the Commission.



## Services to the Community

### Education

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. FOSS also provides vocational training courses to professionals on energy issues.



### Academic Courses

#### **ECE447: Renewable Energy Sources: Photovoltaics**

This course covers theoretical and practical aspects of photovoltaic technology and in particular introduces students to aspects of solar generation, technology characteristics, design principles and system types. The course covers the following: Introduction to renewable energy sources with main emphasis on photovoltaic (PV) energy conversion. Current state in Cyprus and potential. Types of photovoltaic systems. History of photovoltaic technology development. Current status: Technology, Policy, Markets, System Design and Sizing, Grid integration.

#### **ECE687: BIPV - Towards nearly zero energy buildings (NZEB)**

This course covers theoretical and practical aspects of building integrated photovoltaics (BIPV) in the realm of nearly zero energy buildings (NZEB). The objective of the course is to train students in NZEB strategies and technologies in order to accelerate the adaptation of the recast EU Energy Performance in Buildings Directive (EPBD), which includes the obligation for all public buildings constructed after the 31<sup>st</sup> December 2018 and all buildings constructed after the 31<sup>st</sup> December 2020 to meet the EPBD NZEB standard.

## Vocational Training

### PV System Designer and Installer

This course covers theoretical and practical aspects for trainees to develop skills and understanding on the design and installation of both stand-alone and grid-connected photovoltaic (PV) systems alongside with innovative topics such as self-consumption, smart meters and storage.

The main topics covered throughout the course include initial site assessments of the installation area using site-survey equipment, risk assessment analysis, system design, installation and basics of commissioning, maintaining and troubleshooting PV systems. Emphasis is also given to all the requirements of a grid-connected PV system according to all related international standards with main focus the design qualification and type approval requirements of terrestrial PV modules, as outlined in IEC 61215 and 61646. The general performance testing requirements according to IEC 62446 are also defined.

### Grid connected PV System minimum requirements for system documentation, commissioning tests and inspection according to EN 62446

Ensuring the long-term quality and safety of a PV system is a necessary requirement in order to assure the best performance and to minimize risks of failure. In addition, the periodic verification of system performance is of utmost importance so as to check whether the system complies with warranty and equipment guarantees, minimizing in this way investment risks. This course covers theoretical and practical aspects for trainees to develop skills and understanding on the minimum requirements for documentation, commissioning and inspection of grid connected PV systems according to IEC 62446. Candidates have the opportunity to operate professional state-of-the-art equipment (located only in a few places globally) and to be trained by worldwide renowned personnel.

### New course on Nearly Zero Energy Buildings (NZEB)

At the end of 2015, a series of free postgraduate level training courses in Nearly Zero Energy Buildings (NZEB) begun around Europe as part of the European project MEnS (<http://www.mens-nzeb.eu>). In Cyprus the courses are offered by the University of Cyprus and specifically FOSS Research Centre for Sustainable Energy. These courses aim to empower building professionals through the development of skills in energy efficiency and integration of renewables in the retrofit of existing housing stock. The objective of the course is to train building professionals in NZEB strategies and technologies in order to accelerate the adaptation of the recast EU Energy Performance in Buildings Directive (EPBD), which includes the obligation for all public buildings constructed after the 31<sup>st</sup> December 2018 and all buildings constructed after the 31<sup>st</sup> December 2020 to meet the EPBD NZEB standard. The focus of the courses will be on the renovation of existing housing stock.

## Educational and Testing Centre

FOSS Research Centre for Sustainable Energy has just begun the procedure to become an Educational and Testing Centre, certified by the Ministry of Energy, Commerce, Industry and Tourism. We will keep the public updated about these new educational goals. FOSS extends its offer to the society by conveying knowledge acquired through its research activities and provides training and education courses to professionals.

### 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.



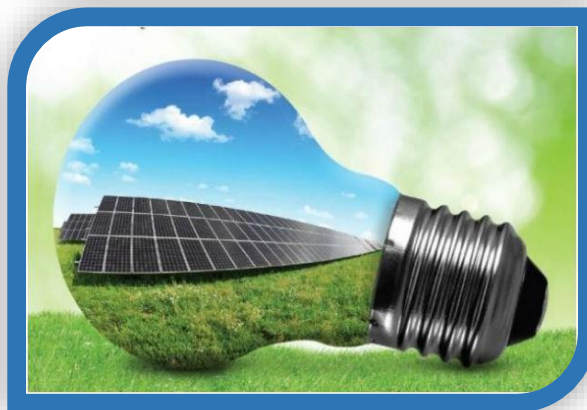
## Government, Local / Regional Authorities and Industrial Services

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

### Seminar aiming for a full and proper information on photovoltaics

An educational workshop titled: “Photovoltaics: good and bad options” was held on the 6<sup>th</sup> of May 2015 to fully inform the public about ways to ascertain the quality of photovoltaic systems and to promote the use of photovoltaic technology in Cyprus. Lectures were delivered on the following subjects: “Definition of quality in photovoltaics” by Dr. George Makrides, Quality Manager at the Photovoltaic Technology Laboratory, “Hidden risks in low-quality solar modules” from Mr. Alexander Phinikarides, Technical Manager at the Laboratory of Photovoltaics and speech entitled "Modern methods of determining the quality of the photovoltaics" by Dr. Ing. Markus Schubert, Deputy Director of the Institute for Photovoltaics (IPV) at the University of Stuttgart.



### Promotion of PV Technology – Challenges and Opportunities

FOSS, through PV-NET, organized the International Conference "Promotion of PV Technology-Challenges and Opportunities", on the 8<sup>th</sup> May 2015, in Cyprus with overwhelming success.

Distinguished speakers were invited by the partners of the PV-NET project that presented the international dimension of the photovoltaic state of the art. These were, the Head of European Commission Representation in Cyprus, Mr. Georgios Markopouliotis, the President of the European PV Technology Platform, Mr. Marco Topič, the representative of EURELECTRIC, Ms. Niina Honkasalo, the Research Associate at HEDNO/Islands Department – Greece, Mr. Antonios Tsikalakis and the representative of EnerStrat, Portugal.



## Workshop on the Spectrally Tuned Solar Cells for Improved Energy Harvesting

A workshop on Spectrally Tuned Solar Cells for Improved Energy Harvesting was held on the 29<sup>th</sup> June 2015, at the Social Facilities Centre, University of Cyprus. The workshop focused on photovoltaic cells that incorporate several active junctions in electrical series and which are exhibiting ever-higher laboratory efficiencies. However, due to the presence of only two terminals in multi-junction PV cells, characterization methods of these cells present additional challenges compared to single-junction ones. The measurement artifacts present during characterization were presented in detail. Outdoor assessment of tandem devices is required to examine the impact of spectral sensitivity of junctions upon their operating efficiencies. Previous studies have predicted that the energy yield at a specific site can be increased by a few percent by ‘tuning’ the spectral response of a triple-junction PV cell to better exploit the local spectral resource. The PV-TUNE project set out to test this hypothesis by designing an outdoor experiment to discover if modeled differences in energy yield arising from spectral response can be detected in the field. Initial analysis of outdoor measurements has revealed differences between the short-circuit currents and fill factors of the cells that is attributed to their spectral response. A detailed and reliable spectral irradiance dataset is needed to assess how the variations in solar spectrum can affect energy yield. The SMARTS atmospheric radiative transfer model was used to generate long-term irradiance data.

## Social Electricity Online Platform (SEOP) Conference

The conference took place on the 5<sup>th</sup> of November 2015 at the University of Cyprus (Social Facilities Centre) in Nicosia, Cyprus. More than 100 participants attended the event, including people from academia, the energy sector, representatives of companies and organizations from the electricity domain as well as university students. At first, the manager of the project, Prof. Andreas Pitsillides gave a welcome speech, commenting on the SEOP project in general. Then, Mr. Constantinos Xichilos, Deputy Director of the Energy Department, Ministry of Energy, Commerce, Industry and Tourism Cyprus delivered a welcome

message on behalf of the department of Energy of the Ministry. After the welcome, Mr. Panayiotis Keliris, Energy Officer at the Cyprus Energy Regulatory Authority (CERA) presented the electricity energy management policy for Cyprus, under the prism of CERA. The programme continued with three presentations which aimed to show the status and achievements of SEOP during its lifetime. First, Dr. Maria Solomou presented the SEOP Platform, involving four online learning modules for energy management, and



Dr. Andreas Kamilaris presented the evolution of the Social Electricity application through SEOP. Then,



Mrs. Jennifer Land discussed the pilot testing of SEOP as it took place in parallel in 8 European countries with the aim of evaluating the online products and tools developed through the project.

During the second part of the conference, two very interesting keynote presentations took place. First, Dr. Avraam Georgiou gave practical tips and advice, based on his research and personal experiences, on how to save energy at home and then Mr. Nikolas Philippou gave an introduction to the SmartPV project, studying how renewable technology and photovoltaics can become smoothly integrated to the grid of Cyprus. Finally, Mr. Wolfgang Eisenreich gave some ideas and directions for future work regarding how to sustain SEOP and Social Electricity after their lifetimes and how to exploit all these online products and tools.

### **FOSS Research Centre for Sustainable Energy at the inauguration of the European Interoperability Centre for Electric Vehicles and Smart Grids**

The inauguration of the European Interoperability Centre for Electric Vehicles and Smart Grids was held on the 28<sup>th</sup> – 29<sup>th</sup> October 2015 in conjunction with the International Symposium "Towards a Transatlantic E-Mobility Market" at the facilities of JRC (Joint Research Centre of the EC) in Ispra, Italy. The chairman of FOSS Dr Venizelos Efthymiou was an invited speaker among key stakeholders from the EU and the USA. The symposium was attended by high level representatives of the European Union, the government of the USA, industry, research organizations and academic institutions, policy makers, regulators, standardization bodies and grid Operators.



The inaugurated testing centre at Ispra, with the state of the art facilities, complements its partner facility in the US Department of Energy's Argonne National Laboratory which has been in operation since 2013 and together the two laboratories will ensure that the next generation of electric cars and smart grids are fully interoperable, based on harmonised standards, technology validation and testing methods. This is an important step towards creating "a single language" for all components that will benefit both the industry and the environment on both sides of the

Atlantic. More information about the two day symposium can be found at the following web address: <https://ec.europa.eu/jrc/en/event/other-event/inauguration-interoperability-centre>

## Awards & Honors

### Top prize at the 29<sup>th</sup> European PV Solar Energy Conference and exhibition

A team from the FOSS Research Centre of Sustainable Energy of the University of Cyprus (UCY) has won the top prize at the biggest conference for photovoltaics in Europe, the 29<sup>th</sup> European PV Solar Energy Conference and Exhibition (EU-PVSEC) which took place between the 22<sup>nd</sup> - 26<sup>th</sup> September 2014 in Amsterdam, Netherlands. The paper entitled “Robust Principal Component Analysis for Computing the Degradation Rates of Different Photovoltaic Systems” by Andreas Kyprianou, Alexander Phinikarides, George Makrides and George E.

Georghiou has won the best visual presentation award in the field of Operations, Performance and Reliability of Photovoltaics. Considered as one of the main features of the conference, the most outstanding visual presentations have been awarded from over 1500 scientific papers, based on the quality of the contents reported and on the quality of the presentation. The paper deals with the accurate estimation of the degradation rate of photovoltaic (PV) systems.



### Top Reviewer Award 2015, Renewable Energy

Dr. Minas Patsalides, special scientist of FOSS Research Centre for Sustainable Energy, has been chosen by the Editors of the journal Renewable Energy (RENE) as one of its most valued reviewers for the journal in 2015, taking into consideration the number of reviews he undertook for the journal, and won the Renewable Energy Reviewer Award 2015 in the second year of this new reviewer recognition programme. This Award is given only to reviewers that have completed 10 or more reviews. Elsevier, like most scientific publishing companies, relies on effective peer review processes not only to uphold the quality and validity of individual articles, but also the overall integrity of the journals they publish.



### Best Student Paper Award at the World's Largest Conference for Photovoltaics

PhD student Alexander Phinikarides of the FOSS Research Centre of Sustainable Energy and the PV Technology Laboratory of the University of Cyprus (UCY) has won the Best Student Paper Award at the world's largest conference for photovoltaics, the 42<sup>nd</sup> IEEE Photovoltaic Specialists Conference (PVSC) which took place between the 14<sup>th</sup> and 19<sup>th</sup> June 2015 in New Orleans, LA, USA. Out of more than 1500 submissions in 11 different technical areas, the paper entitled "Estimation of Annual Performance Loss Rates of Grid-Connected Photovoltaic Systems Using Time Series Analysis and Validation through Indoor Testing at Standard Test Conditions" by Alexander Phinikarides, George Makrides and George E. Georghiou

won the best student paper award in the area of System Performance Modelling, based on the technical contribution of the work in the field, the quality of the oral presentation and the student's role in the field of research.



### Journal paper included in Top 25 Hottest Articles

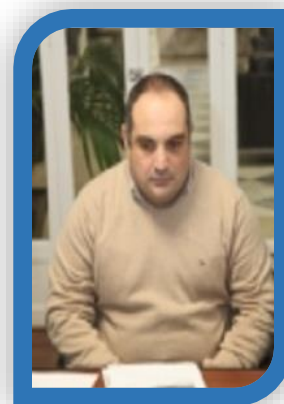
The journal paper by Dr. Alexandros Arsalis (Postdoctoral Research Fellow) and Prof. Andreas N. Alexandrou entitled "Thermoeconomic modeling and energy analysis of a decentralized liquefied natural gas-fueled combined-cooling-heating-and-power plant" published in the Journal of Natural Gas Science and Engineering (Volume 21, November 2014, Pages 209-220) was included in the Top 25 Hottest Articles in the period October to December 2014 in the category Earth and Planetary Sciences in ScienceDirect, Elsevier (link: <http://top25.sciencedirect.com/subject/earth-and-planetary-sciences/9/journal/journal-of-natural-gas-science-and-engineering/18755100/archive/57/>).



In this paper the authors propose a small-scale combined-cooling–heating-and-power (CCHP) plant as a possible alternative to large-scale, centralized, electricity-only power plants. The study analyzes whether the proposed system could be an ideal candidate for distributed generation applications, especially in locations which are distant from centralized power plants. The system considers fueling with liquefied natural gas (LNG), which is a safe and transportable fuel option. The study includes a basic thermodynamic analysis, followed by an energy and cost analysis. The simulation results signify a potential for further investigation of the proposed system, since its performance results in significant thermodynamic and environmental improvements, when compared to an equivalent conventional system.

### Highest citation on IET SMT papers in Google Scholar

The journal paper by Dr. D. Evagorou, A. Kyprianou, P. L. Lewin, A. Stavrou, V. Efthymiou, A. C. Metaxas and G. E. Georghiou, entitled “Feature extraction of partial discharge signals using the wavelet packet transform and classification with a probabilistic neural network” (IET Science, Measurement & Technology, Volume 4, Issue 3, May 2010, p. 177 – 192), was included in the 10 Top cited IET SMT papers in Google Scholar. The article was about Partial discharge (PD) classification in power cable accessories and high voltage equipment in general is essential in evaluating the severity of the damage in the insulation. In this article, the PD classification was realised as a two-fold process. Firstly, measurements taken from a high-frequency current transformer (HFCT) sensor were represented as features by means of a transformation to the classifier and secondly, the probabilistic neural network (PNN) classifier itself was capable of effectively recognising features coming from different types of discharges. The feature that was used as a fingerprint for PD characterisation was extracted from the moments of the probability density function (PDF) of the wavelet coefficients at various scales, obtained through the wavelet packets transformation. The PNN classifier was used to classify the PDs and assess the suitability of this feature vector in PD classification. Four types of artificial PDs were created in a high voltage laboratory, namely corona discharge in air, floating discharge in oil, internal discharge in oil and surface discharge in air, at different applied voltages, and were used to train the PNN algorithm. The results obtained here (97.49, 91.9, 100 and 99.8% for the corona, the floating, the internal and the surface discharges, respectively) are very encouraging for the use of PNN in PD classification with this particular feature vector. This article suggests a feature extraction and classification algorithm for PD classification, which when combined together reduced the dimensionality of the feature space to a manageable dimension, and achieved very high levels of classification.



## Publications

### Journals

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**Technical Reports**

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## Projects

### **Identifying The Hidden Costs of Net Metering Practices and Extrapolating Their Impact on Losses Cost and Benefit Allocation (HIDNET)**

Many residential electricity customers have (or will have) the ability to generate their own electricity using roof top PV systems. However, the current net-metering rules result in EAC incurring operating costs that are in addition to the costs accounted in its published domestic tariffs. This is attributed to the time varying nature of the costs associated with net metering. Moreover, it is widely claimed that net-metering practice will impact on the relative mix of fuel costs and reliability costs that a customer imposes on EAC. In general, under net-metering, fuel costs will decrease more than will the reliability costs. However, the fuel costs will not decrease proportionally with the decrease of the net energy requirements imposed by the PV net-metered customers. In contrast, there are increasing concerns that net energy metering policy may cause substantial cost shifts between energy customers with PV systems and other non-PV customers, particularly in the residential market.

To this end, one should consider a simple case where EAC has two net-metered customers that are served at the same point of the distribution network. In some occasions one customer may be delivering electricity at the same time that the other customer will be consuming electricity. Although they are served by the same distribution substation, the electricity meters used for their billing charges are at their premises. This may entail that the electricity meters are located several meters from the common point on the distribution system. The service wires to transfer the energy from one customer to another will unavoidably incur electrical losses. These electrical losses (which can be minor or substantial) are additional hidden costs incurred by EAC. These losses are caused by net-metered customers but eventually tolerated by other customers that do not have net-metering. The above enquiry poses a very interesting problem that inquires a thorough, top-down analysis framework. The analysis framework will be coupled to the University of Cyprus developed methodology on costing the losses up to the 11 kV distribution network.

Funding programme: Industrial funding

Budget: ~€40,000

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

Dates: January 2015 - April 2016

Partners: University of Cyprus, Distribution System Operator (DSO), Cyprus.

### **Meeting of Energy professional Needs (MEEnS)**

MENS is a project conceived in order to provide and enhance the Nearly Zero Energy Buildings (NZEB) skills of building managers such as engineers and architects through a series of accredited training activities developed by 9 universities and 3 market players. MENS aims: - To increase the knowledge and skills of at least 1800 building managers (engineers, architects) in NZEB design and construction, out of which 50% would be women or unemployed. - To create and implement a new education and training program for such professionals in 10 countries, under the European Qualifications Framework provisions and based on desired and common learning outcomes of Level 7.- To create and implement an innovative, interdisciplinary education and training program with an integrated approach, focusing on real case studies.

Funding programme: Horizon 2020

Budget: € 1,478,160.00

UCY: € 99,173.00

Dates: March 2015-August 2017

Partners: Energia-Da Srl, Knowledge Transfer Network Limited, Aristotelio Panepistimio Thessalonikis, Brunel University London, University Of Cyprus, Universitatea Tehnica Cluj-Napoca, Dublin Institute Of Technology, Energy Consulting Network Aps, Radio-Television Belge De La Communauté Française, Ss. Cyril And Methodius University In Skopje, Université Libre De Bruxelles, Universitaet Kassel, Universitat Politecnica De Valencia.

### **Early and reliable detection of degradation in photovoltaics (PV-EXPERT)**

The project primarily foresees the development of cooperation opportunities between Cypriot and Israeli organizations in the field of PV. Solar energy is vital for the future energy mix of both countries which makes the project very timely and important. The work targets to achieve the development of a novel tool for early detection of degradation in PV which will also include new critical failure and degradation modes emerging in hot climates. In order to achieve this, it is imperative to gain scientific understanding of the aging processes involved which compromise substantially PV performance. The ultimate goal of the project is to develop a novel PV performance monitoring system equipped with various advanced monitoring algorithms that enable reliable degradation rate estimation at the early-stage of operation of the PV systems, ensuring thus good quality installations to be ensured.

Specifically, the scientific and technological objectives of the proposed project include:

- The development of degradation rate algorithms that will reside as software modules on the existing PV performance monitoring system of the Israeli Company.
- A complete procedural protocol starting from data acquisition and filtering, outage correction to time series analysis techniques for the calculation of the degradation rate in real-time for PV systems. This need has been clearly highlighted recently in the relevant IEC and IEA committees.
- The assessment of new degradation and failure mechanisms, such as PID, that will lead to the development of novel models for accurate lifetime predictions based on real operating conditions. The models will be further integrated to the monitoring system as diagnostic and analysis tools for accurate measurement of PID and failure detection.

Finally, as the technological objective of the project is to integrate the developed algorithms and failure diagnostic models to a PV performance monitoring system, the end product will be essential to all stakeholders such as utility companies, integrators and investors and in general the PV community as a robust and reliable performance monitoring tool for operating PV systems.

Funding programme: Cyprus Research Promotion Foundation

Budget: € 379.800

UCY: € 94,320.00

Dates: June 2015-June 2017

Partners: University of Cyprus, GESOLAR Cyprus, M.G. Lightning.

### **Development of innovative educational material for building integrated photovoltaics (Dem4BIPV)**

The project's specific objective is to develop innovative educational material for higher education on the important topic of Building-Integrated Photovoltaics (BIPVs) while its ultimate aim is to improve the quality and relevance of higher education to the labour market needs, since there is currently a gap in the knowledge and skills of graduate architects, engineers, planners and designers etc. in relation to BIPV system installation. According to the EC (COM(2012) 669) European education and training systems continue to fall short in providing the right skills for employability, and are not working adequately with business or employers to bring the learning experience closer to the reality of the working environment. The project addresses this weakness by creating a new learning experience for graduates who are interested in specializing on BIPV, thus offering better and well-rounded education on this subject and bridging the gap between education and work.

Funding programme: ERASMUS+

Budget: € 421,381.00

UCY: € 105,830.00

Dates: September 2015-September 2018

Partners: University of Utrecht, University of Cyprus, Deloitte Cyprus, Fachhochschule Technikum Wien, Wirtschaft und Infrastruktur GMBH and Co.

### **Analysis of the present and future power system in Cyprus (Grid30)**

The Joint Research Centre (JRC) is the European Commission's in-house science service which employs scientists to carry out research in order to provide independent scientific advice and support to EU policy. Its work has a direct impact on the lives of citizens by contributing with its research outcomes to a healthy and safe environment, secure energy supplies, sustainable mobility and consumer health and safety. JRC is a key player in supporting successful investment in knowledge and innovation foreseen by the Horizon 2020 Work Programme, the EU's programme for research and innovation.

JRC was requested to conduct a study on the power grid system and the electricity market of Cyprus in order to shape a national strategy which meets the targets set for 2030. In addition to the EU strategy for 2030, this study will take into consideration the results of the study entitled "Renewable Energy Roadmap for the Republic of Cyprus", conducted by the International Renewable Energy Agency (IRENA), on behalf of the Cypriot government.

JRC issued a European tender and FOSS was selected as the most qualified partner to prepare the above very demanding study. With this partnership, FOSS has worked conscientiously to contribute to the energy issues of our country and successfully deliver all the undertaken deliverables. Most of the work was completed by the end of 2015 but pending work was scheduled to be delivered by the end of May 2016.

Funding programme: Joint Research Centre (JRC)

Budget: € 42,000.00

UCY: € 42,000.00

Dates: September 2015-April 2016

Partners: University of Cyprus, Joint Research Centre (JRC).

### **Development of higher education teaching modules on the socio-economic impacts of the renewable energy implementation (DESIRE)**

Better understanding of the socio-economic impacts of implementing renewable energy and energy efficiency (REEE) technologies enables faster and more sustainable development of the REEE market. However, this knowledge field is underrepresented in the existing technically overwhelmed teaching curricula at universities and hence, is considered a deficit that should be reduced. By doing this, a proper preparation of qualified working force needed to sustain the development of the REEE market will be ensured. The importance of this project comes from tackling this problem by integrating the socio-economic dimension in REEE teaching programmes offered at HEIs in beneficiary countries. In this context, this project aims at developing and implementing interdisciplinary teaching modules and training courses on the socio-economic impacts of REEE on university teaching level. While the teaching materials target graduate and post-graduate students, the training courses are designed to train the teachers involved in the process. The teaching modules will be prepared by the project partners in close cooperation with associated partners from the society, academia, public and private sectors.

Funding programme: ERASMUS+

Budget: € 985,055.00

UCY: € 102,963.00

Dates: October 2015-October 2018

Partners: German Jordanian University, University of Jordan, University of Cyprus, Cairo University, Aswan University, Sapienza University, Wuppertal Institute, Technical University of Dresden, Damascus University, Tishreen University.

### **Development of quality system through EnerGy Efficiency CourcEs (DIEGO)**

The main objective of DIEGO project is to improve the capacity of 6 Universities on renewable energy, energy efficiency and sustainability, training new experts prepared for the labour market. The project aims at answering the growing request of energy in Latin America and the necessity to cover it with clean and sustainable sources. All countries involved in DIEGO have a great potential in terms of renewable energy generation. The National Governments are promoting national laws in supporting RES adoption, mainly of small systems, which can contribute to the reduction of poverty, guaranteeing the electricity also in the remote areas. The application of new incentives and regulations for the spreading of RES has to be supported by the presence of experts and technicians in the field of renewable technologies.

Funding programme: ERASMUS+

Budget: € 991,350.00

UCY: € 80,446.00

Dates: October 2015-October 2018

Partners: Sapienza University of Rome, University of Cyprus, University of Cadiz Spain, Universidad San Carlos de Guatemala Guatemala, Universidad Rafael Landívar de Guatemala Guatemala , Universidad de la República Uruguay , Universidad Nacional De Chilecito Argentina, Universidad Nacional Del Sur Argentina , Universidad Nacional De San Luis.

**Promotion of Innovation Culture in the Higher Education in Jordan (INVENT)**

This project concentrates on strengthening and enhancing the role of higher education institutes and universities in innovation capacity building, technology transfer and commercialization of applied scientific research outcome in Jordan. Because of the limitation in natural resources and the relatively weak innovation-based industries, Jordan is expected to face economic difficulties during the next few years. Moreover, the rapid growth in population due to the normal increase and the forced migrations due to the political unrest in the region are expected to put the Jordanian economy under substantial pressure. The Jordanian economy is a developing-economy with most of its GDP coming from the services sector. The current national strategies focus on enhancing manufacturing and raising production in order to achieve a sustainable economic growth.

Funding programme: ERASMUS+

Budget: € 879.400

UCY: € 37.840

Dates: October 2015-April 2016

Partners: Jordan University of Science and Technology, University of Cyprus, The University of Jordan, Mutah University, Princess Sumaya University for Technology, Applied Scientific Research Fund, Hochschule für Technik, Wirtschaft und Kultur Leipzig, University of Deusto, Consorzio Arca, Paulo & Beatriz – Consultores Associados, Lda, Creative Thinking Development, Almotahida Education Group, Amman Chamber of Industry, Al Urdonial Lil Ebda, Higher Council for Science & Technology.



**European quality COurse system for Renewable Energy Development (ECO-RED)**

The increasing use of fossil fuels to meet growing Vietnamese energy demand (by 10% per year) goes against the need to prevent dangerous climate change. Renewable Energy Systems (RES) are a key solution. Vietnamese HEIs aren't offering a training program specialized on RES in either undergraduate or graduate level and their main goal is to become leading universities in Higher Education, looking to standardize education programs oriented to society demands and international accreditation criteria. ECO-RED project aims at contributing to the modernization, accessibility and Internationalization of 3 Universities in Vietnam (HUST, CUT and HCMUT), promoting the collaboration between Europe and Vietnam, supporting the adoption of innovative programmes and fostering a close collaboration between HEIs and labour market.

Funding programme: ERASMUS+

Budget: € 970,404.00

UCY: € 111,775.00

Dates: October 2015-October 2018

Partners: Hanoi University of Science and Technology, Ho Chi Minh University of Technology & Cantho University, Sapienza University of Rome, University of Cyprus and Jagiellonian University, Poland.

### **Smart Control Systems for Energy Management: New Master Degree (SEM-SEM)**

The Middle East countries are going through a period of change where governments are forced to address the need for greater access to economic opportunity. With a challenging economic environment and a growing social demand, governments believe that subsidy reform especially in energy and food might help reconcile social protection and secure fiscal positions. With almost \$17 billion spending every year in Egypt and \$2.3 billion spending every year in Jordan. Creating a smart energy environmental project will positively affect the consumption sector through monitoring consumers' habits for energy saving purposes. This project seeks to build a new consortium of academic partners in Egypt, Jordan and Europe, whose aim is providing the market with competent young professionals ready to manage and control smart systems. The consortium should also support young professionals, and developed industries with the required training and awareness for energy saving purposes.

A professional new masters degree in Smart Control Systems for Energy Management Engineering is to be established. This masters will develop mechanical and electrical engineers in the field of Quality Energy Management and Saving. Also, the ability to establish such masters program on time will fulfill the job market requirements. This project includes the Bologna system in Egyptian and Jordanian Universities. The new masters program will be designed to follow the Bologna system's instruction, which will encourage student exchange between the consortium members.

Funding programme: ERASMUS+

Budget: € 981,618.00

UCY: € 48,054.00

Dates: October 2015-October 2018

Partners: AIN Shams University, University of Cyprus, Alexandria co., Arab Academy for Science, Eurotraining Educational Organization, Helwan University, Instituto Superior Tecnico, Jordan Iniversity of science and technology, Mutah University, Nile University, Universidad de Oviedo, University of Jordan, Staffordshire University.

## **Stimulating scientific excellence through twinning in the quest for sustainable Energy**

### **(Twin PV)**

Twinning is a European Union instrument that aims at excellence through collaboration with world-renowned research institutions in Europe. The main aim of the project is to enhance the research conducted at the University of Cyprus (UCY) through targeted twinning activities with two internationally-leading research institutions, namely the Austrian Institute of Technology (AIT) and the Technical University of Denmark (DTU). In particular, the aim will be to stimulate excellence and innovation capacity at UCY primarily in the field of photovoltaics (PV) and grid integration in smart grids. Twinning activities will include knowledge transfer and exchange of best practice between AIT/ DTU and UCY. This project will entail significant benefits for all institutions involved in terms of enhancement of their Research and Innovation (R&I) capacity in science and technology and raising their staff's research profile.

It is envisaged that by twinning with AIT and DTU, FOSS Research Centre for Sustainable Energy will reach a high international calibre and will put Cyprus on the map as regards research excellence and technological development in which the country is currently underperforming. Moreover, it is anticipated that the project will form the knowledge basis for setting the appropriate mechanisms for boosting innovation practices at UCY and in Cypriot academia in general as well as transferring knowhow regarding building spin-off companies in Cyprus.

The project will begin on the first day of 2016.

Funding programme: Horizon 2020

Budget: € 1,012,173.75

UCY: € 388000.00

Dates: January 2016-December 2018

Partners: University of Cyprus, AIT Austrian Institute of Technology, Danmarks Tekniske Universitet.