Description of integrated pilots/demonstrations/field tests/existing practices

1. Name of the case:

DER low voltage Test Facility (DER-TF) and Demand side Management Experimental Houses (DSM-EH)

2. What is integrated with DSM

DG	X
Energy storage	X
Smart grid technologies	X

3. What is the level of commercialization

Research project	X
Demonstration	
Field test	
Existing practice	

4. Where to find more information?

CESI RICERCA S.P.A.
Milan, Italy
www.cesiricerca.it

5. Objectives of the case

To offer experimental testing platform for DER and DSM experiments

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Description of the infrastructure:
CESI RICERCA can offer two experimental platforms:

1) DER Test Facility (DER-TF)
It consists in a LV microgrid, connected to the MV grid by means of a 800 kVA transformer.
It is constituted by several generators with different technologies (renewable and conventional), controllable loads and storage systems. DER-TF can provide electricity to the main grid with a maximum power of 350 kW.

The following distributed energy resources are available at the present time:

- a hybrid renewable energy system consisting of a photovoltaic plant (10 kW_P), a lead-acid storage system, a diesel engine coupled with an asynchronous generator (7 kVA), a simulated asynchronous wind generator (8 kVA)
- five PV fields of different technologies for a total nominal power of 14 kW;
- a solar thermal plant with a parabolic dish and a Stirling engine (10 kW);
- a ORC CHP system fuelled by biomass (10 kW_E, 90 kW_{TH});
- a CCHP plant with a gas microturbine (105 kW_E, 170 kW_{TH}, 100 kW_{RE});
- a Vanadium Redox Battery (42 kW, 2 hours);
- a Lead Acid battery system (100 kW, 1 hour);
- two high temperature Zebra batteries (64 kW, 30 minutes);
- a high speed flywheel for Power Quality (100 kW, 30 seconds);
- a controllable three-phase resistive-inductive load (100 kW + 70 kVAR);
- a capacitive load and several R/L loads with local control (150 kVAR).

All these DERs are connected to the microgrid by mean of a configuration and interconnection board that allows the microgrid operator to change the interconnections of DERs manually or by mean of remote commands from a computer. In this way it's possible obtaining different grid topologies: radial grids and also meshed configurations. There's also the opportunity to extend feeders till one kilometre.

The interconnection board and all the DERs are provided with electrical measure equipments, constituting an high-speed Data Acquisition System (DAS), that has been set up to collect and analyze the experimental data derived from the field test.

In the picture below a schematic representation of the DER-TF is showed.

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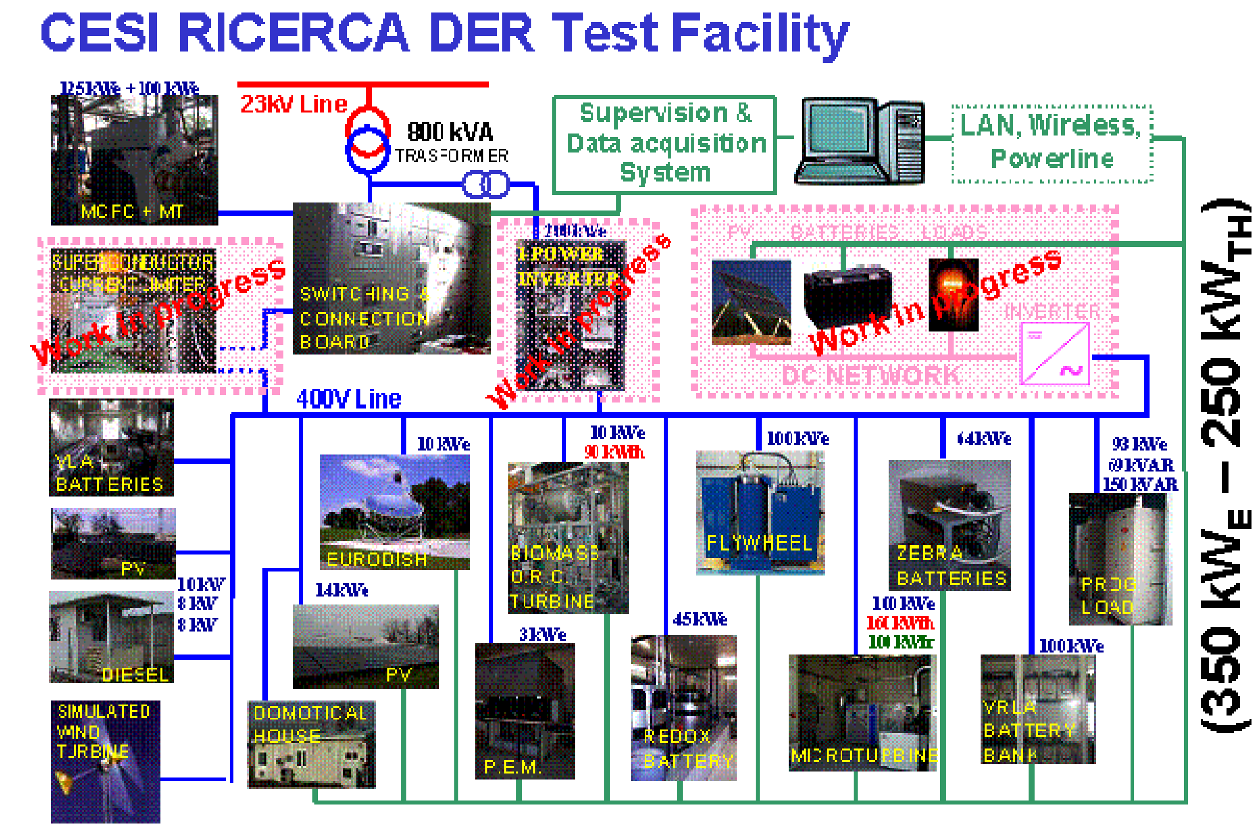


A Communication system has been developed with different technologies: LAN Ethernet, Wireless and Power Line. A supervision and control infrastructure has been also implemented, providing several services:

- Interface with distributed resources (equipped with their local control systems): the control system gets measurement and sends commands and set-points
- Archive functions: data storage and retrieval, in order to permit further analysis
- Standard TCP/IP interface towards optimisation applications.

The CESI RICERCA DER Test Facility is a complete and well-structured system with different generators, storage systems and loads that well reproduces a real microgrid, allowing researchers to develop studies and experimentations on DERs. Within the proposed project, CESI RICERCA DER Test facility will be used to give access and providing services to researchers for their experiments, demonstrations and validations of the operation of an actual microgrid in interconnected and islanding mode and of its behaviour during disturbances such as voltage and frequency variations.

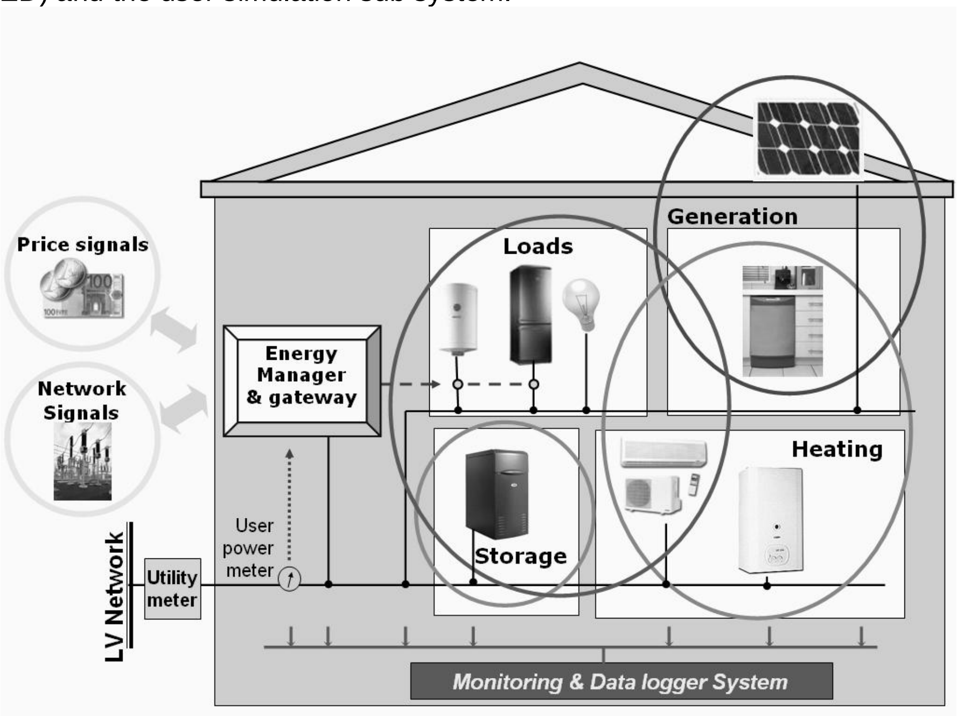
2) Demand side Management Experimental Houses (DSM-EH)

The CESI RICERCA DSM-EH is a 60 m^2 building representing a common residential flat with living room, kitchen, bedroom, and bathroom. The central element of DSM-EH is a Home Energy Manager & gateway (GED), combining signal received from retailer (tariffs) and distributor

(emergency) and user preferences regarding comfort and energy saving. In order to succeed with this management, several functions have been developed and tested. The main functionality implemented is represented by load and heating management, i.e. the possibility of switching off some appliances when particular circumstances occur or decide whether if it is better to use electric or gas devices for HVAC purposes. For example, when a power reduction is required because of high electricity price or emergency network condition, GED switches off some appliances according to desired priority, and the gas heating is preferred to heat pumps.
This facility makes possible to carry out several tests on different energy management strategies but also simulates the user presence, thanks to an appropriate sub-system which operates each single domestic appliance as it may do a real family living in a house. To carry out these functions, there are:

- Home energy manager & gateway (GED), that manages loads and thermal system; this platform is equipped with a monitoring, acquisition and data storage system;
- a commercial home automation system managed by GED to control loads, heating system etc.;
- an automation system that switches on and off each load according to profiles representing different family habits ("user simulator"),
- a whole set of common appliances,
- heating system (boiler + fan coils and air conditioners).

Figure below shows a scheme of the CESI RICERCA facility with Home energy manager & gateway (GED) and the user simulation sub system.



This "experimental house" already comprises a storage unit and a photovoltaic conversion generator; a micro cogenerator (µCHP) will be installed soon.

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Commercial of the shelves components and technologies are used to build the infrastructure. Java™ with OSGi™ specifications are used to maximize dynamic interaction (upgradeability) and interoperability. OSGi technology (www.osgi.org) is an Universal Middleware that provides a service-oriented, component-based environment for developers and offers standardized ways to manage the software lifecycle. OpenWebNet™ communication protocols (www.myopen-bticino.it) is used to interface commercial home & building automation system.
TCP/IP protocol and XML format are considered because are widely used and it is very probably that their diffusion will extend even further in next years, becoming a de facto standard. They permit also to pass easily from virtual environment to real test facility, changing only the device GED communicates with ("move the plug from a socket to the other").
DSM-EH is fully integrated into DER-TF; the central Control Unit of DER-TF is able to control also DSM-EH. It is possible to perform research and tests involving both DER-TF and DSM-EH.

Future developments
By the end of 2008, a low voltage DC microgrid will be implemented and directly connected to the main microgrid of DER-TF. In fact, the installation of new generation units, as gas combustion engine with rotor speed control and PV fields, storage systems, programmable loads, and a 125 kW DC/AC interface rectifier, to allow power flow exchange between the two microgrids, is scheduled for middle 2008.
This will be a major upgrade of DER-TF enabling improved operation flexibility and wider research opportunities for DER-TF, in terms of management and control strategies. It is expected that the DERRI users community will benefit considerably from this upgrade and its related new research topics and opportunities.

Services currently offered by the infrastructure:
With reference to the following diagram, URA is a supervision and control system that provides several services:

- Interface with distributed resources (equipped with their local control systems): URA gets measurement and sends commands and set-points
- Archive functions: data storage and retrieval, in order to permit further analysis
- Standard TCP/IP interface towards optimisation applications.

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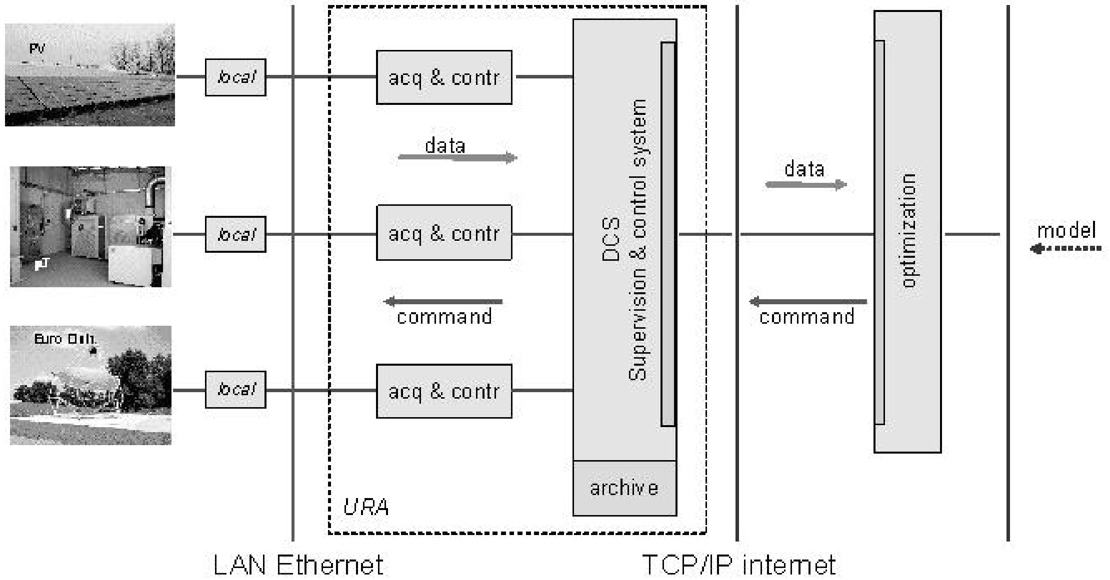

Optimisation procedures shall get data and send commands using a communication library to exchange information with URA, trough standard TCP/IP interface. This communication library will be supplied, in order to be integrated in a generic optimisation application. Availability of the library and use of such a standard permits:

- Testing both from local and remote laboratories, thanks to the Internet communication.
- Remote testing of communication and SW optimisation procedures before carrying out tests on the real facility.
- Remote access from different users, where specific profiles could be set. For example, depending on nature of research activity or working phase, some users could only read data from generators, while others may send command to a sub-set of resources.

A further improvement could be represented by a standard procedure to set algorithms into the optimisation layer, for example by means of state-transition diagrams as in Matlab Stateflow© library.