Introduction to NTUA Smart Grid Research Activities

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Smart Grids Research Unit – Electric Energy Systems Laboratory

School of Electrical and Computer Engineering

National Technical University of Athens

ERIGrid Workshop "Advanced power system testing using Hardware in the Loop simulation", 23 Nov. 2018, NTUA, Athens

National Technical University of Athens (NTUA)

National Technical University of Athens (NTUA)

- Foundation year: 1837
- 9 Schools, 512 faculty members, 4.090 external collaborators, 23.914 students
- At NTUA operate 194 laboratories. In 2015, there were ongoing 1423 national and European research projects.
- Of the 120.000 qualified engineers active today in Greece, over 40% are NTUA graduates.

National Technical University of Athens (NTUA)

1. School of Civil Engineering
2. School of Mechanical Engineering
3. School of Electrical and Computer Engineering
4. School of Architecture
5. School of Chemical Engineering
6. School of Rural and Surveying Engineering
7. School of Mining Engineering and Metallurgy
8. School of Naval Architecture and Marine Engineering
9. School of Applied Mathematical and Physical Science

School of Electrical and Computer Engineering
Division of Electric Power

Laboratories:

1. **Electric Energy Systems**
2. Electric Machines and Power Electronics
3. High Voltages and Electrical Measurement Techniques
4. Economic-Energy-Environment Modelling
5. Lightning

Electric Energy Systems Lab - Personnel:

- 5 Professors: N. Hatziargyriou, E. Dialynas, C. Vournas, G. Korres, P. Georgilakis
- PhD students, Post-doctoral researchers, research associates
- Administrative and technical staff

The Smart Grids Research Unit – Smart RUE – operates in the framework of the Electric Energy Systems Laboratory.

Research Areas of the Electric Energy Systems lab

- Transmission & Distribution
- Power System Planning
- Power System Analysis
- Power System Stability
- Power System Dynamic Performance
- Dynamic Security Assessment
- Power Control Techniques
- Probabilistic load flow
- Contingency analysis
- State estimation
- Power system protection
- Smart Grids
- Microgrids
- Application of Artificial Intelligence techniques
- Decentralized Control Concepts
- Distributed Generation
- Renewable Energy Resources
- Energy Storage
- Electric Vehicles
- Unit commitment – Economic dispatch
- Energy market

✓ Participation in 38 research projects funded by the EU (coordinated 8 projects)

✓ Collaboration with several industries & utilities: HEDNO, PPC, RAE, IPTO, etc.

Distribution network control

SuSTAINABLE

- New tools for control and operation of the distribution network
- Adaptive protection of distribution network
- RES and load forecast
- Application of the forecast on Rhodes island

iGreenGrid

- Advanced methods for increasing the RES hosting capacity. Solving problems due to DG integration
- 6 pilot projects on MV and LV networks
- Applications on HEDNO network (RES forecast, probabilistic load flow)

DREAM

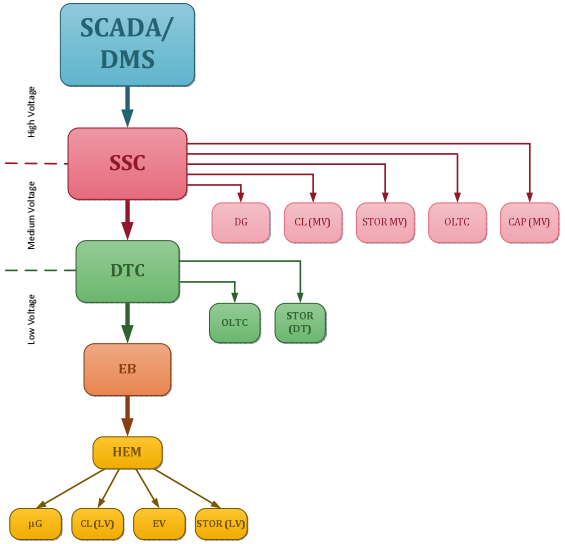
- New tools for management of the distribution network
- Distributed control of the network
- Pilot installation at Meltemi field camp

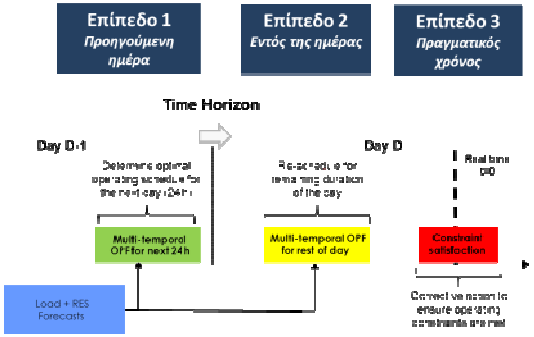
Active Distribution Networks

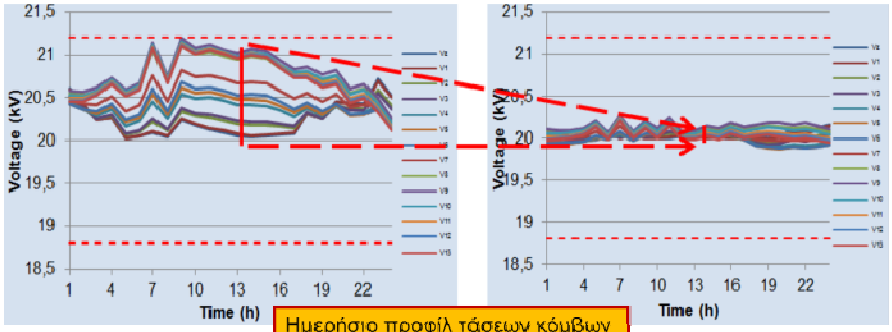
Project Sustainable: **Smart Distribution System Operation for Maximizing the Integration of Renewable Generation**

Development of advanced control concepts of distribution networks:

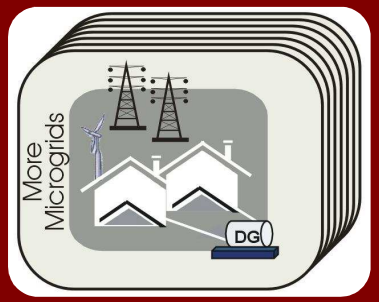
- Load & RES forecast
- State estimation
- Optimum operation (voltage control, losses etc)
- DG and storage management
- Protection







Microgrids (1/2)

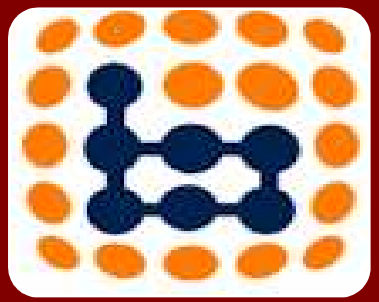


More Microgrids

- Study of all the aspects of microgrids
- New technologies for protection and control
- 7 pilot demonstrations

SmartKYE

- Development of an integrated platform for load management on a neighborhood level
- Public lightning, DG, electric vehicles and buildings
- Applications in Barcelona and Crete



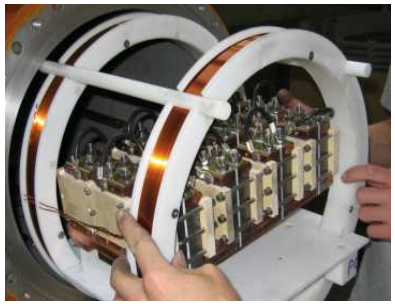
BEAMS

- Development of an integrated platform for load management and DG
- The main goal is the improvement of energy efficiency of the installations
- Applications on football stadium Camp Nou (F.C. Barcelona)

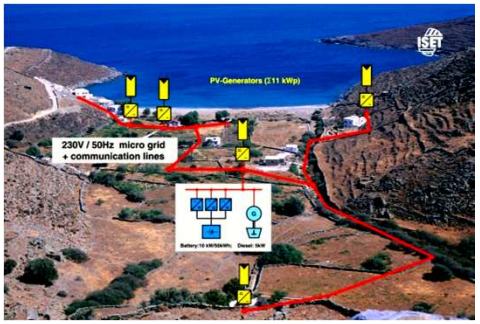
Microgrids (2/2)

The projects Microgrids / More Microgrids aimed at study of all the aspects of microgrids:

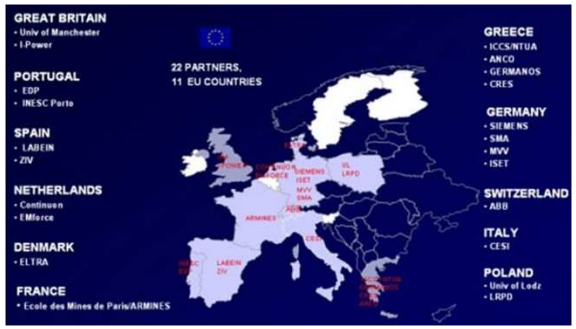
- New DG technologies, power electronics, protection, control of residential loads
- Development of control strategies: centralized and decentralized
- New technologies, e.g. DC Microgrids
- Coordination of several microgrids (Multi-Microgrids)
- Standardization issues
- Demonstration in 7 locations
- Effect of microgrids on the operation and development of the distribution network



Testing of fault current limiter



Kythons microgrid



22 participants from 11 countries

Forecast of RES production and loads

Anemos.plus

- Wind production forecasts: including probability of error
- Development of management tools which take into account the error probability
- Applications in Crete

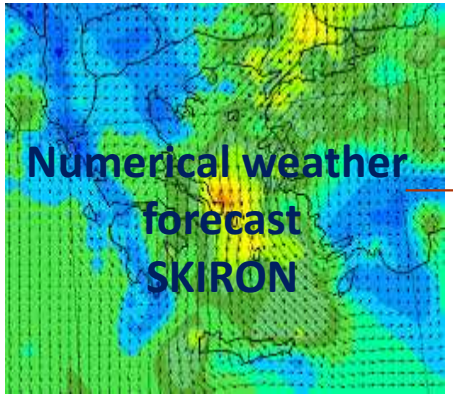
SafeWind

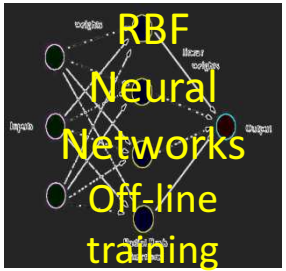
- Short-term forecast (0-6 hours) of extreme variations of RES production
- Mid-term (2-3 days) estimation of the behavior of Wind Parks
- Applications in Crete

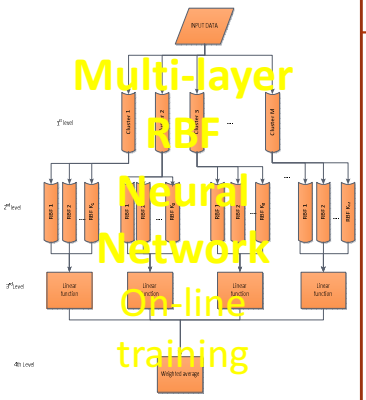
ANEMOS

- First generation of forecast tools
- Applications in Crete

Software package: Forecast of wind farm and PV generation & loads







W/F ANEMOS ALKYONIS

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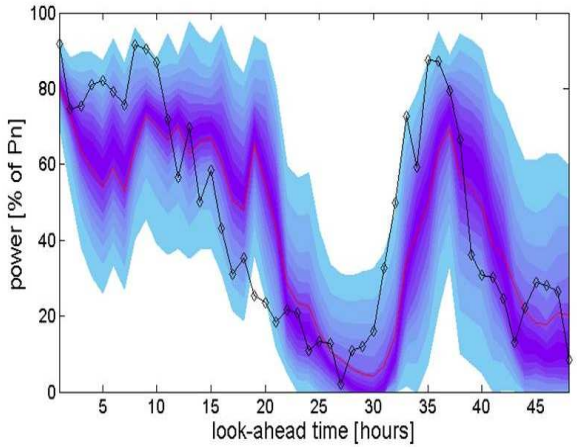
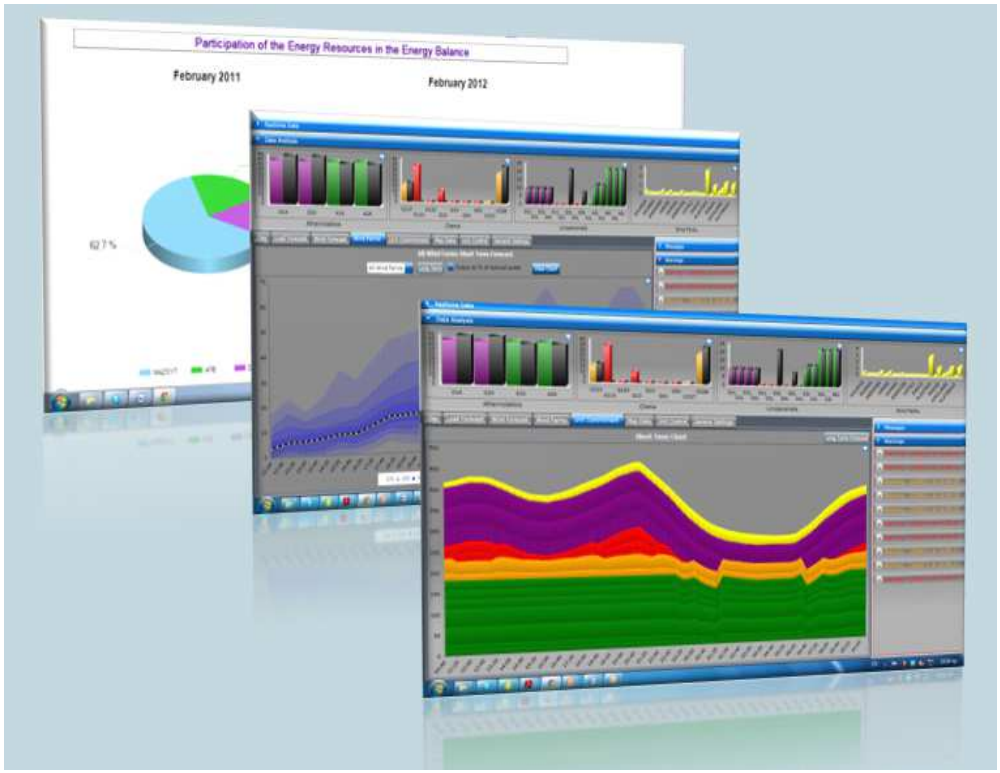


Applied to:

- Optimum integration of RES
- Dispatch of Power units
- Energy market
- Solving congestions

Energy Management and Efficiency software package for remote installations

- Forecasting of load consumption, wind and PV production
- Optimization/ Unit Commitment/ Scheduling
- Dynamic security monitoring
- Monitoring of energy efficiency with statistical and mathematical indices
- User friendly graphic environment
- Successfully tested in non-interconnected islands with high RES penetration in Greece and abroad



Research Projects- Electric Vehicles (Evs)

MERGE

- Impact study of the additional charge load of electric vehicles on power networks
- Analysis of regulatory issues in EU countries
- Developing a Roadmap for electric mobility

FastInCharge

- Standardized inductive charging station to charge electric cars either stationary (static charger) or on the route on special road lanes (dynamic charger)
- Study of the impact of fast (30kW) inductive charging on urban distribution networks
- Pilot implementations.

COTEVOS

- Standardized electrification infrastructures to examine the compatibility of commercially available electric mobility technologies with the corresponding international standards (IEC 61851, ISO15118, OCPP, …)
- Standardized charging station compliant with IEC61851 and OCPPv1.5
- Integrated management system to provide advanced services

Prototype EV charging station

- The research team has already developed a prototype charging station model that adopts current standards (e.g. IEC61851 and OCPPv1.5).
- The station has successfully passed the IEC6185 compatibility tests at the Joint Research Center, ISPRA, Italy.
- It has been also successfully tested in commercial electric vehicles (e.g. BMW i-3, Renault Kangoo, Nissan Leaf, Energica motor).

ICT and Smart Grids

Smart House / Smart Grid

- Develop Tools for Demand Response Applications
- Big Data Management
- Develop tools for home automations

SmarterEMC2

- Develop tools for demand response and Virtual Power Plants
- Assessment of the impact of **various telecommunication technologies** on smart grids applications

Nobel Grid

- Development of new generation of Smart Meters
- Development of novel tools for grid management integrating the smart meters capabilities

Residential Wind Turbines

- Rotor diameter: 2.4m–4.2m
- Axial flux permanent magnet synchronous generator (0.6W–2kW)
- Connection to the LV network
- Connection to off-grid systems (e.g. telecommunication stations)
- Rural Electrification in developing regions (2 projects in Ethiopia, 1 in Nepal, 1 in South Africa)

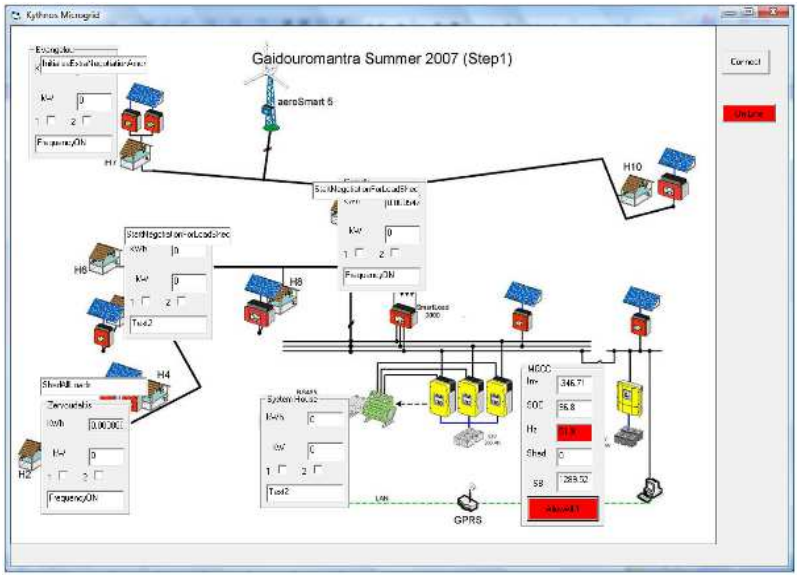
Intelligent load controllers

Scope

- Aiming at energy efficiency and optimized use of electricity in urban residences
- Main characteristics:
  - Electrical measurements of the house and monitoring of household appliances
  - Automated Management of flexible loads
  - User Interface

Applications

- Meltemi field camp*
- Kythnos island
- Demand response, flexibility market, ancillary services etc.
- Video: https://www.youtube.com/watch?v=gGoSA4PTykU



**Received award by the «European Smartgrid Technology Platform»*

Automation Systems

Laboratory infrastructure for:

- industrial automation
- substation automation

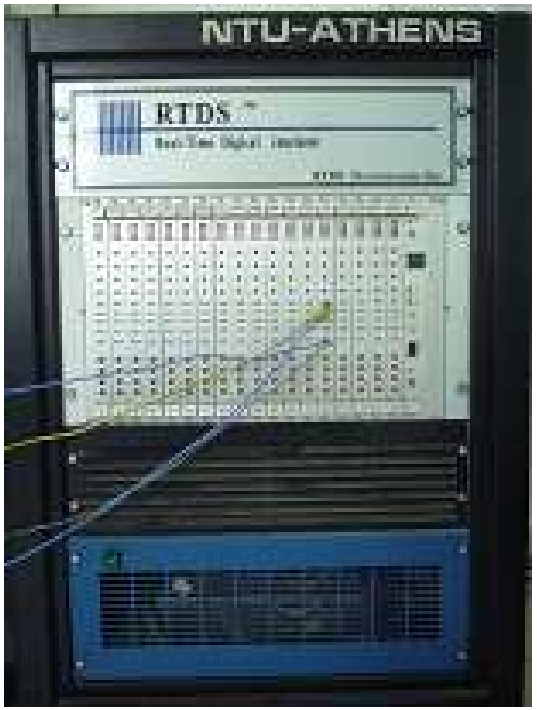
in the framework of several national and EU research projects

SCADA for controlling electric machines

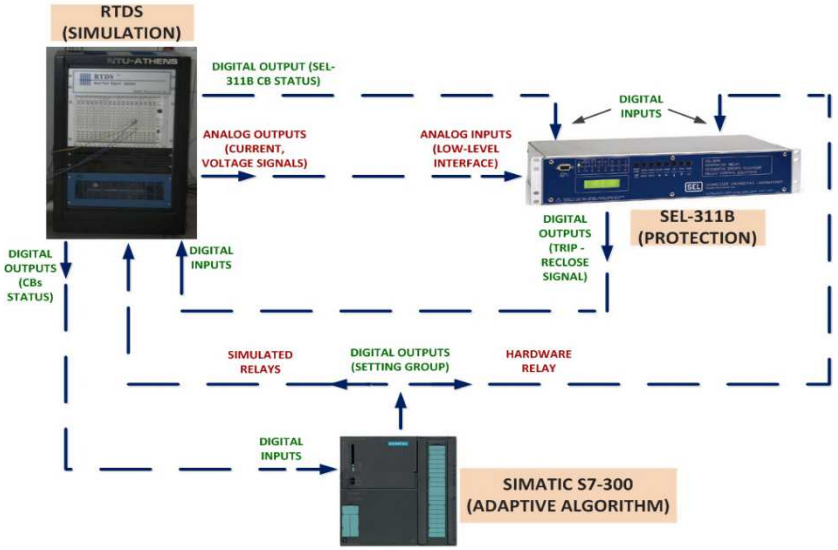
Energy monitoring system

Real-time simulation with RTDS at NTUA

- RTDS® was purchased in 1997 (RTDS Technologies Inc. was founded in 1994)
  - 18 TPC cards: 36 single phase nodes (time-step: 50 μs)
- Upgrades in:
  - 2012: two 3PC cards
  - 2015-2017: two GPC cards (time-step: 1-2 μs)
  - 2018: mid-size cubicle
- Upgrade planned for early 2019



RTDS-based adaptive protection



Structure of adaptive protection scheme

RTDS-based implementation of closed-loop adaptive protection scheme

On-going EU projects

H2020 projects:

- **ERIGrid**: Integrated research infrastructure for smart grids
- **WiseGRID**: Solutions, technologies and business models for an open, consumer-centric European energy grid
- **Shar-Q**: Peer-to peer interoperability network that connects neighbourhooding RES and storage ecosystems
- **iDistributedPV**: Affordable integrated solutions to enhance the penetration of PV using storage, demand management etc
- **GriDSOL**: Smart renewable hubs with concentrated solar plant and biogas integrated with PV
- **CROSSBOW**: Cross-Border management of variable renewable energies and storage

Marie Skłodowska-Curie Action:

- **TESTBED**: Staff exchanges on testing ICT for a smarter grid

Thank you for your attention!

Electric Energy Systems Lab,
Smart Grids Research Unit

www.smartrue.gr