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DER-IREC 22@ Microgrid

Technology for a new energy model

ACC10 Cooperation Centres

CIRCUTOR is participating in trade projects dealing with industrial research and experimental development.

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ACC1Ó Competitivitat per l'empresa
Generalitat de Catalunya

(*) ACC1Ó is the agency set up by the Catalan Government to make Catalan enterprise more competitive throughout the world. Its key aims are to drive innovation, internationalisation and attract inward investment.
www.acc10.cat/en

Introduction

CIRCUTOR is participating in trade projects dealing with industrial research and experimental development.
In this project, managed through **ACC10**(*) and with regional development funds from the European Union (project co-funded by FEDER as part of the 2007-2013 Operational Programme of Catalonia), a consortium of businesses and research centres has been set up in order to carry out joint research in the field of microgrids, which will doubtless result in a revolution similar to that brought about, in its day, by centralised, high-voltage, long-distance distribution.

In the 2010.02 publication, a presentation was made of the challenges involved in this project, which at the time was starting to be developed. We also committed ourselves to releasing a publication at the end of it, publicising the results and the reality attained.

Microgrid Concept

A microgrid is a system that unites diverse generator sources of potentially renewable energy, energy storage and loads. They may operate independently or be connected to distribution lines.

The use of the resources of the microgrid itself can be modified in accordance with many factors

- ***Environmental.*** The use of alternative energy may be prioritised in order to reduce CO2 emissions.

- ***Market.*** Based on energy cost, the microgrid will focus on self-sufficient consumption, storage, or delivery to the distribution lines.

- ***Backup.*** In the event of contingencies or the needs of the distribution lines, its default settings can be modified, whether to help correct the problem or during disconnections for maintenance purposes, etc.

This involves *intelligence* in the functioning of the microgrid, an immediate response, and a completely proactive system in the general distribution network, which broadly defines the concept of the SMARTGRID or intelligent network, which would bring together a set of microgrids.

Consortium Presentation

This collaboration centre is formed by the companies GTD Sistemas de Información (project leader), Circutor, Cinergia and Endesa Electrical Distribution, with the participation of research agents Barcelona Digital Centre Tecnologic, Centro de Innovación Tecnológica CITCEA-UPC and the Institut de Recerca en Energía de Catalunya (IREC)

The companies that are part of the group have wide-ranging experience with clusters and collaboration projects.

- **GTD Sistemas de Información**, a R&D company, has participated in multiple collaboration projects, CENIT among them, and within the European framework program in FP5, FP6 and FP7, as well as participating in the aeronautics cluster.

The challenge faced by the project required two clusters to come together (Energy and ITC), which possess their respective experience.

The ITC cluster is represented by **Barcelona Digital**, which is the centre of ITC technology within the Catalonia network of technological centres and performs research in the areas of mobility, security, and health.

IREC represents the Energy cluster, and has as its objective technological research and development in the field of energy and its production, transformation, distribution and use.

Finally, **CITCEA-UPC** is a landmark university research centre characterised by its experience in the fields of mechatronics and enertronics.

Project

Project Benefits

A microgrid is a system that unites diverse micro-generators, storage devices and loads into a single system, which provides electrical as well as heat energy.
The CERtos Microgrid concept – US Department of Energy

- **CIRCUTOR** is part of the ITEC-Btec Energy Efficiency cluster, as well as the MIT&C energy platform.

- **Endesa Electrical Distribution** is part of the clusters and has long experience of participating in collaborative projects. It also participates in a range of landmark Catalonian, state, and European platforms and associations.

- **Cinergia** is a technology-based company dedicated to designing and manufacturing bespoke power electronics equipment.

In the future, optimum management of microgrids will make possible:

- Energy Efficiency
- Emission Reduction
- Increased use of renewable energies
- Reduction of energy costs
- Greater power supply security
- Minimisation of wasted electricity

General Objectives

- To create a DER – IREC 22@ MICROGRID platform for experimentation, which provides experimental data to various operators in the sector.

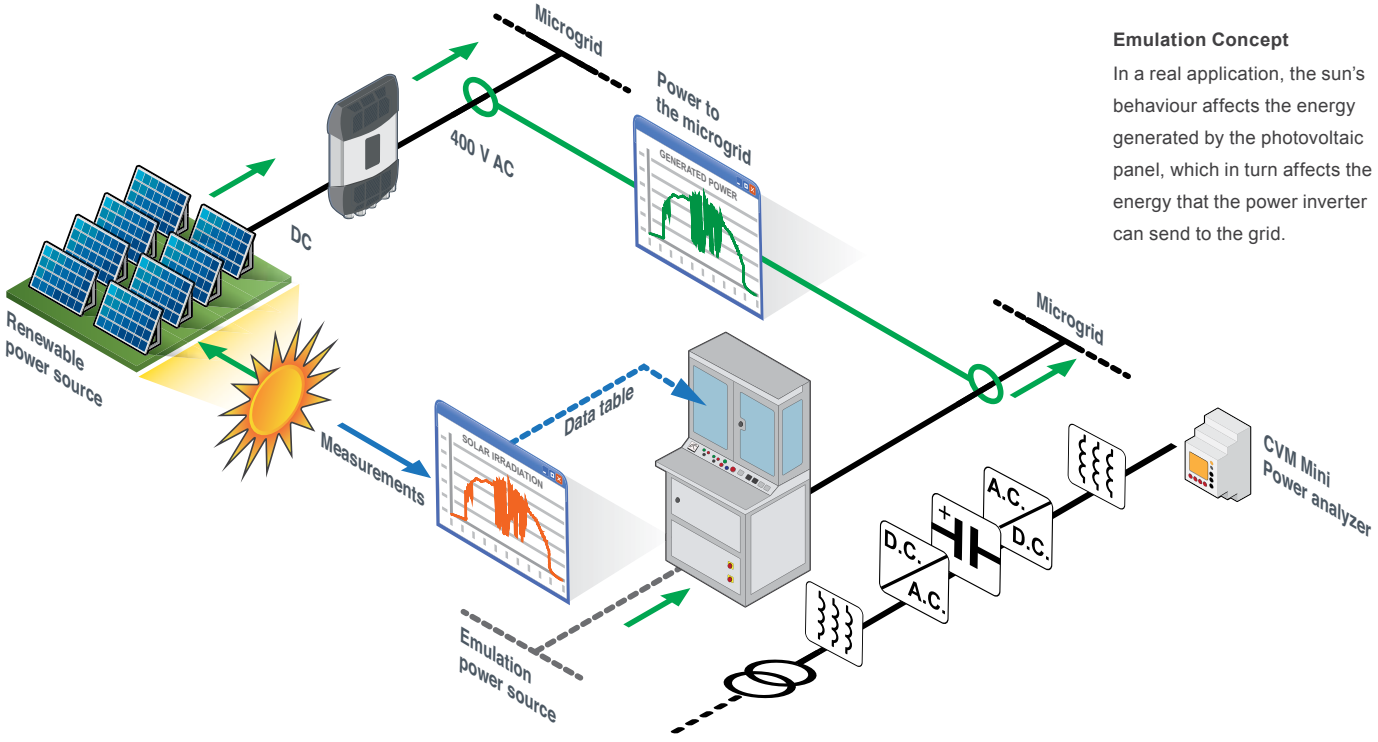
- To identify and overcome the technical barriers that impede the adoption of the new paradigm of distributed energy resources represented by microgrids.
- To consider and foresee the impact that the electric vehicle will have on the new energy model and on the microgrids that will make it possible.
- To analyse new energy-management models that take into account the interaction between microgrids and distribution lines.
- To envision new products and services originating from the paradigm change which will arise within the electrical sector in the years to come.
- Algorithms for the exchange of energy between the microgrid and distribution lines based on simulation of price signals
- Microgrid communications systems: virtualization of devices and improvements in current protocols
- Technologies that may enable the DER model to be scalable. Technologies applicable to larger networks or an "N" of equal networks
- New standards to enable interoperability of equipment from different manufacturers within the same microgrid
- Environmental effects produced by operation of the microgrid: characterisation of environmental conditions .

If we have a curve that characterizes the behaviour of solar radiation over a given period, simply loading it in the emulator will allow the emulator to behave as an inverter would under these conditions, and will generate real power, which will be measured, analyzed and interpreted by the system.

That is to say, the amps will actually circulate through the system (watts), unlike a simulator in which everything is at the software level (bits).

With this system we can emulate any actual good behaviour, based either on information collected from radiation sensors, wind sensors, etc., or on hypothetical conditions by creating a table that recreates the desired situation.

Based on this system, 5 units have been developed with the capacity to emulate the behaviour of the various elements that we can find in a microgrid:



Emulation Concept

In a real application, the sun's behaviour affects the energy generated by the photovoltaic panel, which in turn affects the energy that the power inverter can send to the grid.

Project R & D challenges

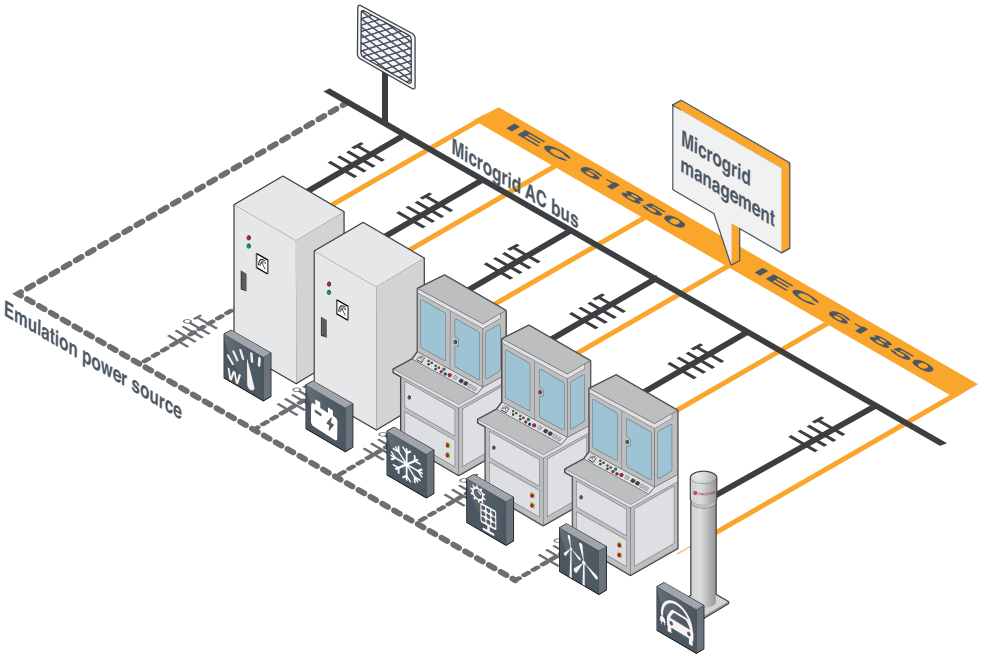
- Optimisation of microgrid management according to economic as well as technical criteria
- Algorithms for optimisation of the interrelation between the mix of renewable energy sources and the electrical vehicle load

Objectives and challenges reached

Emulation Concept

In a real application, the sun's behaviour affects the energy generated by the photovoltaic panel, which in turn affects the energy that the power inverter can send to the grid.

- Photovoltaic and wind generation, etc.
- Consumption in weather conditions (depending on the external temp), EV load, future use of EV as storage (V2G or V2H), etc.
- The distribution lines
- Any new generator or consumer system



Each emulator has an algorithm that allows you to manage the behaviour of the power transducers to interact within the microgrid itself, depending on the instructions entered (environmental, market, support).

Project experimental environment

To test the various systems interacting with each other and thus verify all the algorithms, measurement systems and power transducers, the following scenario is established:

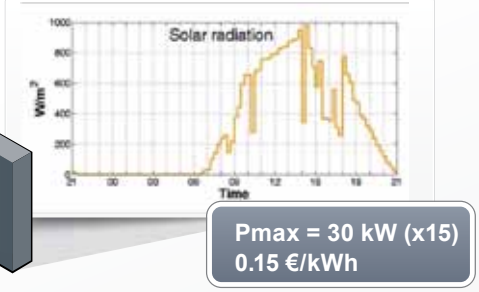
- **Photovoltaic Power Generation**
- **Wind Power Generation**
- **Storage (battery)**
- **Consumption (HVAC heating, ventilation and air conditioning)**
- **Distribution**

Finally, a price policy has been established for both energy sales and purchasing, making it another variable to consider within the microgrid.

Conditions:

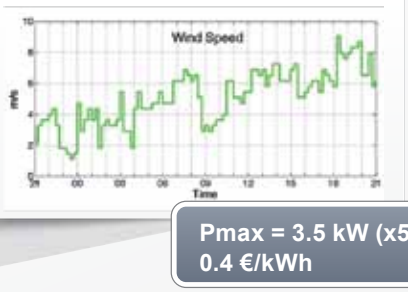
Start Date:	15th July 2011-21:00
Location (data to emulate):	Forum (Barcelona)
Real duration:	24 hours
Emulation duration:	24 minutes
Time scale:	1 hour = 1 minute

Solar radiation curve



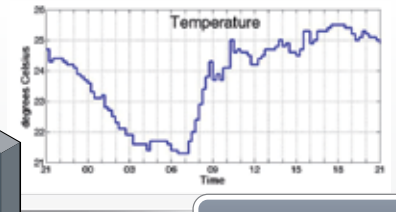
Pmax = 30 kW (x15)
0.15 €/kWh

Wind speed curve



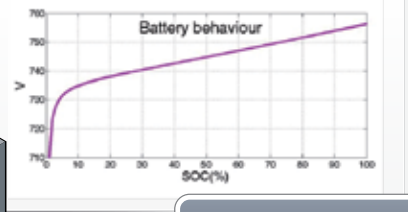
Pmax = 3.5 kW (x5)
0.4 €/kWh

Outside temp. evolution curve



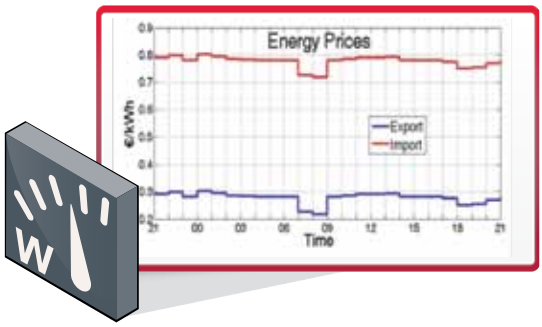
Pmax = 10 kW (x4)
Set Point 22.5 °C

Battery load curve

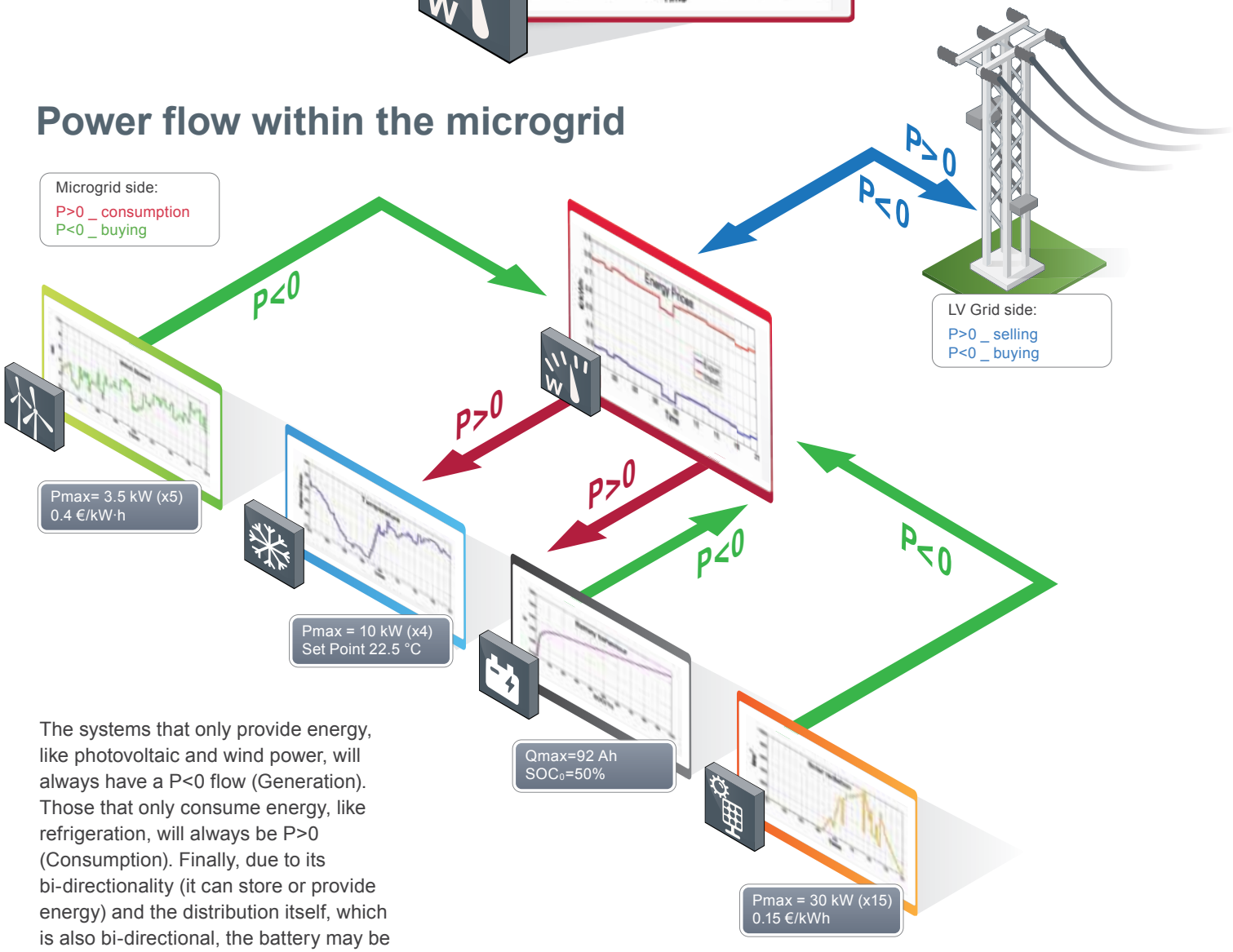


Qmax=92 Ah
SOC_0=50%

Once the role of each emulator within the microgrid has been determined, we can identify how the energy flows will move.



Power flow within the microgrid



The systems that only provide energy, like photovoltaic and wind power, will always have a P<0 flow (Generation). Those that only consume energy, like refrigeration, will always be P>0 (Consumption). Finally, due to its bi-directionality (it can store or provide energy) and the distribution itself, which is also bi-directional, the battery may be P<0 or P>0, depending on the situation.

During the entire emulation, the SCADA system captures the electrical parameters (voltage, current, active power and reactive power in the four quadrants and energy) through the metering devices distributed among the emulators.

Finally, having analyzed this information, we can see the behaviour of the entire microgrid during the emulation.

You can observe how the energy flows have adapted to the required conditions in real time.

At night, as consumption is not required for HVAC, the batteries were charged.

At times of peak consumption the energy produced and the energy accumulated in the batteries was used to mitigate this effect.

It has been shown that the intelligence of the Microgrid, in the form of the algorithms implemented, performs real time management of all of the assets.

During the entire emulation, the SCADA system captures the electrical parameters

Finally, having analyzed this information, we can see the behaviour of the entire microgrid during the emulation.

Importantly, although the environment has been emulated, the current flows between the different elements are real and the passage from an emulated environment to areal one is very small, as opposed to a simulation where one environment is “computerized” and the other is electric.

The great advantage is that just as this environment has been created, we can create any other one that allows us to validate the solutions that will make the distributed model a reality.

Project participants at the Consortium Stand at the Smart City Expo taken place in Barcelona, and general view of the stand.

Conclusions

The attained results have met all the objectives of the project.

- We have an experimentation platform suitable for all stakeholders.
- We have demonstrated the technical viability of the distributed generation model.
- The EV is not only not a problem but an active part of this new model.
- We have shown the need for new management models based on proactive systems.
- This project has also given us a glimpse of new development challenges that will undoubtedly appear on the market in product form in coming years.

And of course it has highlighted the smooth operation of the consortium, in which, apart from a high level of technological knowledge, there have been extraordinary personal qualities. It is certain that we will work together in the future on new challenges.

Presentation of the Project at the Smart City Expo World Congress held in Barcelona

It was impossible to imagine a better framework than this event to present the results of this project. Indeed the Smart City Expo World Congress ended its first edition as the new international landmark in the field of intelligent cities. For four days, Barcelona brought together 6160 professionals, 118 companies and 367 speakers to debate how the cities of the future must be. Delegations from 51 cities on five continents also attended.