EXPERIMENTAL MICROGRID

The Hybrid Power Plant and Microgrid laboratory purpose is bilateral: it can be used in order to study the performance of stand-alone or interconnected microgrids, but also as a simulator of autonomous weak grids, like power systems of islands. The Microgrid is a low voltage 3-phase electric network where all DER components are connected. The maximum power of a single component should not exceed 20 kW. The communication and control is obtained through Interbus. Apart from Interbus, the hybrid system includes a power quality meter for monitoring quantities like active and reactive power at the mains. The communication of this system with the control console is achieved through the Modbus protocol. A visualisation for supervision, monitoring and control has been developed in LabVIEW. The test site is appropriate for connecting DER units to evaluate their performance in a microgrid environment. Load controllers and distributed generation unit controllers may be applied in order to implement demand side and energy management optimisation. Storage technologies are also available, such as electrochemical (batteries) and chemical (Hydrogen). The test site is equipped with high performance devices which offer lots of capabilities for different cases of study. The system is divided into three major parts: the power components, the control system and the communication interface.

- Photovoltaic generators: The system comprises two independent PV arrays (PV1 at 1,1 and PV2 at 4,4 kWp capacity).

- Photovoltaic inverters: Each of the above PV generators is interconnected with a three phase power line through PV inverters. More analytically, PV1 is interconnected through a single phase inverter of 1,1 kW nominal power, while PV2 is at the moment partially used since it is interconnected through a 2,5 kW inverter which has the capability of 1-phase operation.

- Battery storage: The system is equipped with two separate battery banks for the storage of the electricity. These systems have the following features:
    - One bank consists of 48 lead-acid (FLA) battery cells of 2V and 400Ah each.
    - The second battery system consists of 30 lead-acid cells of 2V, 690Ah, connected in series.

- The interconnection of the batteries with the AC grid is obtained through two independent systems:
    - One three-phase battery inverter at 9 kW, 96 Vdc, 230/400 Vac. This device has the capability of operation as voltage source (grid-forming) or current source (grid-tied operation). In each of these modes the controllable quantities is the voltage and frequency or the RMS current.
    - Three single phase battery inverters of 4 kW, 60 Vdc, 230 Vac. These devices have multiple possibilities of operation with most interesting the three-phase operation during which one of the three inverters (Master) controls the other two (Slaves) through an RS485 communication port, the single-phase operation with only one of the three inverters, grid-forming operation where voltage and frequency are controlled, grid-tied operation where current is controlled and finally droop mode.

- One diesel genset of 400 Vac, 50 Hz, 12 kVA. The purpose of this generator is bilateral which means that it can be used as a backup system in the case where a stand-alone system is considered, or as one of the generators of a simulated microgrid.

- Loads: The system includes a load bank of resistors resulting 13 kW. These loads are equally distributed into the three phases. Apart from the resistive loads, the system includes a three-phase capacitive load, a three-phase induction motor of 2 kW and one small single phase water pump.

- Load controllers: One of the most innovative possibilities of the system is the use of load controllers which are electronic devices responsible for shedding loads when necessary. Additional load controllers are available having the ability to regulate the power production from generators either based on market criteria (by using special purpose software called as “agent”).

- One reverse osmosis desalination unit of max demand 3 kW used for simulation of the load in stand-alone solar systems is islands for water production.

The already existing system which is described above has the ability of interconnection with the installations of the RES & Hydrogen Technologies Integration Section, of CRES. More analytically the devices that can be integrated in the system are:

- One Proton Exchange Membrane (PEM) fuel cell: The PEM fuel cell has a nominal power of 5 kW (DC). A DC/AC three-phase system has also been integrated in the PEM fuel cell system in order to supply AC electricity to the microgrid. Hydrogen consumption is 40 NL/min when producing 3 kW and 75 NL/min when the fuel cell produces 5 kW.

- One PEM electrolyser: The electrolyser has a nominal hydrogen production capacity of 0.5 Nm3/hr, at a pressure of up to 14 bar. The AC feed of the PEM electrolyser is single phase, 240 V, 50 Hz, isolated.

- The storage of the RES & Hydrogen Technologies Laboratory is a compressed hydrogen storage tank at a maximum pressure of 16 bar. The compressed hydrogen storage tank, which has already been installed has a physical volume of 3000 L, and has a nominal hydrogen storage capacity of 50 Nm3.

Both fuel cell and electrolyser units add in the hybrid/microgrid lab not only innovation but also flexibility for plenty of experiments and studies which cover a wide range in the RES field.

The communication and control layer consists of the system Interbus which is equiiped wit analog and digital I/O devices. The latter communicate through serial protocol, transferring data to the interface console and control signals to all controllable devices.

Finally, one of the most critical parts of the operation system is user interface developed in LabVIEW. This application provides the user with some capabilities like:

- Easy access to all the devices. This contains the control of operation of each device. All the controls are fully automated which means that through the interface the operator can perform any desired experiment.

- Data acquisition monitoring and storage to files for further processing.

- Ability of operation remotely through web publishing tool and OPC servers.

- The modular construction of the interface as well as the multiple features provided by the platform makes the modifications very easy.

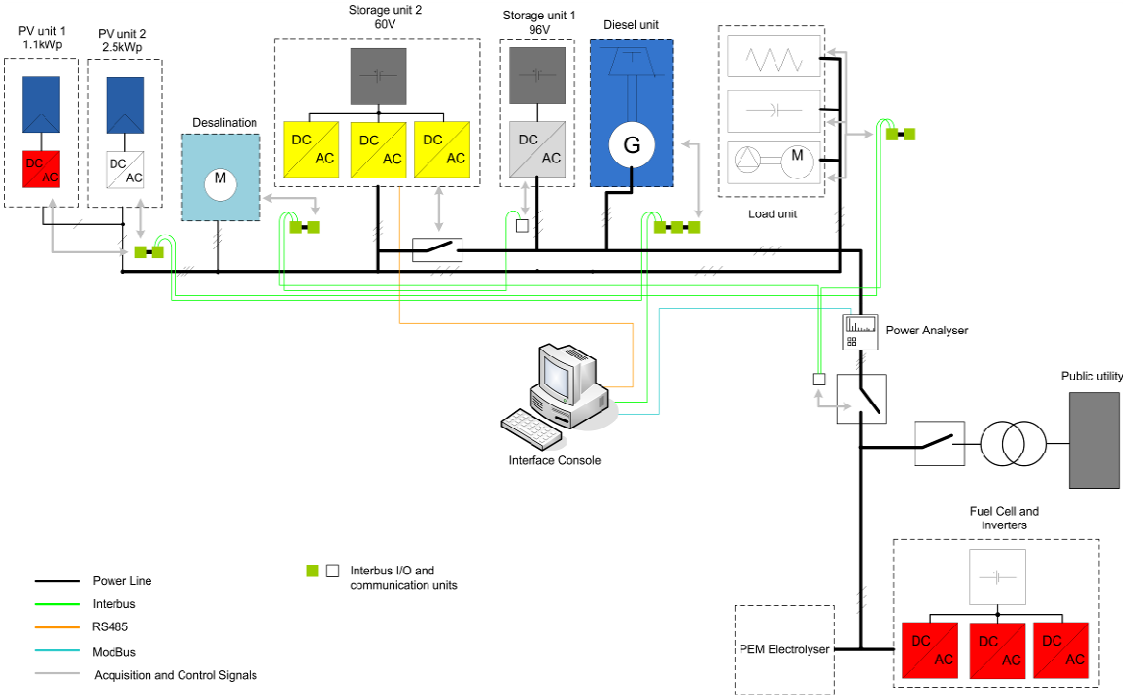

Fig.1 Block diagram of the Hybrid system and Microgrid test site of CRES

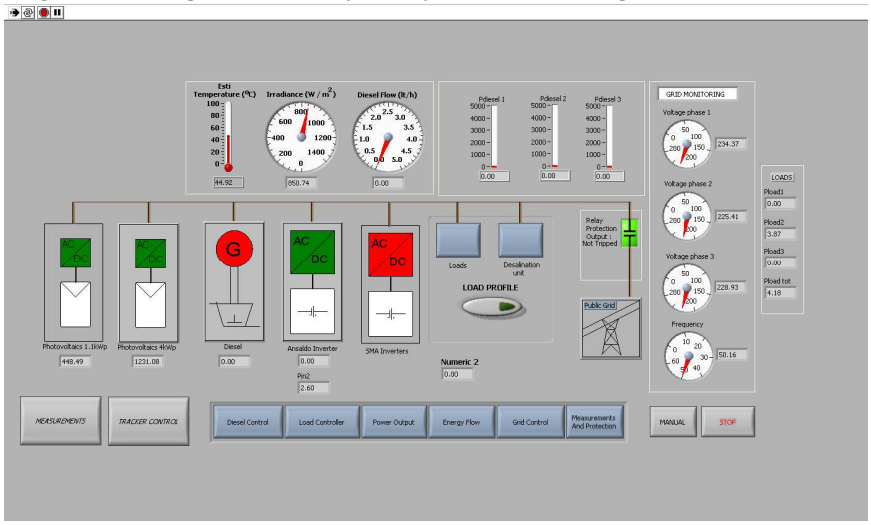

Fig. 2 Graphical Interface