SIRFN Capability Summary
RSE- Ricerca sul Sistema Energetico (Italy)

Introduction

RSE has laboratories and facilities to perform applied research on DER and Smart Grids.

Main research activities areas are:

• **Renewable Energy and DER Integration** researches are performed both at experimental and simulation level**.**
Experimental activities focuses on RE generation systems and their integration with DERs like storage systems, CHP generators, loads.
Distributed Energy Resources Test Facility (DER-TF) allows research activities on grid management and control, energetic and technical optimization, reliability, flexibility and safety and Power Line communications

• **Energy storage** activities are primarily focused on performance, operating limits, reliability and safety of stationary and vehicular applications. Different battery technologies are investigated: Lead, Redox, Lithium, Sodium-Nickel. Testing activities are performed at RSE Battery laboratory and, for larger scale application, at DER-TF

• **Power Electronics and Controls** research activities involve hardware and software power conditioning units development mainly focused to grid protection islanding operation and direct current microgrid application. Activities are performed on DER-TF and Grid Protection Lab

• **SCADA and Cyber Security R&D** involves analysis on grid control SCADA systems communication requirements and experimental tests on physical anomalies and cyber attacks to ICT network components, having a critical role in power grid operation.

Research activities are conducted mainly on behalf of the Italian Ministry of Economic Development, often in collaboration with industry and academic partners.

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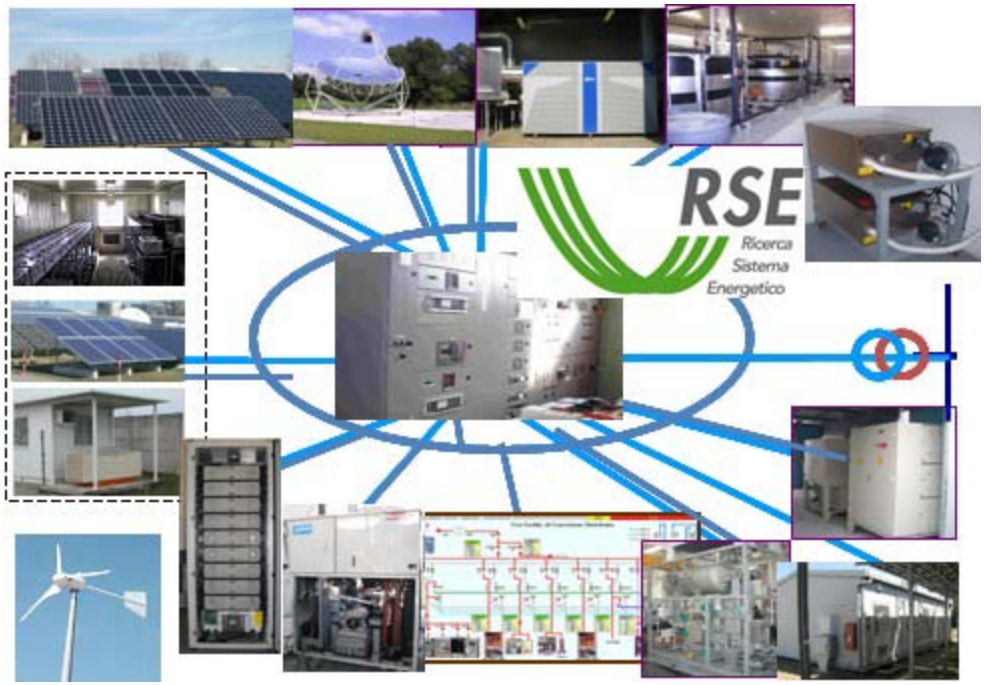

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Renewable Energy and DER Integration

Desired Level of SIRFN Participation: **3**

- 1 = Low 2 = Med 3 = High

Description of Activities

RSE performs research activities on commercial and emerging technologies suitable to integration of Renewable energy and Distributed resources in smart grids.

Both components and system integration are analyzed and experimentally evaluated including:

- PV (standard and innovative) evaluation as regard performances, reliability and grid interconnection (Inverters, including standardization)
- Interaction among inverters, grid protection and power quality
- Evaluation of electrochemical storage systems (Lead, Redox, Lithium, Sodium-Nickel) performances, development of reference stationary use profiles and integration in low voltage grids
- DER integration including PV and CHP generators, storage systems and demand response
- Weather forecast integration for RE forecast and storage systems optimization for network quality improvement (peak shaving, energy shifting)
- Power Line Communications in LV and MV networks: reliability and performances assessment and system characterization

The activities involve hardware and software optimization and control development. Testing activities are conducted at RSE DER Test Facility (DER-FT) that is a reconfigurable grid able to simulate different grid topologies and Batteries & Grid Protection and PLC labs. RSE is a member of the DERlab network.

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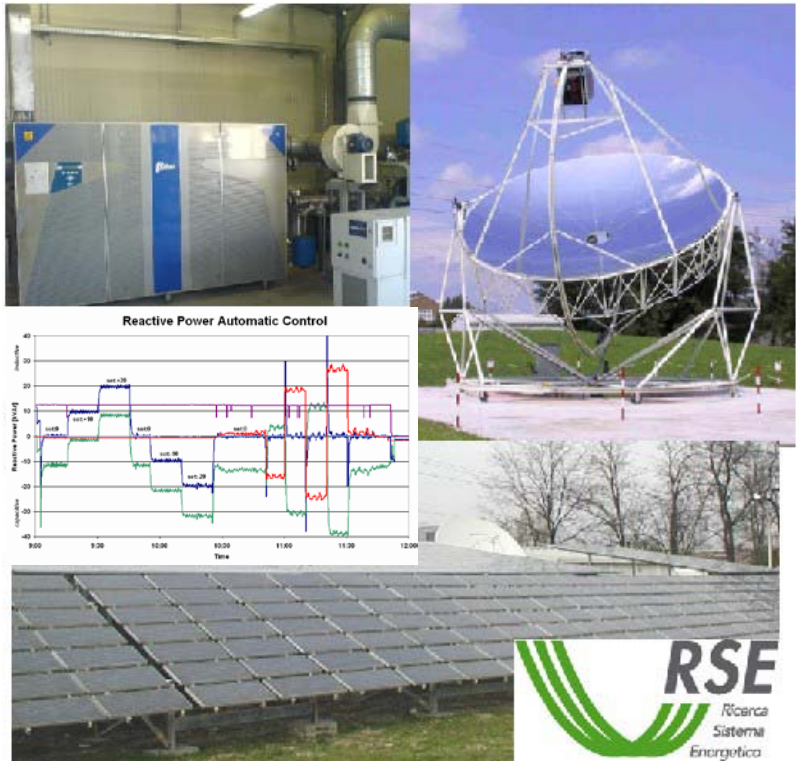

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SIRFN Subtask 2.2

Buildings Automation

Desired Level of SIRFN Participation: **1**

- 1 = Low 2 = Med 3 = High

Description of Activities

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SIRFN Site Focus Area Lead(s):

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PEV Integration

Desired Level of SIRFN Participation: **3**

- 1 = Low 2 = Med 3 = High

Description of Activities

Research on EV integration is the most recent area under development at RSE in the field of Smart Grid and DER.

Current activities are:

• Participation in demonstration projects for characterization and monitoring of EV LV charging

• Development of testing procedures for EV battery packs and modules (also in V2G schemes)

• Development of Optimal Power Flow algorithms for smart charging

• Set up of software applications for optimization of distribution networks operation and planning

• Development and assessment of experimental methods for evaluation of specific energy consumption at the wheel

Future planned activities are:

• Testing of Optimal Power Flow algorithms for smart charging

• Installation and characterization of fast charging points

• Inductive charging tests on light duty EVs

• Testing of innovative charging systems with V2G capabilities

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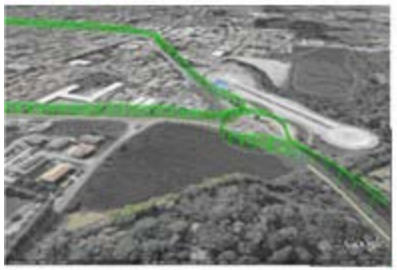

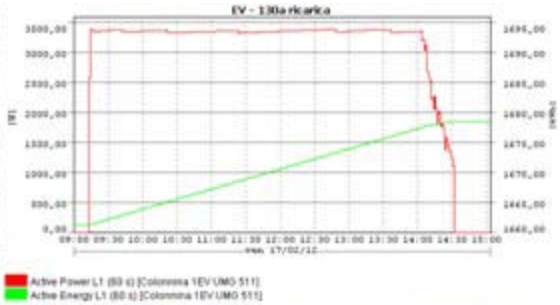

Microgrids

Desired Level of SIRFN Participation: **3**

- 1 = Low 2 = Med 3 = High

Description of Activities

RSE operates actively in microgrids area with experimental activities in AC and DC grids.

In particular, current activities are:

•Testing of a AC microgrid focused on interaction between central control and DER resources decentralized control

•AC microgrid energetic optimization with power and energy control at DSO interface

•Hybrid AC microgrid (PV, wind generator, diesel genset, loads) test off-grid or grid-connected to DER-TF

•HW & SW control system development and testing for local DER control in islanding operation (voltage and frequency support)

•DC (400V) microgrid development and testing with local control and operation off-grid or grid-connected to DER-TF. Activities focused on control strategies (centralized algorithms for DC network management and local control algorithms for Power electronic converters) for DC network stability and power quality with integration of RES, controlled sources and storage systems.

Experimental activities are conducted in DER-TF and in DC microgrid (connected to DER-TF by a bi-directional Inverter)

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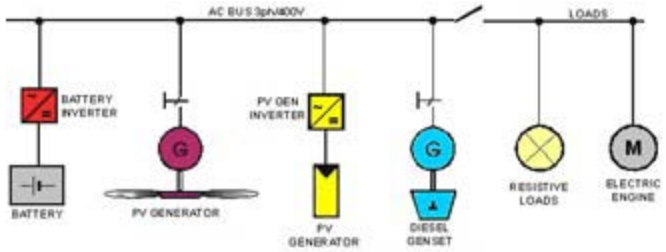

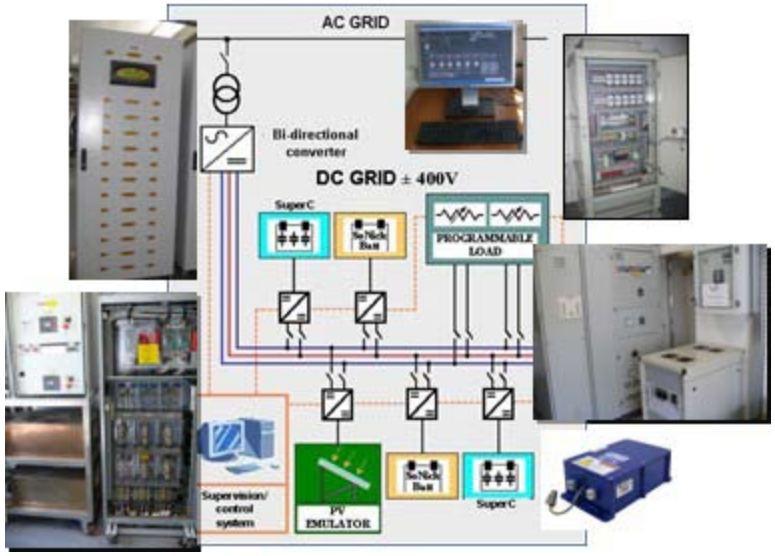

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Distribution Automation

Desired Level of SIRFN Participation: **3**

- 1 = Low 2 = Med 3 = High

Description of Activities

- RSE is exploring different approaches to improve 'active network' performances by means of advanced operation. In particular, RSE is carrying out extensive analysis to evaluate possible benefits deriving from the adoption of innovative local and centralized control approaches.Among them, RSE is developing a centralized controller ("VoCANT") to increase the hosting capacity of the network by means of Voltage control of Medium Voltage feeders, also in presence of storage units operated by the DSO.
- The controller is based on a technical-economic optimization algorithm. Starting from forecasted load and generation, and considering technical constraints and dispatching costs for active and for reactive power, the algorithm generates for each time period a set of commands for controllable resources that guarantees achievement of technical goals minimizing the overall dispatching cost.
- The tool could be employed both online and offline. It allows to evaluate how different resources are managed by the algorithm with respect to their technical and economic features ('business models').
- In 2012 field testing activities of the controller in real time operation of real MV networks will be started.

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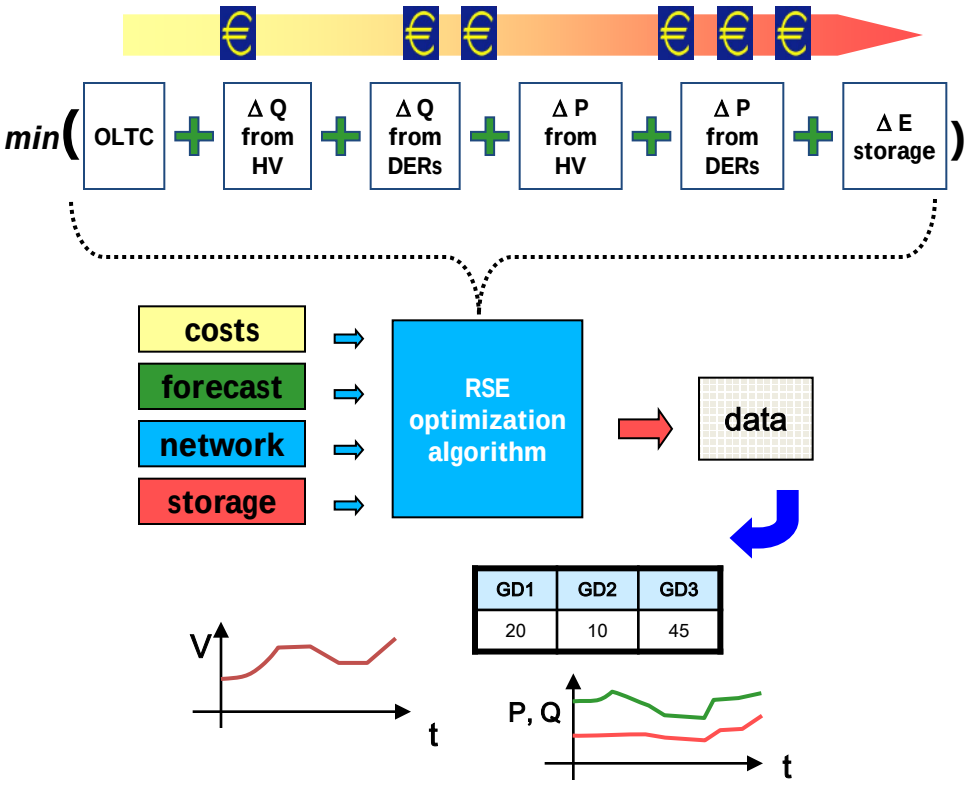

SIRFN Subtask 2.6

Cyber Security

Desired Level of SIRFN Participation: **3**

- 1 = Low 2 = Med 3 = High

Description of Activities

The PCS-ResTest (Power Control Systems-Resilience Testing) Laboratory manages a test ICT (Information and Communication Technology) platform for running repeatable experiments over realistic control scenarios of HV/MV distribution grids, and collecting data statistics on attack successfulness. With such an experimental setup it is possible to scale down the control system architecture to a manageable size integrating essential intelligent units of critical operation scenarios over which to evaluate the capability of security measures to protect smart grid communications from physical anomalies and advanced persistent attacks. In order to satisfy the most critical cases, the final objective of the security countermeasures for grid control systems is to withstand data losses, spurious data and transmission delays.

The experimental activity focuses on the communication requirements peculiar of the SCADA (Supervision, Control and Data Acquisition) systems deployed in grid control, such as continuous *availability,* stringent *response times*, *authenticity* and *integrity*, *undisturbed* execution of acquisition and actuation sequences based on *ordered* flows of measurements, events and commands, *no interferences* of operational flows with data flows for the remote management of communication and control devices.

The experiments concern physical anomalies and cyber attacks to ICT network components, such as routers and SCADA system components, having a critical role in power grid operation.

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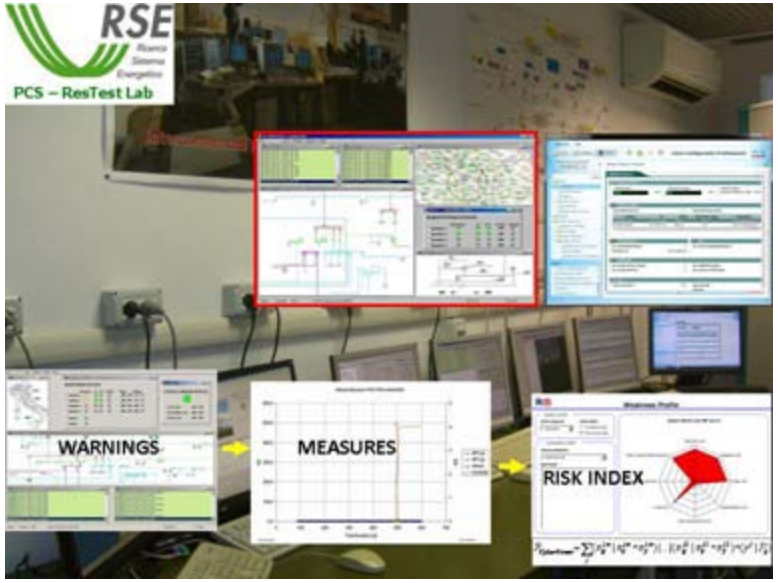
- Grid control applications → DSO operations, station level protections, TSO emergency management (load shedding, voltage stability), active grid operation (anti-islanding protections, voltage control)
- Grid standard communications → IEC 60870-5-104, IEC 61850, HSRP, TCP/UDP/IP
- Grid security controls → firewall, VPN, IPSEC, IPS
- Grid Attack tools → flooding tasks, intrusion malware
- Grid Communication analyzers → application logs/network packets, application warnings, performance measures, graphics, risk indexes



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Summary of Capabilities: Equipment and Technology

DER-TF:

AC and DC sources:

- 32 kWp PV system, 18 independent PF fields with 18 inverters (230V AC, 1ph)
- 100kWe gas microturbine, CHP (170kWth)
- 6kWe gas IC engine, (CHP, 13 kWth)
- 10 kWp solar thermal plant with a parabolic dish and a Stirling engine (Dish Stirling)
- 3 kWp mini wind generator
- 7kW diesel genset (connected to Hybrid microgrid)
- 50 kW programmable DC (IV curve) simulator, up to 400V
- 200 kW bi-directional inverter to create a secondary microgrid at variable voltage and frequency

Programmable loads:

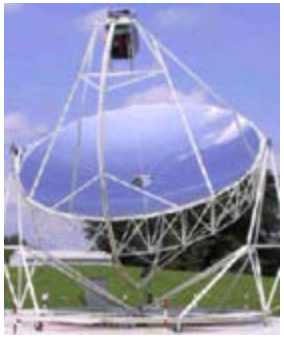
- Fully programmable resistive (100 kW), inductive (70 kVAr), capacitive (150 kVAr) 3 phase load (400V) with single phases independent control
- Programmable resistive load (2x30kW) connected to DC microgrid

Energy Storage:

- 50 kWh, 90kWp high temperature Sodium-nickel battery connected to 150 kVA, four quadrant inverter
- 36 kWh, 60kWp Lithium ion battery connected to 100 kVA, four quadrant inverter
- 90 kWh, 45kWp Redox Flow Battery
- 60 kWh lead-acid battery bank (connected to Hybrid microgrid)
- 36 kWh,60kWp Sodium-nickel batteries and 60kWp (4 sec) superC banks connected to DC microgrid

Energy Storage

PV Fields



Dish Stirling

Application to Subtasks:

- 2.1 DER and RE Integration: High
- 2.2 Building Automation: Low
- 2.3 PEV Integration: High
- 2.4 Microgrids: High
- 2.5 Distribution Automation: High
- 2.6 Cyber Security: High

Summary of Capabilities: Equipment and Technology

Battery & Grid Protection Labs:

AC and DC sources:

- 12 kVA AC programmable Grid Simulator, up to 270V 3 phase (generation 12kVA, sink 4kW, 8kVA)
- Portable 3 phase grid simulators; Voltage: 0÷300V, Current:0÷30A (3 outputs), 90A (1 output)-N°2
- Programmable 10 kW DC (IV curve) generators; Voltage: 0÷500V, parallel and series connection – N°2
- Programmable 30 kW DC generators; Voltage: 0÷600V, Current:0÷50A
- Programmable 6 kW DC generators; Voltage: 0÷60V, Current:0÷100A

Programmable loads:

- Variable 3 phase load; resistive 6kW per phase, Inductive & capacitive 6kVAr per phase
- 21 kW Programmable Electronic load 600V, 360A
- Programmable Electronic load 60V, 450A

Climate chambers:

- 26 m^3 climate chamber (3.6x2.4x3m); operation temperature -20÷+60°C
- 225 l climate chamber ;operation temperature -40 ÷ +180°C. humidity range 10 ÷98%

Battery cyclic test equipment

26 m^3 climate chamber

Application to Subtasks:

- 2.1 DER and RE Integration: High
- 2.2 Building Automation: Low
- 2.3 PEV Integration: High
- 2.4 Microgrids: High
- 2.5 Distribution Automation: High
- 2.6 Cyber Security: High

Summary of Capabilities: Data Acquisition and Analysis

DER-TF:

Data Acquisition:

- Decentralized (DERs) data acquisition and system control
- Centralized grid configuration, DERs data collection and storage, DERS operation and set point control, optimized grid operation control, DSO interface management
- Decentralized HMI for monitoring and control and historical data base (10 s averaged data) available to all PC connected to RSE net
- Meteorological data and weather forecast (24, 48,72h) elaborated by RSE
- Communication based on TCP/IP

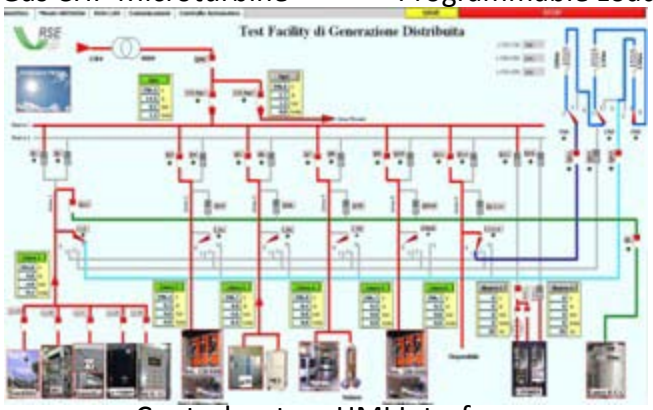
Laboratory Standards and Certifications:

Test Configurations:

- 800kVA, 400V, three-phase grid with two main bars and 6 feeders configurable (locally or remotely) at the interconnection board in order to obtain different grid topologies: radial grids and also meshed configurations. Possibility to extend feeders till one kilometre. Connected to grid. Access to all DERs
- 200kVA, three phase microgrid operated by bi-directional inverter at different voltage (360-440 V) and frequency (45-65 Hz) levels. Connected do DER-TF. Access to all DERs

Gas CHP Microturbine

Programmable Loads



Control system HMI Interface

Application to Subtasks:

- 2.1 DER and RE Integration: High
- 2.2 Building Automation: Low
- 2.3 PEV Integration: High
- 2.4 Microgrids: High
- 2.5 Distribution Automation: High
- 2.6 Cyber Security: High