ACROSS

Centre of Research Excellence
for Advanced Cooperative Systems

The 1st ACROSS Workshop on Cooperative Renewable Energy Systems

(ACROSS-WCRES 2012)

November 22, 2012, Zagreb, Croatia

IEEE CROATIA SECTION

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CAPACITIES

organized by:

Centre of Research Excellence for Advanced Cooperative Systems of the

University of Zagreb Faculty of Electrical Engineering and Computing

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Organizers

Centre of Research Excellence for Advanced Cooperative Systems, University of Zagreb Faculty of Electrical Engineering and Computing
Contributing groups:

- Laboratory for Renewable Energy Systems
- Optimal Control Group
- Electric Power System Dynamics, Automatization and Control
- Computer Aided Design of Distribution Networks
- Environmental Noise Control
- Autonomous Mobile Robotics

Sponsors

European Commission under grant no. 285939 (FP7-ACROSS)
University of Zagreb Faculty of Electrical Engineering and Computing
IEEE Croatia Section Control Systems Society Chapter
IEEE Croatia Section Power and Energy Society Chapter

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Mario Vašak, Croatia

Dear Colleagues,

On behalf of the Technical Programme Committee it is my pleasure to welcome you to University of Zagreb Faculty of Electrical Engineering and Computing (UNIZG-FER) for the First ACROSS Workshop on Cooperative Renewable Energy Systems.

Following the ACROSS project idea of inter-disciplinary approach to strategic research domains of robotics, embedded systems and renewable energy systems, the objective of the workshop is to bring together professionals from academia and industry in the area of systems control, power engineering and acoustics in order to foster synergy between them and identify cross-cutting research challenges in renewable energy systems engineering.

The workshop highlights challenges in different levels of renewable energy systems engineering: from (i) the renewable energy source level where efficiency, lifetime and environmental influence are addressed, through (ii) local sources integration level (microgrids) where cooperation of renewable sources with storages, loads and grid are addressed to (iii) power grid level where concepts of microgrids integration in smart grids are addressed. The Workshop program includes invited lectures by seven distinguished international researchers presenting state-of-the-art in renewable energy systems research and development, from both the academic and industrial perspective. Furthermore, the program is enriched with shorter talks given by ACROSS centre experts in control and power engineering which will be a representative cut-through of the current and planned research endeavours of UNIZG-FER in cooperative renewable energy systems and will help to identify synergy possibilities.

The Workshop is organized by the UNIZG-FER Centre of Research Excellence for Advanced Cooperative Systems (ACROSS Centre in short) and is funded by the European Commission under FP7 ACROSS project (grant no. 285939).

I wish you all a pleasant and successful participation in the First ACROSS Workshop on Cooperative Renewable Energy Systems.

With my best wishes,

Nedjeljko Perić

General Chair

Thursday, November 22, 2012; UNIZG-FER Grey Hall

	Opening session	
10:00… …10:15	**Welcome address, short info on ACROSS and workshop** Ivan Petrović, UNIZG-FER (ACROSS coordinator)	
10:15… …10:30	**Laboratory for Cooperative Renewable Energy Systems at UNIZG-FER** Nedjeljko Perić, UNIZG-FER Dean and Head of Laboratory for Cooperative Renewable Energy Systems	

	Renewable energy sources – design, operation and integration in the environment, Part I	
10:30… …11:00	**Invited lecture: Design of Very Large Wind Turbines: Challenges and Opportunities** Carlo L. Bottasso, Politecnico di Milano	page 6
11:00… …11:30	**Invited lecture: Acoustic Effect of Wind Turbines in Urban Residential Areas** Jian Kang, University of Sheffield	page 6

	Poster session	
11:30… …12:00	**R&D of UNIZG-FER ACROSS Team and Končar Electrical Industries in the Areas of Renewable Energy Systems and Energy-efficiency, Coffee break**	pages 13-14

	Renewable energy sources – design, operation and integration in the environment, Part II	
12:00… …12:30	**Invited lecture: Industry Experience in Design and Control of Renewable Energy Systems** Mate Jelavić, Končar Electrical Engineering Institute	page 7
12:30… …12:45	**Raising Availability of Wind Turbines: Generator-fault-tolerant Control** Mario Vašak, UNIZG-FER	page 13
12:45… …13:15	**Invited lecture: Control of Solar Thermal Plants** Eduardo F. Camacho, University of Seville	page 7

Thursday, November 22, 2012; UNIZG-FER Grey Hall

	Poster session	
13:15… …14:30	**R&D of UNIZG-FER ACROSS Team and Končar Electrical Industries in the Areas of Renewable Energy Systems and Energy-efficiency, Lunch**	pages 13-14

	Integration of renewable energy in the energy grid	
14:30… …15:00	**Invited lecture: State-of-the-art and Research Challenges in Microgrids Design and Operation** Pavlos Georgilakis, National Technical University of Athens	page 8
15:00… …15:30	**Invited lecture: Challenges in Power Converters for Renewable Electricity Integration in Smart Grids** Miro Milanovič, University of Maribor	page 9
15:30… …15:45	**UNIZG-FER R&D Projects in Cooperative Renewable Energy Systems** Mato Baotić, UNIZG-FER	page 11
15:45… …16:00	**Regional Cooperation of Smart Grids Technology Platforms Austria-Croatia-Slovenia** Davor Škrlec, UNIZG-FER	page 12
16:00… …16:30	**Invited lecture: Price-based Control of Electrical Power Systems: FP7-e-PRICE** Andrej Jokić, University of Zagreb Faculty of Mechanical Engineering and Naval Architecture	page 10

	Closing session
16:30… …17:00	**Drawing conclusions of the workshop: Identified cross-disciplines ties**

Design of Very Large Wind Turbines: Challenges and Opportunities

Carlo L. Bottasso, Politecnico di Milano, Italy

It is expected that the exploitation of off-shore resources will be achieved by very large wind turbines in the 10-20 MW class. By going off-shore, one can access large wind resources, often located in deep waters, avoiding some of the environmental and public acceptance concerns raised on-shore. Many innovative ideas are being proposed for the reduction of the cost of energy produced of these machines, including novel configurations at the system level, improved sub-components, advanced generators, cost-effective support structures, light-weight low-solidity and high-speed rotors equipped with active and passive load mitigation technologies.

The understanding of the effectiveness of all such innovations calls for advanced design tools and their validation, that can capture the relevant physical process and allow for the designer to explore with confidence the design space, understanding all necessary trade-offs. This is spurring a new wave of development of models and methods that improve on the capabilities that have supported so far the design of wind turbines. In this talk we will review some recent developments in this field, present some relevant applications, and highlight future needs and areas where progress still needs to be made.

Acoustic Effect of Wind Turbines in Urban Residential Areas

Jian Kang and Chia-Jen Yu, University of Sheffield, United Kingdom

Wind turbines, as an important source of renewable energy, have many advantages from the environmental sustainability viewpoint, but they could also cause serious noise pollution. The aim of this study is to explore the sound distribution patterns of wind turbines in urban areas, especially residential areas, so that the effect of urban texture can be examined. The acoustic simulation with generic urban configurations shows that wind turbines could have significant noise effects in a large area, especially in the case of multiple sources. The effect of land form is insignificant in terms of the difference caused in source-receiver distance, but various land forms can bring considerable SPL differences in terms of noise barrier effects of buildings and ground profile. In terms of turbine height, when it is increased from 10 m to 46 m, the SPL increase could be 10-20vdB in far fields. The simulation in two existing residential areas with added wind turbines shows that between wind turbines and road traffic, the noise effects have significantly different tendencies, due to the differences in building arrangements and densities, as well as frequencies. At lower frequencies the effect of wind turbines is more significant than that at higher frequencies and this difference is greater with increasing building height and density. It is therefore important to consider the consequent patterns of complaints when new wind turbines are planned.

Industry Experience in Design and Control of Renewable Energy Systems

Mate Jelavić, Končar Electrical Engineering Institute, Croatia

The talk will bring up some of the Industry experience gained in the KONČAR Electrical Industries over the realisation of recent renewable energy projects. Two case studies will be covered: Megawatt-scale wind turbines and Autonomous hybrid power supply system. The focus with both case studies will be put on the control system. The control system design, testing and optimisation process will be described.

Megawatt wind turbines are very complex plants operating unmanned in harsh weather and operational environment. Their safe and efficient operation relies on their control system so great efforts have been made in KONČAR in order to optimise the system for the particular operating conditions. Some of the improvements in the control algorithms necessary for a wind turbine to cope with extremely strong and turbulent winds present in the coastal part of Croatia will be explained. Attention will be also paid to the control system sustainability defined as the capability of the producer to support the system over long life time (typically 20 years for wind turbines). A possible solution through a platform approach will be presented.

The autonomous power supply systems usually utilise the primary sources – sun and wind to feed the off-grid or weak-grid consumption while excess energy is stored in batteries. This basic concept has been augmented in the KONČAR Hybrid Box® solution with hydrogen fuel cells. In this way a 100% coverage of the load is assured while the zero emission operation is maintained. The design and operation of such a system will be described. Again, the special emphasis will be put on the control system and its optimisation to achieve safe and efficient plant operation.

Control of Solar Thermal Plants

Eduardo F. Camacho, University of Seville, Spain

The use of renewable energy, such as solar energy, experienced a great impulse during the second half of the seventies just after the first big oil crisis. At that time economic issues were the most important factors and the interest in these types of processes decreased when the oil prices fell. There is a renewed interest in the use of renewable energies nowadays driven by the need of reducing the high environmental impact produced by the use of fossil energy systems. There are two main drawbacks of solar energy systems: a) the resulting energy costs are not yet competitive and b) solar energy is not always available when needed. Considerable research efforts are being devoted to techniques which may help to overcome these drawbacks, control is one of those techniques. A thermal solar power plant basically consists of a system where the solar energy is collected, then concentrated and finally transferred to a fluid. The thermal energy of the hot fluid is then used for different purposes such as generating electricity, the desalination of sea water etc. While in other power generating processes, the main source of energy (the fuel) can be manipulated as it is used as the main control variable, in solar energy systems, the main source of power which is solar radiation cannot be manipulated and furthermore it changes in a seasonal and on a daily base acting as a disturbance when considering it from a control point of view. Solar plants have all the characteristics needed for using advanced control strategies able to cope with changing dynamics, (nonlinearities and uncertainties). As fixed PID controllers cannot cope with some of the mentioned problems, they have to be detuned with low gain, producing sluggish responses or if they are tightly tuned they may produce high oscillations when the dynamics of the process vary, due to environmental and/or operating conditions changes. The use of more efficient control strategies resulting in better responses would increase the number of operational hours of the plants. The talk describes the main solar thermal plants, the control problems involved and how control systems can help in increasing their efficiency. Some illustrative examples are given.

State-of-the-art and Research Challenges in Microgrids Design and Operation

Pavlos S. Georgilakis and Nikos D. Hatziargyriou, National Technical University of Athens, Greece

Microgrids and multi-microgrids are state-of-the-art low and medium voltage (MV) power distribution networks consisting of distributed generation (DG) units, storage devices and flexible loads, operated connected to the main power network or islanded, in a controlled, coordinated way.

The multi-microgrids are related to a higher level structure, formed at the MV level, consisting of several microgrids and DG units connected on several adjacent MV feeders, together with controllable MV loads. The coordination of several microgrids and other DG units requires the adoption of a hierarchical control scheme that enables the multi-microgrids to provide the flexibility and controllability necessary to support secure system operation even when isolated from the upstream high voltage network.

From the customer point of view, microgrids and multi-microgrids provide both thermal and electricity needs, and in addition enhance local reliability, reduce emissions, improve power quality by supporting voltage and reducing voltage dips, and potentially lower costs of energy supply. From the Utility point of view, application of distributed energy sources can potentially reduce the demand for distribution and transmission facilities. Clearly, distributed generation located close to loads will reduce flows in transmission and distribution circuits with two important effects: loss reduction and ability to potentially substitute for network assets. Furthermore, the presence of generation close to demand could increase service quality seen by end customers. Micrograds can provide network support in times of stress by relieving congestions and aiding restoration after faults. These benefits need to be quantified and incorporated into an appropriate commercial and regulatory framework.

Technical challenges associated with the operation and control of microgrids are immense. Effective energy management within microgrids is a key to achieving vital efficiency benefits by optimizing production and consumption of heat, gas and electricity. The coordinated control of a large number of distributed sources with probably conflicting requirements and limited communication is a very challenging problem imposing the adoption of distributed intelligence techniques.

Challenges in power converters for renewable electricity integration in smart grids

Miro Milanovič, University of Maribor, Slovenia

Energy shortage, limited sources of fossil fuels, greenhouse gas emissions, and political decisions in the European countries provoke the researcher to increase the use of renewable energy sources. The solar radiation that reaches Earth’s surface is a renewable energy source. It is converted into electricity in Photovoltaic Power Plants (PVPPs) using solar cells and inverters. The inverter provides the conditioning of the solar cells and converts the direct voltage from the solar cells into the electricity network alternating voltage. The inverter structure and operation principle must provide the conversion of solar radiation into electricity with the best possible efficiency. From this point of view the emerging micro-inverters seem to be one of the most promising solutions, where the most challenging part of research, concerning optimal inverter topologies, operation principles as well as integration of components and functionalities, has to be done. The existing electricity networks were not designed to accept a mass penetration of distributed electricity generation, like PVPPs. Therefore, their mass penetration causes problems concerning power quality, voltage profiles and stability in the electricity networks. These problems should be solved with the developing concepts of active electricity networks called “smart grids”, where each distributed generation unit actively contributes (mostly with reactive power but also with active power generation) to the stable operation with acceptable power quality and voltage profiles.

A smart grid is an electrical grid that uses information and communications technology to gather and act on information, such as information about the behaviours of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. The smart grid idea can be applied on the connection of power sources as are photo-voltaic systems.

Price-based Control of Electrical Power Systems

Andrej Jokić, University of Zagreb Faculty of Mechanical Engineering and Naval Architecture, Croatia

The EU electric power system experiences a fundamental change in the quasi-monopolistic, top-down oriented, stable, and reasonable predictable arrangements of the past. It now spans continents, has hundreds of millions consumers and hundreds of thousands of producers, from nuclear power plants to privately-owned and operated badly predictable renewables such as solar cells, wind and microturbines and operates in an increasingly liberalized market. These developments pose huge challenges for its reliable and economic operation. E-Price project focuses on the real-time power imbalance in the power net, which arises as a consequence of errors in the prediction of both production and demand. As this power imbalance will increase both in size and in frequency, present arrangements to cope with this imbalance are no longer valid. They are neither reliable nor economic anymore. This project proposes an advanced ICT and control framework for ancillary services (reserve capacity) which allows a more intelligent solution by giving consumers and producers clear, real-time financial incentives to adapt their consumption/production according to the actual needs of the power system. This design is based on a distributed control structure, enabled by a fast ICT infrastructure and advanced control theory to reliably and economically deal with the necessary ancillary services. Decisions by consumers, producers, power exchanges and TSOs can be taken locally, based on local or national preferences and regulation. Still, the embedded incentives of the proposed framework can guarantee that all these local decisions together contribute to the global objectives of the EE power net: a reliable electric energy supply at the lowest costs.

Instead of investing in additional expensive and environment-unfriendly reserve production or storage facilities with a low utilization rate, the reliability and economy are enforced by intelligent ICT and control.

Raising Availability of Wind Turbines: Generator-fault-tolerant Control

Mario Vašak, UNIZG-FER, Croatia

The task of UNIZG-FER within project MONGS – Monitoring of Wind Turbine Generator Systems was to develop fault-tolerant control algorithms for common wind turbine generator faults: rotor bar defect and stator winding isolation fault. The developed fault-tolerant control ensures that the diagnosed generator fault no longer propagates and that the energy production of the wind turbine is kept on the maximum attainable level under emergency circumstances. The fault-tolerant control is thought as an autonomous reaction mechanism to diagnosed, localized and characterised faults, where fault diagnosis represents the recognition of fault, localization represents the determination of the fault location on the machine flux path and characterisation represents the determination of maximum allowed stress on the faulty part of the machine. The focus was put on squirrel-cage induction machines used in wind turbines.

The undertaken research has yielded a general procedure for fault-tolerant control in case of diagnosed, localized and characterised generator faults in wind turbines. The basic idea resides on the fact that the instantaneous locations of the machine stress are related to the current locations of the machine magnetic flux amplitude as well as to its movement relative to the faulty part. Following that, stress on the machine components is reduced prior to the moment when some of the machine flux amplitudes reaches the localized faulty part on the machine flux path, in a way that the stress on the faulty part is kept at or below the maximum allowed level. On the remaining part of the flux path (the healthy part) the machine stress is manipulated always below its nominal value in a way to allow the wind turbine operation to be kept on the optimum level for certain faulty conditions. This procedure is applicable to various types of generators, especially large-power generators where it is not allowed or desired to simply stop the generator whenever a fault is diagnosed.

UNIZG-FER R&D Projects in Cooperative Renewable Energy Systems

Mato Baotić, UNIZG-FER, Croatia

The talk gives a brief description of UNIZG-FER involvement in two projects in the area of cooperative renewable energy systems.

AEOLUS - Distributed Control of Large-Scale Off-shore Wind Farms (FP7 project, 2008-2011)

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A typical wind farm behaves as an uncoordinated collection of wind turbines (i.e., as a source of significant stochastic disturbances in the power system), with each turbine independently controlled to maximize its local power production. However, to ensure full integration of wind farms in the electric power system, as demanded by the grid codes, they should respond to the requirements of the grid operator similarly to the classic power plants. The main goal of Aeolus was to research and develop models that allow real-time predictions of flows and incorporate measurements from a set of spatially distributed sensor devices. In Aeolus the flow information is used as a basis for new control paradigms that acknowledge the uncertainty in the modelling and dynamically manage the flow resource in order to optimise specific control objectives.

MICROGRID - Optimization of Renewable Electricity Generation Systems Connected in a Microgrid (Croatian Science Foundation, 2012-)

The main problem in the usage of renewable electrical energy sources (REES) is their intermittency, which leads to problems in regulation of the power system. This problem exists both on a local production/storage/consumption level and on the power system level and becomes more pronounced with the increasing contribution of REES in the total energy production. A natural solution is to derive a coordinated and dynamic planning strategy for production/storage/consumption of electric power. With a local information- and power-connection of REES, energy storage facilities, and consumers in a system – a microgrid – one can control resulting energy flows while considering techno-economical criteria and the local energy yield forecast.

Regional Cooperation of Smart Grids Technology Platforms Austria-Croatia-Slovenia

Davor Škrlec, UNIZG-FER, Croatia

Regional initiative for cooperation within Framework Programme 7 in the area of Smart Grids was launched in 2007. in Vienna during the meeting organized by Austrian Institute for Technology. As a result of this meeting Austrian Technology Platform started in 2008. and Slovenian Technology Platform in 2009. They are organised on the principles of EU Smartgrids technology platform. In 2010 an initiative for establishing national technology platform also arose in Croatia. Most activities of regional cooperation are conducted by joint applications on calls for research projects, partnership within Smartgrids ERANet, EEGI and Grid+ initiatives/projects. From 2010 researchers and professional engineers from these countries organize annual meeting where they have opportunity to present results from demonstration and research projects in smart grids area, and exchange practical experience. More about national technology platforms can be found on web pages – http://www.smartgrids.at, http://www.smartgrids.si and http://www.smartgrids.hr.

AEOLUS – Distributed Control of Large-scale Off-shore Wind Farms

Vedrana Spudić, Mate Jelavić, Mato Baotić, Nedjeljko Perić,
UNIZG-FER, Croatia

MONGS – Monitoring of Wind Turbine Generator Systems

Vinko Lešić, Nedjeljko Perić, Mario Vašak, UNIZG-FER, Croatia

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ThermalMapper – Thermal 3D Modeling of Indoor Environments for Saving Energy

Ivan Maurović, Marija Đakulović, Ivan Petrović, UNIZG-FER,
Croatia

Multiwind – Multi-criteria Wind Turbine Control

Vedran Bobanac, Martina Marinković, Marko Gulin, Nedjeljko Perić,
UNIZG-FER, Croatia

Advanced Control and Estimation Strategies in Complex Systems

Vlaho Petrović, Tamara Hadjina, Nikola Hure, Nedjeljko Perić,
UNIZG-FER, Croatia

Control System of the Fuel Cells Energy Source with the Cogeneration

Toni Bjažić, Tomislav Pavlović, Željko Ban, UNIZG-FER, Croatia

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Microgrid – Optimization of Renewable Electricity Generation Systems Connected in a Microgrid

Marko Gulin and Mato Baotić, UNIZG-FER, Croatia

UrbanWater – Intellignet Urban Water Management System

Mario Vašak, UNIZG-FER, Croatia

CADDIN – Computer Aided Design of Distribution Network

Matija Zidar, Davor Škrlec, Marko Delimar, UNIZG-FER, Croatia

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Environmental Noise Control

Hrvoje Domitrović, Kristian Jambrošić, UNIZG-FER, Croatia

Wind turbine control system KONCAR KONwecs

Končar Electrical Engineering Institute, Croatia

Hybrid autonomus power supply KONCAR Hybrid box

Končar Electrical Engineering Institute, Croatia
