Interreg Sudoe

EUROPEAN UNION

IMPROVEMENT

European Regional Development Fund

NEWSLETTER N°1

THE IMPROVEMENT PROJECT IS RUNNING

IMPROVEMENT-Integration of Combined Cooling, Heating and Power Microgrids in Zero-Energy Public Buildings under High Power Quality and Continuity of Service Requirements

Co-Funded by the Interreg SUDOE programme of the European Union Grant Number SOE3/P3/E901

KICK-OFF MEETING OF THE IMPROVEMENT PROJECT IN CORDOBA

The project "**INTEGRATION OF COMBINED COOLING, HEATING AND POWER MICROGRIDS IN ZERO-ENERGY PUBLIC BUILDINGS UNDER HIGH POWER QUALITY AND CONTINUITY OF SERVICE REQUIREMENTS", IMPROVEMENT**, co-financed by the **INTERREG SUDOE Programme** within Priority Axis 3, Low Carbon Economy, was officially launched on January 15th 2020 at the headquarters of the University of Cordoba.

The **IMPROVEMENT** project is constituted by a consortium of 9 entities: Besides the National Hydrogen Centre, CNH2 as main beneficiary of the project, with the rest of beneficiary partners are the National Laboratory of Energy and Geology of Portugal (LNEG), the National School of Mechanics and Aerotechnics (ENSMA), the University of Cordoba, the University of Castilla-La Mancha, the University of Perpignan Via Domitia, the Higher Technical Institute of Lisboa; the Andalusian Energy Agency and the General Directorate of Energy, Regional Ministry of Finance and European Projects of the Andalusian Government. In addition to this consortium, there are eight associated beneficiaries from three countries in the SUDOE Region: Green Power Technologies S.L; NEC RENOVABLES S.L; La Axarquia Hospital; Irradia Solar Engineering; Regional Energy Climate Agency Occitanie; Regional Energy and Environment Agency of the Algarve; Sustainable Construction Platform Association; and Intermunicipal Community of Algarve.

Main goal of the project

The main goal of the project is the development of the necessary elements for the deployment of a new generation of renewable microgrids for the supply of thermal energy (heating and cooling) and electrical energy. This technology will enable the quality and continuity of the electricity supply to be improved, which are fundamental aspects in buildings in which high technology equipment is predominant, and which also entails high energy consumption in electricity, heating and air conditioning. Examples of this kind of buildings are hospitals, research centers or transport stations, among others.

More info

The project development is focused on Microgrid based on advanced energy management system, with hybrid storage supported by hydrogen, batteries and ultracapacitors. In addition, control techniques based on Model Predictive control (MPC) will be applied to the system in order to guarantee the correct integration of renewable energy systems and the improvement in the energy efficiency of the addressed public buildings for their transformation into nearly Zero Energy Buildings (nZEB).

The **IMPROVEMENT pilot project** proposes to implement and validate the developed solutions in 2 pilot plants. One of them consists in an experimental microgrid platform located at the CNH2 facilities in Puertollano (Ciudad Real) in which the innovative different technical solutions are tested and integrated.

The other pilot plant is carried out in Lisbon, under the direction of the Laboratorório Nacional de Energia e Geologia (LNEG), with the support of the Higher

Technical Institute of Lisboa (IST), that integrates the renewable heat/cooling generation systems in a microgrid for the conversion of an existing public building into a zero energy balance one.

In addition, the the University of Cordoba is responsible for developing a power control system for microgrids with high power quality requirements based on a network of intelligent IoT (Internet of Things) sensors. In parallel, the the University of Cordoba collaborates with the the University of Castilla La Mancha that develops specific power electronics.

The General Directorate of Industry, Energy and Mines of the Regional Ministry of Finance and European Funding participates in the consortium, analyzes the regulatory framework by proposing the necessary recommendations to facilitate their adoption in the region; and the Andalusian Energy Agency, that studies the applicability and requirements of the proposed solutions, participates in their validation, once they have been developed, and draw up specific plans to implement the results of the project through the Energy Network of the Regional Government of Andalusia (Redeja).

On the other hand, the National Superior School Mechanics and Aerotechnics and the University of Perpignan Via Domitia UPVD is in charge of the development of energy management system for microgrids with hybrid storage under minimum degradation criteria and prioritization of renewable consumption, through the implementation of advanced algorithms including energy prices, energy generation and energy consumption forecast tools.

TECHNICAL VISIT TO THE AXARQUIA HOSPITAL IN MALAGA.

The following day, January 16th 2020, was devoted to visit the facilities of The Axarquia Hospital, which is participating as an associated beneficiary. The Málaga-Axarquía Healthcare Area experts emphasized the importance of this project for the development of renewable energies in Andalusia.

Integrated in the Energy Network of the Andalusian Government (REDEJA), the hospital in Malaga will simulate the best solutions achieved in this project, to convert it into a zero energy balance building, using passive (canopy, efficient windows, adequate insulation and orientation) and active components (efficient air conditioning, radiant floors,...), and incorporating the advanced energy management and storage systems developed in the European project **IMPROVEMENT**.

PILOT PLANT AT HIDROGEN NATIONAL CENTER FOR HYDROGEN TECHNOLOGY EXPERIMENT AND FUEL CELLS

The **CNH2 pilot plant** has two main parts, an electrical microgrid part and a thermal system.

As we already know, due to the health crisis, 2020 was a somewhat complicated year for the development of the pilot plants due to the difficulty of being present in the different laboratories.

Despite this, it was possible to **work on different advances in the electrical microgrid**, carrying out the development of the different control algorithms that will provide the microgrid with intelligence.

Once it was possible to start attending the center where the pilot plant and the electrical microgrid are installed, different tests were carried out to verify the correct operation of the different power electronics equipment (inverters, converters...) and their integration into the microgrid.

Within the thermal system, advances were made in a more conceptual way, analyzing and reviewing the different requirements that were necessary to be able to complement this system with the electrical microgrid. In particular, they were looking for different suppliers of phase change material (PCM) and a company capable of carrying out the installation of the geothermal heat recovery system.

INTERVIEW THREE QUESTIONS TO PARTNERS

Felix García Torres PhD, Responsible of the Microgrids Laboratory of CNH2 until August 2021

Felix García Torres PhD, received his title of Industrial Engineer specializing in Electricity in 2004, from the University of Seville, obtaining a doctorate from the same University in 2015, with the thesis "Advanced Control of Renewable Generation Microgrids with Hybrid Energy Storage" . His professional career has always been linked to research related to renewable energy and energy storage. He started working at the Western Catholic University in Angers (France), carrying out a SCADA system for a microgrid for the generation of heat and electricity in 2004, later he joined the Renewable Energy Laboratory belonging to the Institute of Industrial Automation of the Council Superior of Scientific Research, where he worked on different projects such as the CSIC's Strategic Intramural project for the Generation of Hydrogen through aqueous solutions with sucrose and the Development of the Possible House, in the Plaza OIKOS-Agua y Energía at the Zaragoza Expo 2008. He was working in the spin-off company of the University of Seville, GreenPower Technologies. Coinciding with the creation of the National Hydrogen Center, he joined in 2009, as part of the initial team of Engineers in charge of creating the Singular Scientific Technical Installation of the National Hydrogen Center, where he works as Head of the Microgrids Laboratory until August 2021.

What were the reasons why National Hydrogen Centre decided to participate at the Improvement project?

The **IMPROVEMENT** Project was born as a joint initiative of National Hydrogen Centre (CNH2) and the Industrial Electronics and Instrumentation Group of the University of Cordoba, led by Professor Antonio Moreno PhD, focused on advanced electronics

applications to improve supply quality. The potential to couple the autonomy that hydrogen could provide with the need for an advanced infrastructure for energy management in buildings where losses of quality and continuity of supply could lead to criticality situations was detected.

In recent years, numerous projects have been developed to improve energy efficiency in buildings and to integrate renewable energies into them. However, there are still few projects related to the problems of integrating distributed energy resources (DER) in the broadest sense, in environments where high-tech equipment, the so-called "critical loads", is predominant.

This kind of environments are always particular due to the extreme sensibility of this equipment to power disturbances. For scientific considerations in universities and technological centers, as well as, for sanitary reasons in hospitals and for security reasons in military facilities, railways stations or airports, power quality and continuity of supply must be considered as fundamental aspects.

In the same way, as a differentiating character and characteristic of the SUDOE area, this type of facility is characterized by high energy consumption for heating in the winter months and air conditioning in the summer months.

Faced with the technological challenge of improving the energy efficiency of this type of building and basing its consumption on renewable energy while maintaining the quality and continuity of service that the technological equipment of this type of location requires, the three fundamental action lines of the IMPROVEMENT project were proposed.

- 1) To improve the thermal efficiency of this kind of public buildings through the production of solar heating and cooling and the incorporation of active/passive techniques for buildings with zero energy consumption

- 2) To enhance the power quality and reliability of the supply in public buildings with critical loads by developing a fault-resilient power control system for microgrids with an active control of the neutral point and the deployment of a network of IoT power quality sensors.

- 3) To integrate advanced energy management systems for renewable microgrids with hybrid energy storage system under criteria of minimum degradation, minimum cost of use of the storage system and maximization of clean energy consumption.

What will this project bring to Spain and to CNH2?

Hydrogen itself is an energy vector. With this, you can have the best fuel cell or the best electrolyzer, or the most efficient way to generate hydrogen than if you do not look for final application solutions. Both Spain, the south of France or Portugal, which is the SUDOE area, has been characterized by having a high resource both solar and wind, which has always given it a pioneering role in renewable energies.

The **IMPROVEMENT** project seeks precisely to develop a pioneering and clearly disruptive technology at the same time as close to the market for the generation of employment, wealth and technological positioning in the field of energy transition, seeking the leading role of hydrogen as a storage system, given its energy density allows for long periods of energy autonomy in the event of loss of power supply without requiring large spaces for storing energy, as would be the case if the solution were based only on batteries.

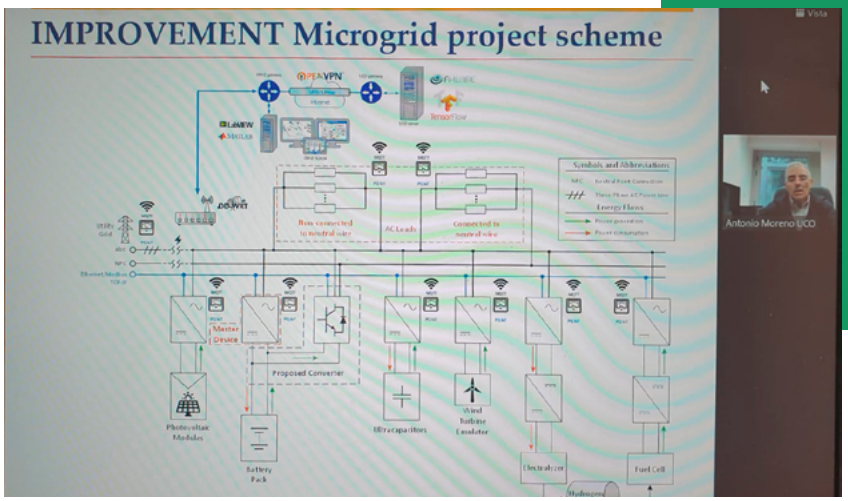
What is the current status with nZEB and hydrogen in Spain at the moment?

In the public buildings there is an important potential for energy saving, which, however, is not being carried out with the importance that it should. In each of them energy is consumed to meet the needs of heating, cooling, availability of domestic hot water, ventilation, lighting, cooking, washing, food preservation, office automation, etc. The sum of this consumption represents 20% of final energy consumption in Spain, a percentage that also tends to increase.

Currently around 75% of the EU's building stock is energy inefficient. That means that a large part of the energy consumed is wasted. The renovation of buildings already in use could reduce total energy consumption in the EU by 5-6% and cut carbon dioxide emissions by around 5%. Despite this, on average less than 1% of national building stocks are renewed each year (depending on the Member States, the percentages range from 0.4% to 1.2%).

As a whole, buildings are responsible for 40% of the EU's energy consumption and 36% of greenhouse gas emissions, mainly generated during their construction, use, renovation and demolition.

Therefore, improving the energy efficiency of buildings will be decisive for the ambitious goal of achieving carbon neutrality established by 2050 in the European Green Deal.



INTERNATIONAL CONFERENCE ON RENEWABLE ENERGIES ON-LINE/ROME, NOVEMBER 2020

Photo of the presentation at the ICREN international conference on Renewable Energies

The University of Cordoba have presented the Improvement Project during the International Conference on Renewable Energies, 25th november 2020.

On November 25th, 2020, the University of Córdoba participated in the International Conference on Renewable Energies, ICREN 2020, in which it presented the **results of the Improvement project** in a plenary conference entitled: **IoT-based submetering for DSM- DR applications in Energy Smart Appliances.** The conference had 500 participants from all over the world. It is an annual meeting that is planned to be held in different countries, initially within Europe, highlighting Asia, the Middle East, Africa and Latin America as target regions of the conference.

Works have been developed under the Improvement project Integration of Combined Cooling, Heating and Power Microgrids in Zero-Energy Public Buildings under High Power Quality and Continuity of Service Requirements, Funded by the Interreg SUDOE programme of the European Union Grant Number SOE3/P3/E901.

Further information:

Link to the meeting: https://premc.org/conferences/icren-renewable-energy/

TECHNICAL PUBLICATIONS FROM PARTNERS

We would like to share with the Improvement Community some of the publications related to the Improvement Project.

- **1.** F. Garcia-Torres, P. Baez-Gonzalez, J. Tobajas, F. Vazquez and E. Nieto, "**Cooperative Optimization of Networked Microgrids for Supporting Grid Flexibility Services using Model Predictive Control**" in IEEE Transactions on Smart Grid, vol. PP, no. PP, pag. PP-PP , doi: 10.1109/TSG.2020.3043821.
  Publication's date: 2020/12/14
  Abstract:
  The transition towards fully renewable energy-based power systems will require to increase the number of reserves at the System Operators' (SOs) disposal to provide flexibility on the energy management process. The microgrid's ability of integrating distributed energy resources, loads and energy storage systems (ESS) appears as a powerful flexibility tool. Nevertheless, the associated control problem of microgrids increases with the number of connected devices. A structuration of the distribution grids in networks of microgrids is proposed, focusing on their ability to provide flexibility services. The complexity of the associated optimization algorithm is faced using Distributed Model Predictive Control (MPC). The algorithm is divided in two steps. The first one is applied to the cooperative participation of microgrids in the day-ahead market. The second step covers the interaction with the SO offering flexibility services in exchange for a financial benefit. The financial benefit is optimally shared between the networked microgrids to satisfy the power profile requested by the SO at the lowest cost. As the proposed control algorithm presents both continuous and binary variables, its associated optimization problem is formulated using the Mixed Logic Dynamic (MLD) framework, which results in a Mixed Integer Quadratic Programming problem (MIQP).

- **2.** Javier Tobajas, Pedro Roncero-Sanchez, Antonio

Moreno-Muñoz, Angel Saez, Ana Estanqueiro, Stéphane Grieu, Ladjel Bellatreche, Rui Costa Neto, Ana Rodríguez, Emilio Nieto, "Integración de microrredes de generación combinada de calor, frío y electricidad en edificios públicos de consumo cero bajo criterios de alta calidad y continuidad de suministro" -"**Integration of microgrids for the combined generation of heat, cold and electricity in public buildings with zero consumption under criteria of high quality and continuity of supply**"- Seminario Anual de Automática, Electrónica Industrial e Instrumentación- Annual Seminar on Automation, Industrial Electronics and Instrumentation (SAAEI 2020)
Publication's date: 2020/09/02
Abstract:
The objective of this work is to present the fundamental lines of the IMPROVEMENT project (SOE3/P3/E0901),co-financedbytheInterregSUDOE Program and the European Regional Development Fund (ERDF). The main objective of the project is to meet the challenge of integrating renewable energies and improving energy efficiency in public buildings in which, due to their field of activity, quality and continuity of supply must be considered fundamental aspects (Hospitals, Research Centers, Military Installations, Transport Stations). These public buildings have a large energy consumption for electricity, heating and air conditioning. For this reason, the project proposes its conversion to Zero Energy Balance Buildings (nZEB) through the integration of microgrids for combined generation of cold, heat and electricity with active control of the neutral and the use of hybrid storage systems for both electrical and thermal energy.

- **3.** Felix Garcia-Torres, Carlos Bordons, Javier Tobajas, Juan Jose Marquez, Joaquin Garrido-Zafra and Antonio Moreno-Munoz, "**Optimal Schedule for Networked Microgrids under Deregulated Power Market Environment using Model Predictive Control**", in IEEE Transactions on Smart Grid, vol. 12, no. 1, pag. 182-191.
Publication's date: 2020/8/19
Abstract:
Microgrids are considered as a key technology for the introduction of renewable energy systems in the electrical market. Nevertheless, microgrids are subject to random conditions such as changes in the energy forecast or component failures which will force microgrids to incur in the penalty costs applied in real time markets. In order to minimize the aforementioned costs, an optimal Energy Management System (EMS) for the economic re-schedule of a network of interconnected microgrids with hybrid Energy Storage System (ESS) under failure conditions is developed and validated using Model Predictive Control (MPC). The algorithm is specifically designed to achieve lower economic losses under failure conditions through the establishment of a local energy market in the network of microgrids than participating in the intraday or real-time markets.

4. F.Garcia-Torres, S.Vazquez, C.Bordons, I.Moreno-Garcia, A.Gil, P.Roncero-Sanchez, "**Power Quality Management of Interconnected Microgrids using Model Predictive Control**", International Federation on Automatic Control World Congress 2020.
Publication's date: 2020/7/13
Abstract:
In this paper, the power quality of interconnected microgrids is managed using a Model Predictive Control (MPC) methodology which manipulates the power converters of the microgrids in order to achieve the requirements. The control algorithm is developed for the microgrids working modes: grid-connected, islanded and interconnected. The results and simulations are also applied to the transition between the different working modes. In order to show the potential of the control algorithm a comparison study is carried out with classical Proportional-Integral Pulse Width Modulation (PI-PWM) based controllers. The proposed control algorithm not only improves the transient response in comparison with classical methods but also shows an optimal behavior in all the working modes, minimizing the harmonics content in current and voltage even with the presence of non-balanced and non-harmonic-free three-phase voltage and current systems.

5. Félix García-Torres; Joaquin Garrido-Zafra, Aurora Gil-de-Castro, Rafael Savariego-Fernandez, Matias Linan-Reyes, Antonio Moreno-Munoz, "**A novel Microgrid Responsive Appliance Controller**", in 2020 IEEE International Conference on Environment and Electrical Engineering and 2020 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe)
Publication's date: 2020/6/9
Abstract:
Due to the myriad of devices and loads that are collected under the Commercial Building Energy Management Systems (EMS) focused on the Industry 4.0 paradigm, it is important to ensure their proper electrical operation. The power quality here requires a granular monitoring approach, reaching a point where each device connected to the microgrid can diagnose that its power supply is optimal. Otherwise, it can participate cooperatively in decision-making to avoid faults or blackouts in the microgrid. In this work, we present a novel Controller to make smart appliances responsive to the grid, either autonomously or managed under

Demand Response policies. Apart from a TRIAC acting as an AC switch, the main advantage lies in its embedded Power quality internet of things (IoT) sensor. It measures a wide spectrum of electrical disturbances, far exceeding the capabilities of other solutions such as the Grid Friendly Appliance Controller, so it is possible to customize a battery of alarms at will, in e.g. according to IEEE-1547. Moreover, although it can act autonomously, its main mission will be to act in coordination, either cooperatively or under the supervision of the EMS.

The IoT platform where the controller would be incorporated is also presented. Finally, two case studies are presented to show their capabilities. With the integration in the microgrid of these distributed submetering systems, with wireless connectivity and under standard communication protocols, a further step will be taken in the development of the Digital Energy Platform, and the improvement of the quality of consumption by the user, as well as information support systems for smart meters.

For further information on the IMPROVEMENT PROJECT please, consult our web page:

https://www.improvement-sudoe.es/

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