MINISTERO DELL'AMBIENTE
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UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
INVEST AND TECHNOLOGY PROMOTION OFFICE ITALY

Republic of Botswana
Ministry of Enviroment, Wildlife and Tourism (MEWT)

GABORONE

BOTSWANA 5-6 July 2017

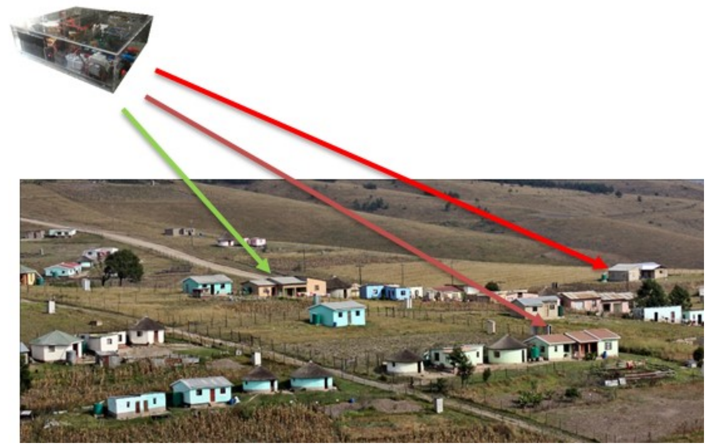
Hybrid Technologies for Isolated Communities and Off-Grid Solutions

UNIVERSITÀ DELLA CALABRIA

CRETA Energie Speciali S.r.l.
Azienda Spin Off UNIVERSITÀ DELLA CALABRIA

Prof. Daniele Menniti
University of Calabria (Italy)
Creta Energie Speciali

Introduction



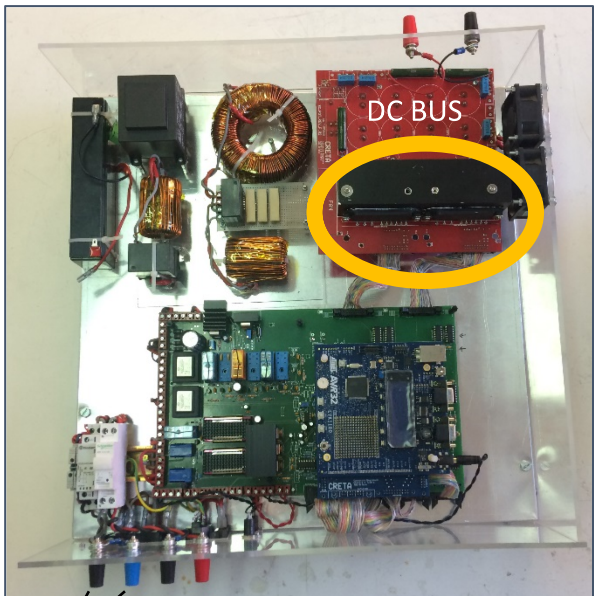
As well known, in order to bring electricity to isolated communities in developing Countries, the exploitation of local renewable energy sources (RESs) is a fundamental task because the extension of the utility grid is often relevantly costly or impracticable. **Building an islanded microgrid** is the solution on condition that the appropriate approach is adopted. Is the **top-down approach** an appropriate approach? The payback of the investment in islanded microgrids could be too long and disadvantageous.

Nano Grid for Home Applications

Our solution for residential applications
is named
Nano Grid for Home Applications
(nGfHA)

A Nanogrid for home applications (nGfHA)

A nGfHA is a small microgrid that serves and supplies residential loads; its rated power typically does not exceed 5kW. A nGfHA has a local dc distribution network, namely dc bus.



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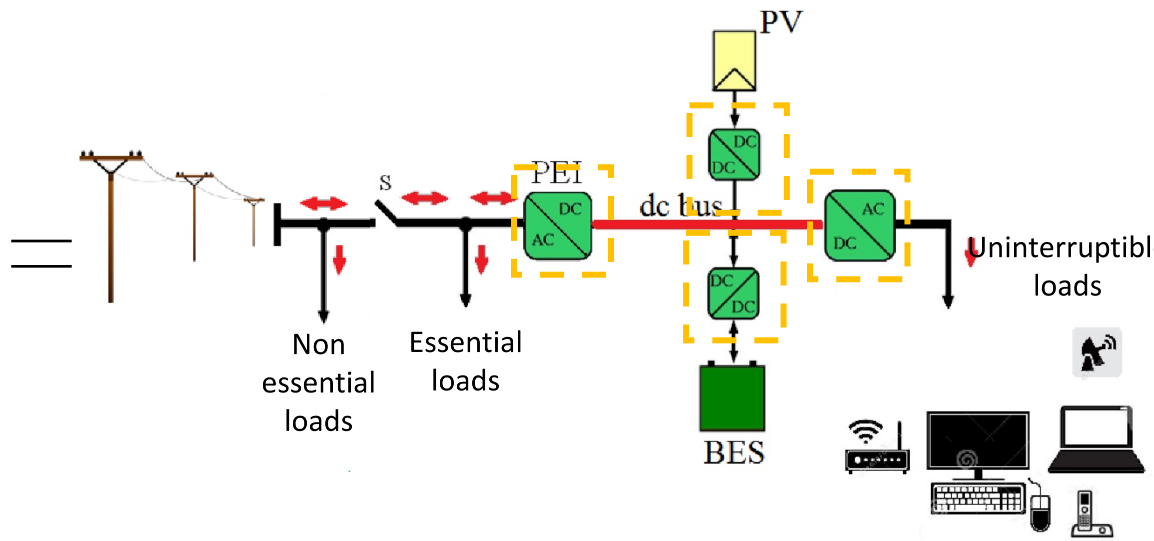
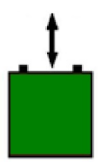


Utility Grid (if any)

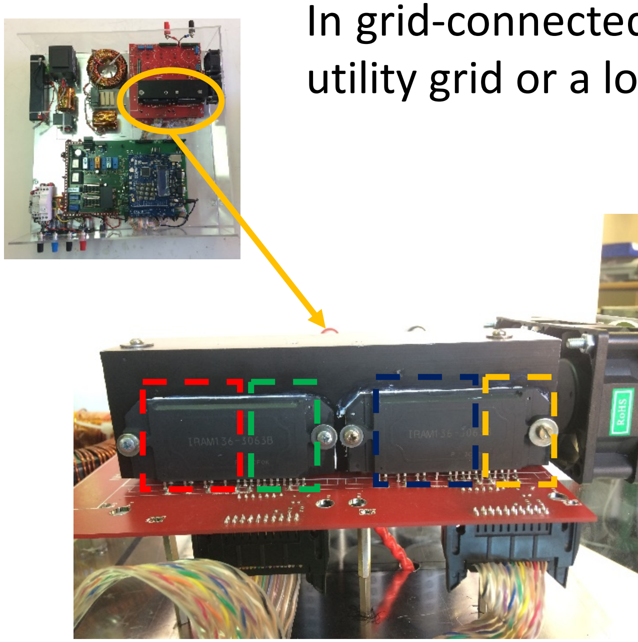


BES

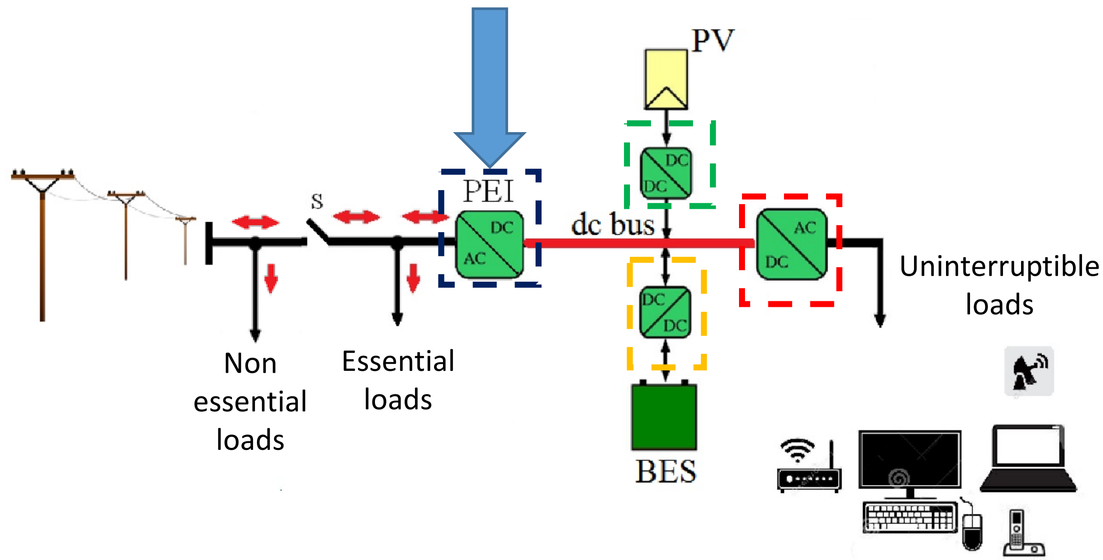
Distributed generators exploiting RESs or conventional sources can be connected to the dc bus; storage systems based on different storage technologies (battery, flywheel, etc) can be connected to the dc bus as well.

A Nanogrid for home applications (nGfHA)

The nGfHA is designed to operate both in grid-connected and islanded mode. In grid-connected mode, the nGfHA connects to the ac network – typically the utility grid or a local ac grid - via a power electronic interface (PEI).

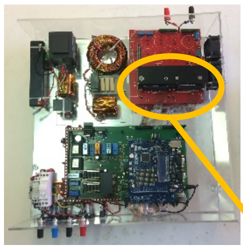


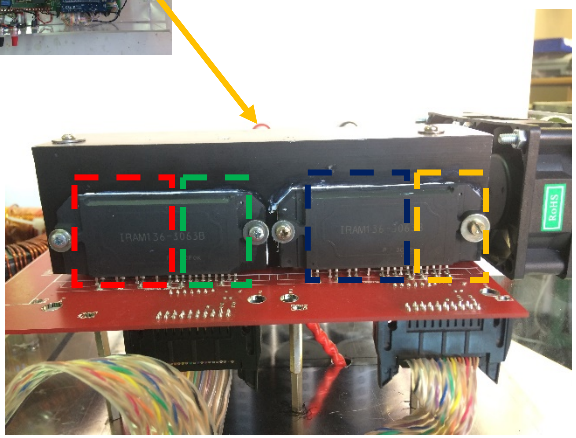
INFINEON
IRAM 136-3063B
(3.3 kW)



A Nanogrid for home applications (nGfHA)

A voltage-controlled inverter ensures a high power quality in supply critical loads, in both above mentioned modalities.





INFINEON
IRAM 136-3063B
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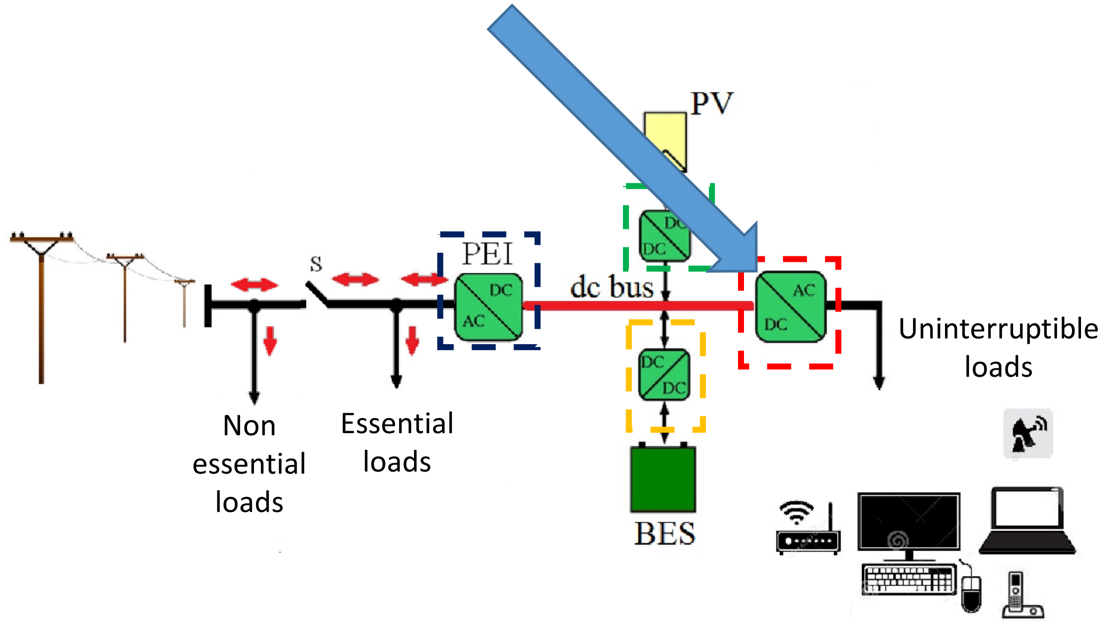
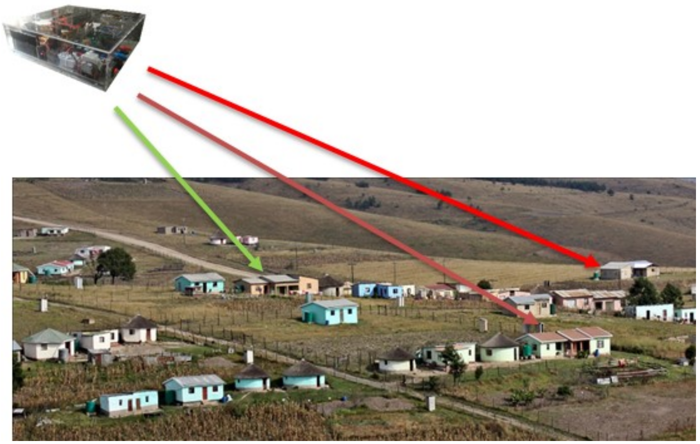


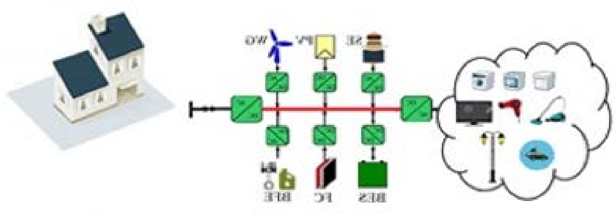
Bottom-up approach



The nGfHA, avoid the classical **top-down approach** and, on the contrary, it allows a **bottom-up approach,** that is an interesting alternative.

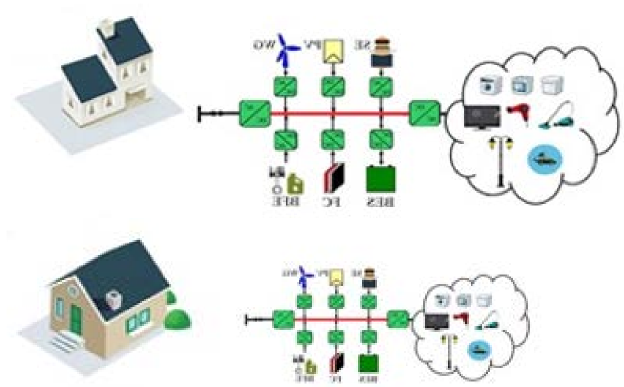
Bottom-up approach

Starting from each islanded nGfHA…



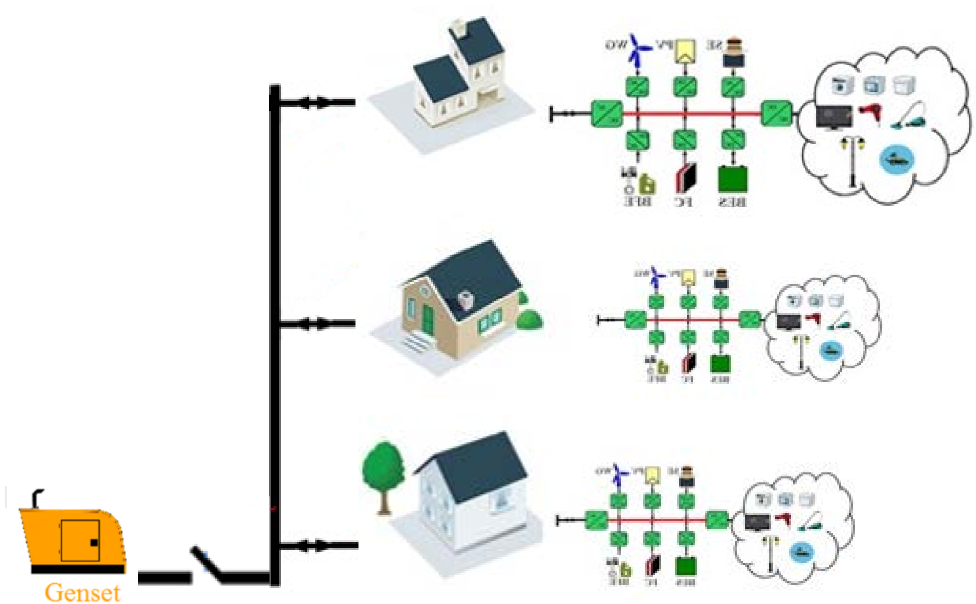
Bottom-up approach

…when the number of nanogrid in the village increase…



Bottom-up approach

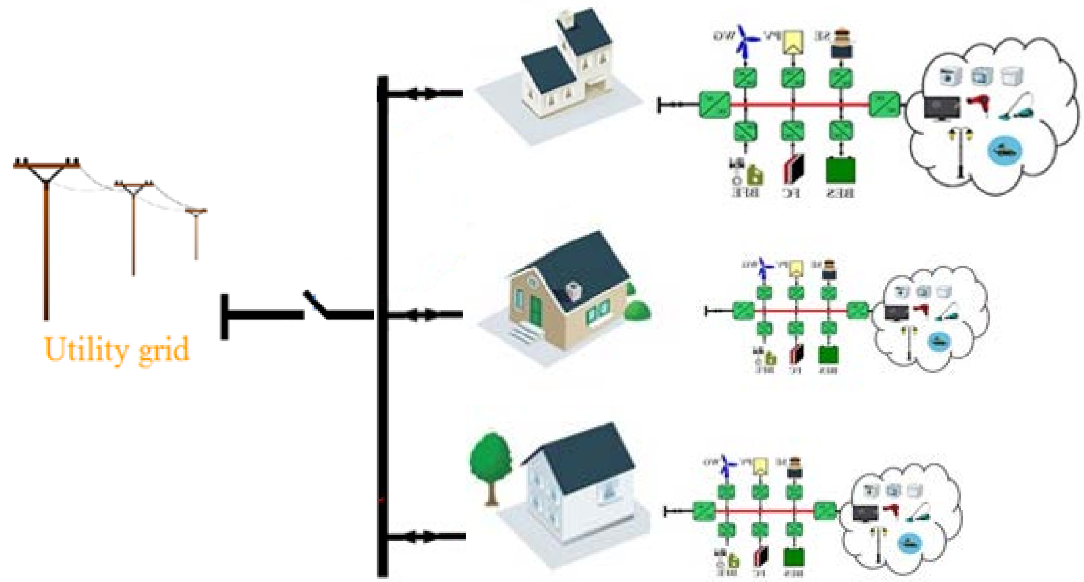
…according to the **bottom-up approach**, can be firstly and gradually set up an islanded microgrid, in line with the number of users which, time by time, will connect each other to improve the reliability and the continuity of the whole system…



Bottom-up approach

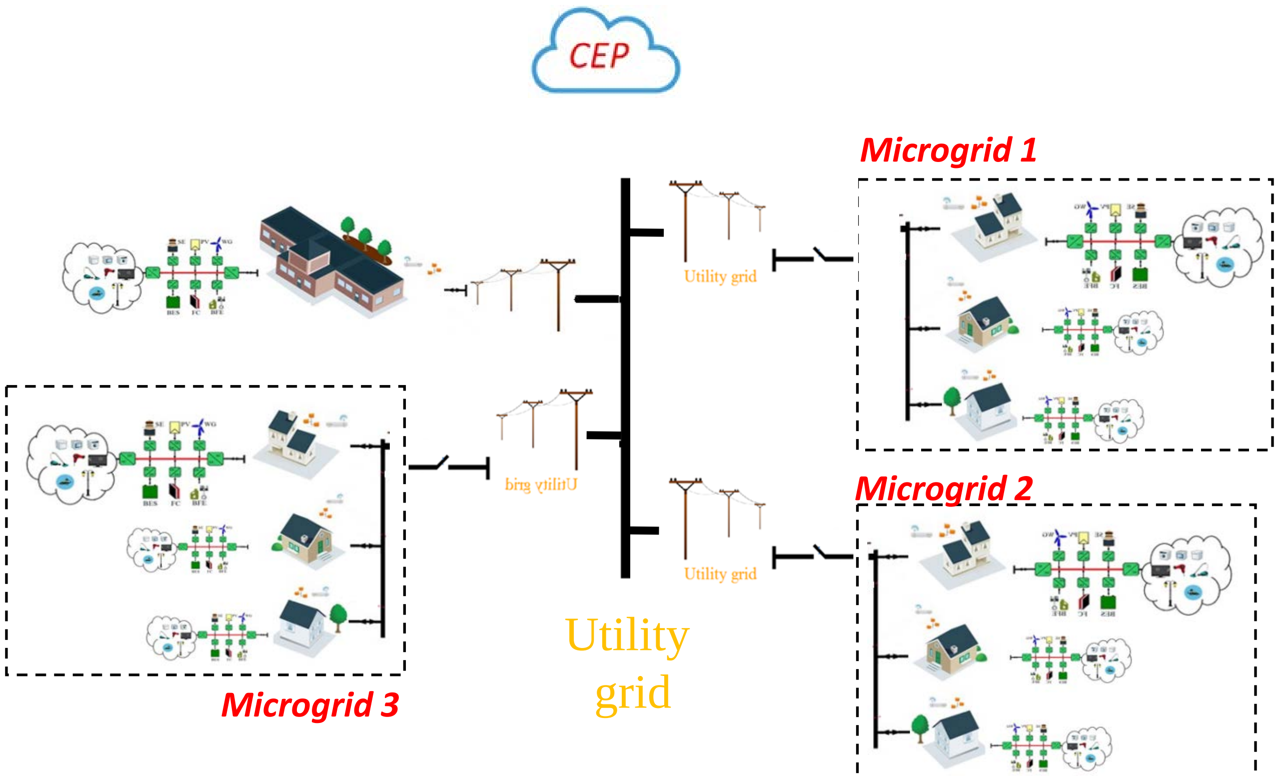
…according to the **bottom-up approach**, can be firstly and gradually set up an islanded microgrid, in line with the number of users which, time by time, will connect each other to improve the reliability and the continuity of the whole system…

especially if, in the future, the microgrid can be connected to the utility grid.



Bottom-up approach

Furthermore, a group of microgrids interconnected each other, by means the utility grid, can be appropriately controlled and managed by an aggregator known as Community Energy Provider (CEP).



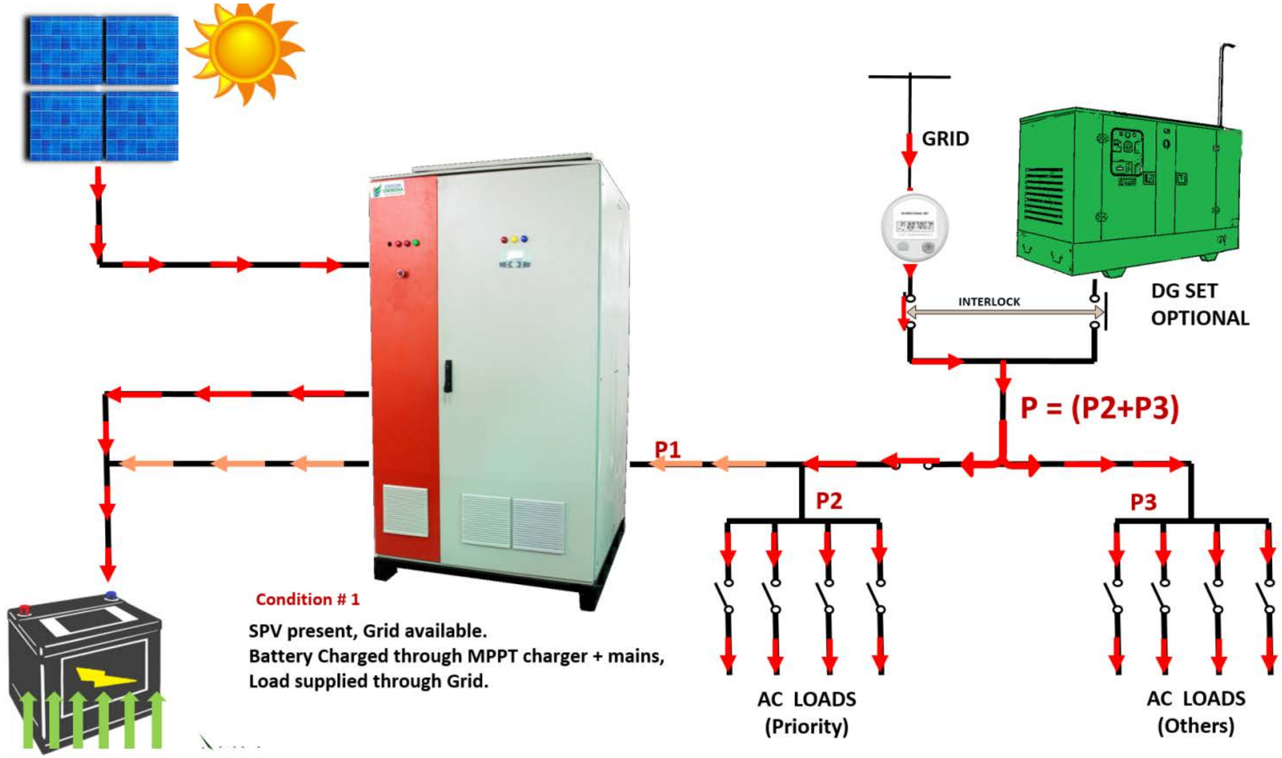
Hybrid inverters

Finally, it is worth to note that the our nanogrid:

is different by the so-called

hybrid inverters for off-grid applications

indeed these inverters, normally, are not designed to interconnect and coordinate each other.



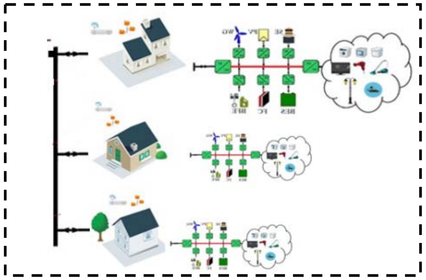
Thanks for your attention!

daniele.menniti@unical.it
daniele.menniti@cretaes.it

An existing smart microgrid

According to the **bottom-up approach**, the islanded microgrid takes place gradually in line with the number of users which, time by time, connect to microgrid so to improve the reliability and the continuity of the service

Microgrid 1



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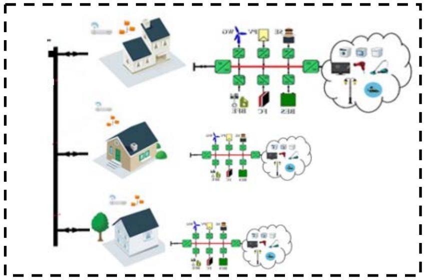
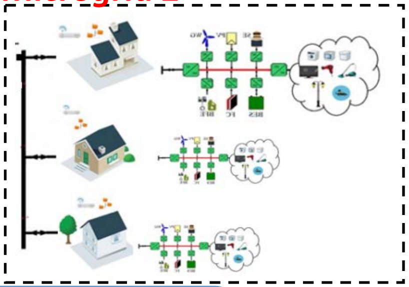


Microgrid 2



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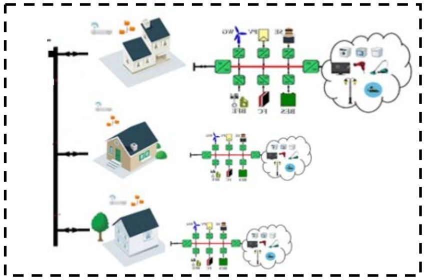
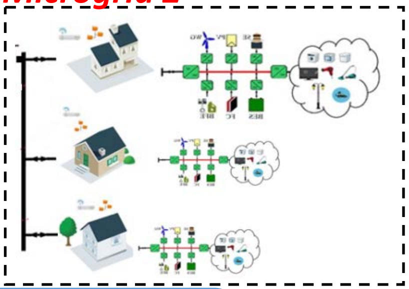
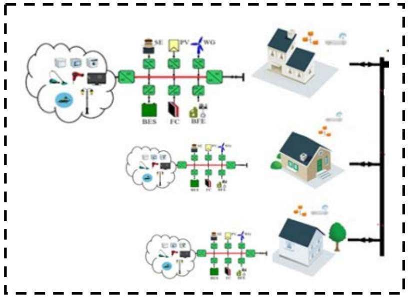


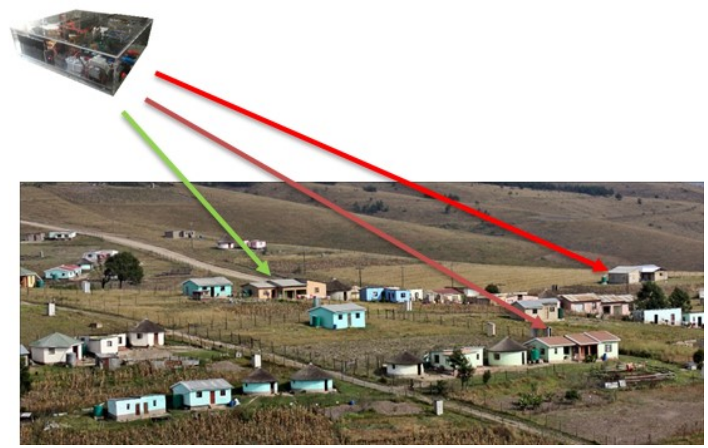
Microgrid 2





Microgrid 3

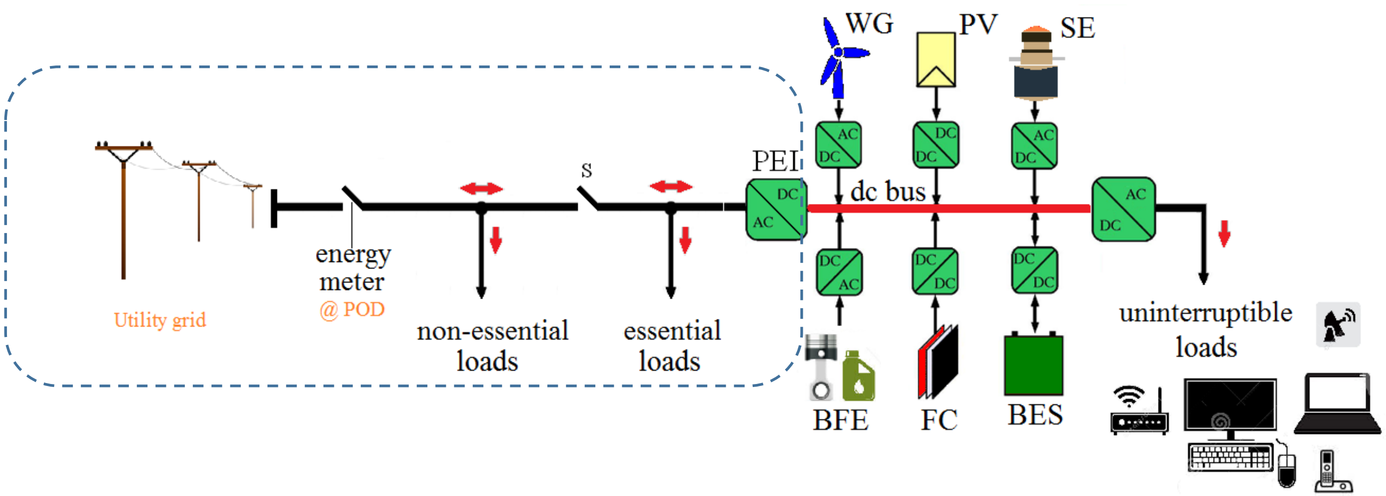
A supply system



The payback of the investment in islanded microgrid when adopting a bottom-up approach is acceptable because it is in line with the actual use. A feasible solution to implement the bottom-up approach illustrated above is to **provide** each home of the isolated community with a **supply system**, which

- exploits the local RESs
- interconnects to similar systems so to realize a cooperative network.

A building block



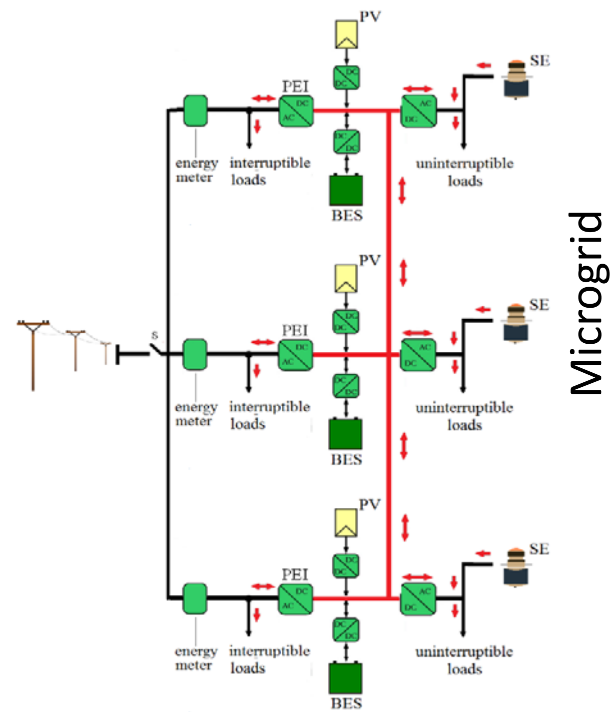
We propose a supply system based on a particular topology of nanogrid; the proposed nanogrid exploits **local RESs** and optimally manages the local generation units, the local storage units and the local loads. Furthermore, the nanogrid has been designed to **easily connect** to others, to **share resources, and to connect to the utility grid (if present)**.

The predisposition to the interconnection, demonstrates that the proposed nanogrid can be considered the **building block** of both ac and dc smart microgrids.

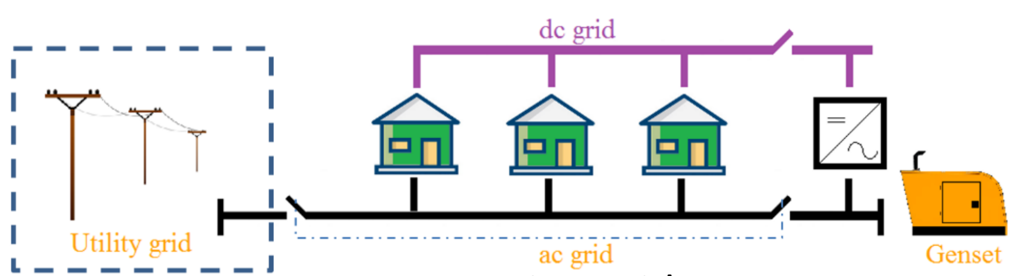
Ease of interconnection

The ease of interconnection of the proposed nanogrid is a strong boost to support and apply intelligent energy management models, both centrally and distributed, even in microgrids for isolated villages of developing Countries. Each village can be organised in one or more microgrids.

Furthermore, a group of microgrids can be interconnected each other and appropriately controlled by an aggregator, especially when a utility grid exists.

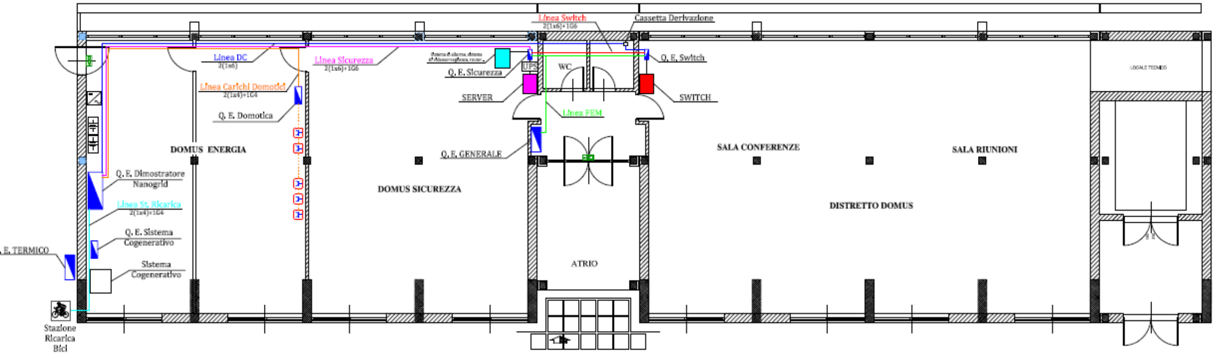


The optimized management of interconnected microgrids returns a smart grid.



An existing smart microgrid

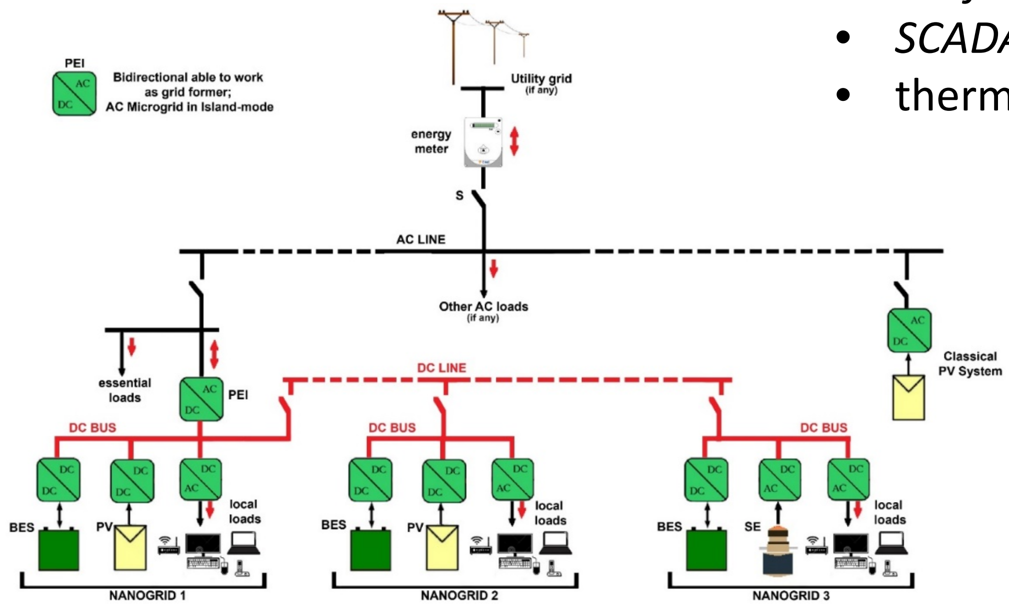
As application we have made up a smart microgrid by the interconnection of three nanogrids, in the campus of University of Calabria. Four different PV generator are mounted on the rooftop of the building (in total 10kWp) hosting the smart microgrid control room.



The control room

The PV plants provide clean energy for each nanogrid and covers almost all the energy demand of three groups of local loads (one for each nanogrid); energy is imported from the 230V-50Hz utility grid only when necessary. Local loads essentially are critical loads because the building hosts various important services such as:

- *ICT facilities,*
- *SCADA*
- thermo-cooling systems.



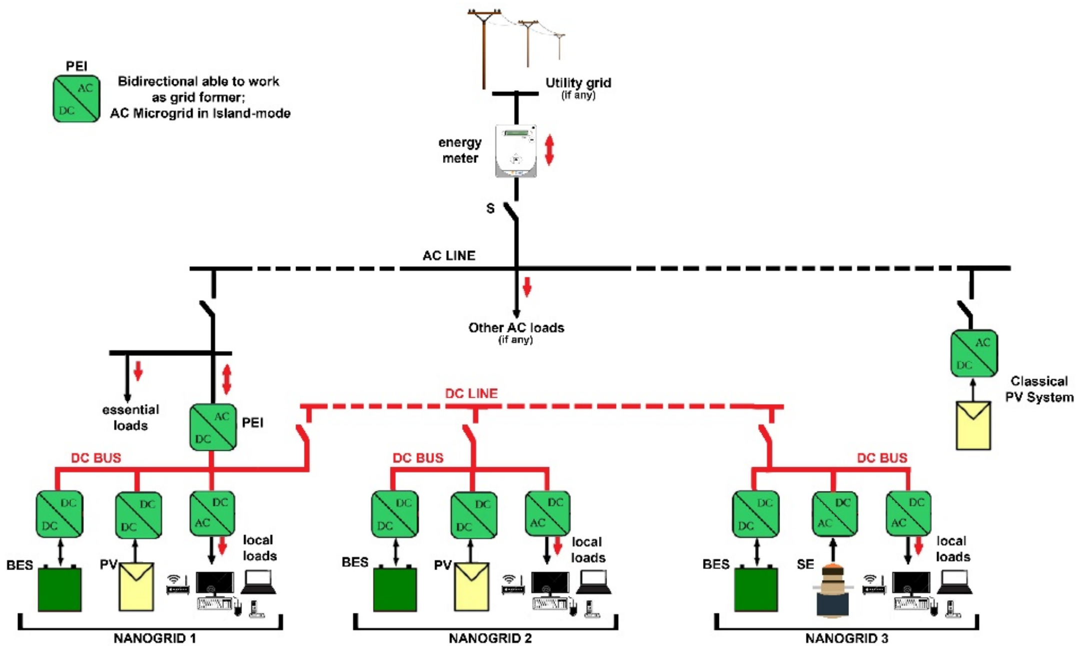
The schematic electric circuit clearly explains how the three nanogrids can be interconnected each other and how their functioning relates to the overall smart microgrid.

The control room

The figure goes inside the control room and shows the control position of the supervisor, the main switchboards and other apparatus and devices. In order to ensure a high power quality and the continuity of power supply to critical loads, the smart microgrid integrates three nanogrids.

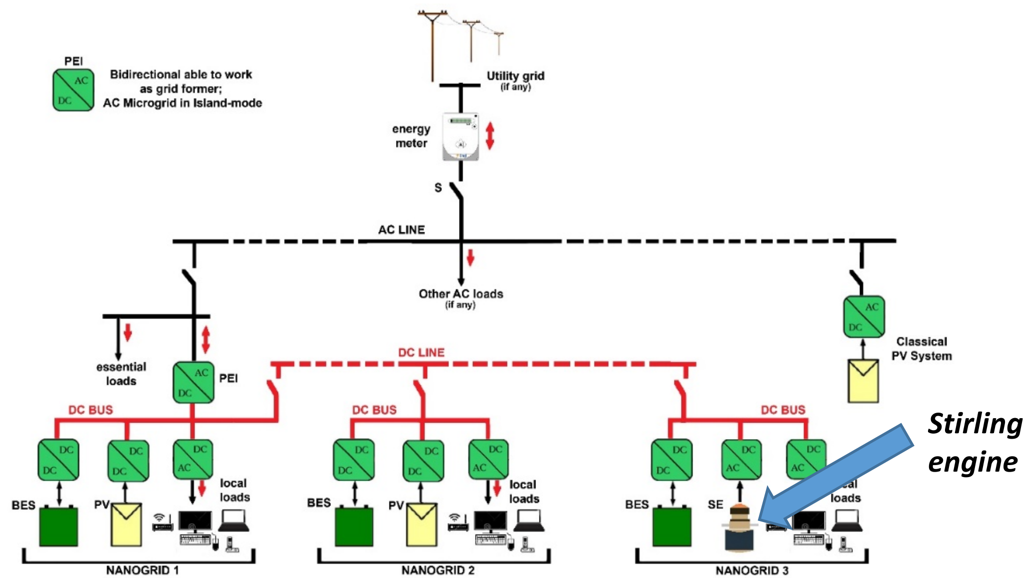
The 1st-2nd nanogrid

The Nanogrid 1 and Nanogrid 2 include converters and a dc bus. A first dc/ac converter supplies a first set of local loads. A second dc/dc converter controls a PV system with a MPPT function. A third dc/dc converter control the charge/discharge of a 11kWh LI-PO batteries energy storage system. In addition Nanogrid 1 has a bidirectional dc/ac (PEI) converter, able to work as grid former; it joins the dc bus to the local ac grid.



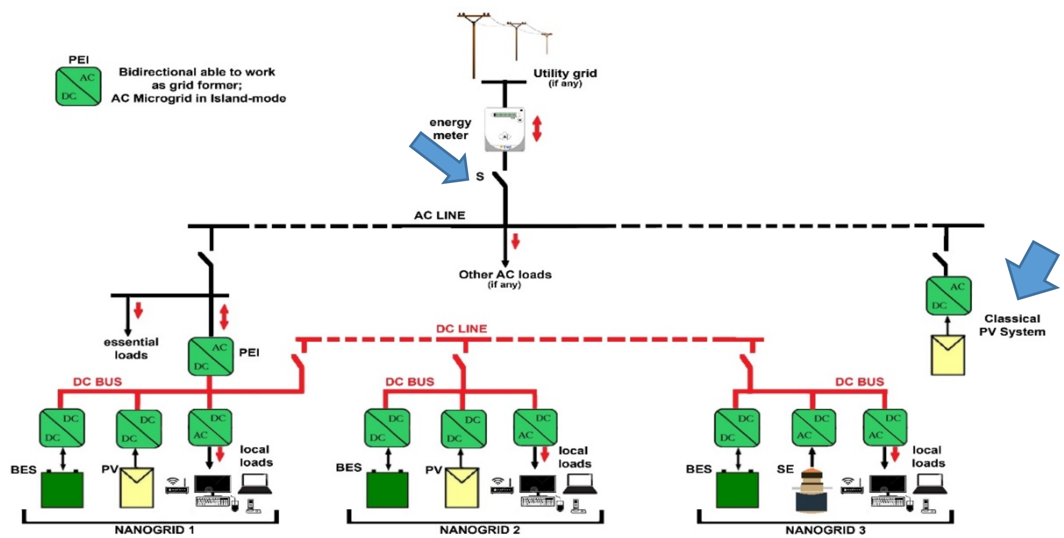
The 3rd nanogrid

The distributed generator connected to the Nanogrid 3 is a linear synchronous generator powered by a free-piston Stirling Engine, installed into a biomass boiler. Such generator can provides power to a third set of critical loads. In addition, the boiler provides thermal power to the heating system. Also for this nanogrid there is a third dc/dc converter to control and charge/discharge a energy storage system of 3kWh that, in this case, is based on lead acid batteries type.



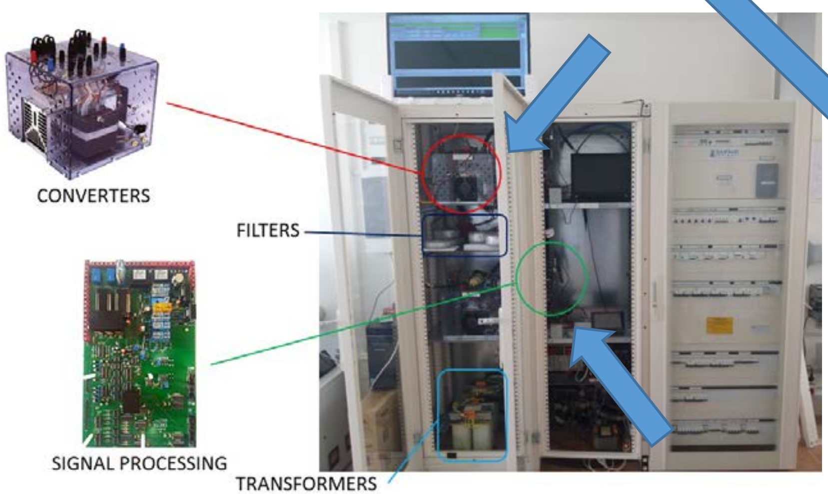
A PV plant and the utility grid

A PV plant comprising the 50% of the PV modules, placed on the rooftop, is directly connected to the local ac grid, by mean a classical PV inverter, so that it contributes to supply all loads belonging to the smart microgrid. By mean the switch S, it is possible to separate the local ac grid by the utility grid. When the switch S change state from Close to Open, then the dc/ac converter of nanogrid 1 change operating mode, from current controlled mode to voltage controlled mode, acting as grid former to continue expoiting the PV energy belonging to the PV plant directly connected to the local ac grid.



Where nanogrids are installed.

The figure on the left shows the compartment where Nanogrids 1 and 2 are mounted; on the contrary, the Nanogrid 3 is enclosed within the case of biomass boiler, shown on the left side of the figure on the right side.



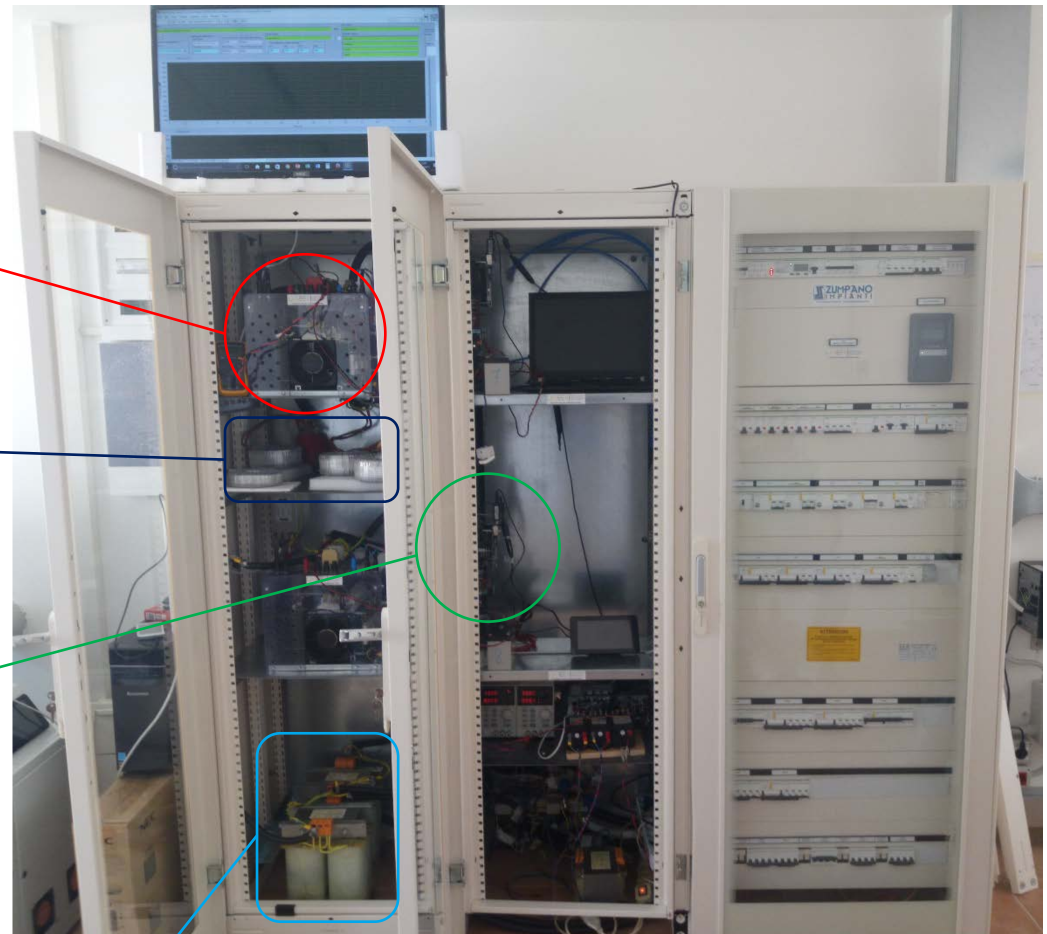
Where nanogrids are installed.

22kW
SEMIKRON
SEMITEACH -IGBT SKM 50 GB 123D SKD 51 P3/250F

CONVERTERS

FILTERS

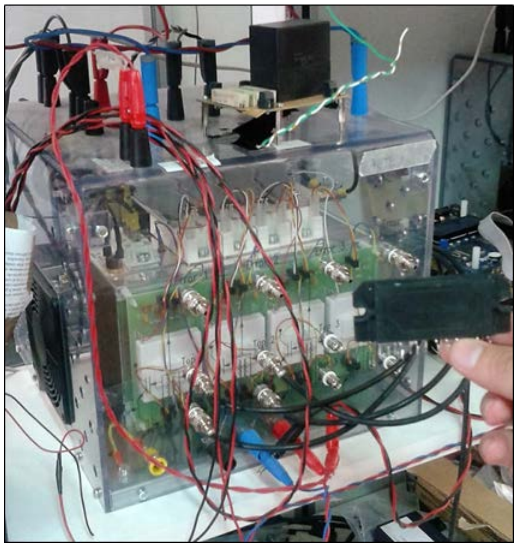
SIGNAL PROCESSING

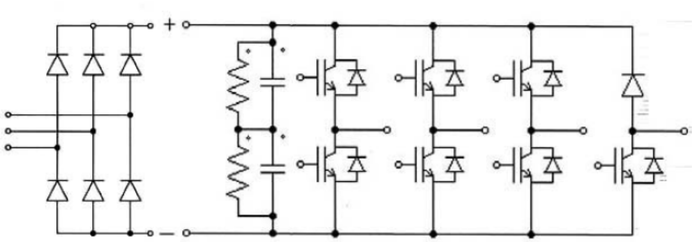


TRANSFORMERS

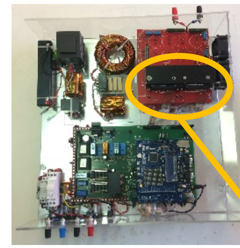
Differences

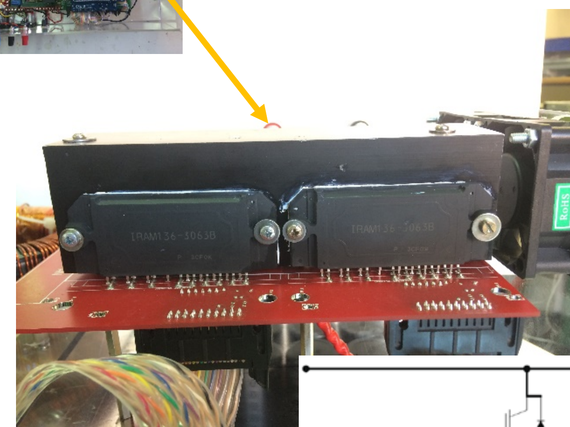
22 kW SEMIKRON
SEMITEACH – IGBT
SKM 50 GB 123D SKD 51 P3/250F





INFINEON
IRAM 136-3063B
(3.3 kW)





nGfHA