Interreg Sudoe

EUROPEAN UNION

IMPROVEMENT

European Regional Development Fund

NEWSLETTER N°3

EVOLUTION OF THE IMPROVEMENT PROJECT

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

1. PROJECT ACHIEVEMENTS

In the newsletter n° 2 we collected the meetings held between the partners the consortium until last July. In this case, we summarise below the meetings held so far between the partners of this consortium:

11-12/05/2022 — IN PERSON/LISBON (PORTUGAL)/ IMPROVEMENT TECHNICAL PROJECT MEETING.

The Lisbon Improvement Meeting was prepared and organised by LNEG and had the participation of the task leaders of the WP3 (LNEG), WP4 (UPVD) and WP5 (CNH2). The May 11stwas dedicated to the organisation, review and scheduling of the work, presented by the leaders and respective partners of the WP3, WP4 and WP5 tasks — respectively LNEG, UPVD, CNH2 and IST. The group are visited the sites and equipment related to the LNEG Pilot Area — rooms, laboratory, technical area and solar thermal, PV and wind equipment — as well as the presentation of the thermal monitoring system through the energy management platform.

The May 12th was the occasion for the interrelated work between tasks WP3, WP4 and WP5 having agreed the intention to hold meetings via TEAMS between teams in the coming weeks. These should take place, such as between the UPVD (leader WP4) and LNEG, on the modeling and control of the thermal system and between CNH2 (leader WP5) with LNEG and the CNH2, on the issues of operation, planning of the test campaign and monitoring (summer) of the solar thermal system of the two pilot areas — Lisbon and Puertollano.

Photo 1. Lisbon Improvement Meeting at LNEG Pilot area, and group photo.

26-27/10/2022. IN PERSON/LISBON (PORTUGAL)/ AWARENESS RAISING EVENT IN PORTUGAL.

Lisbon hosted the second of the three dissemination events that make up IMPROVEMENT's communication plan that took place last October. Aimed at the "Integration of renewable systems in Public Buildings", the event was organised by LNEG (National Energy and Geology Laboratory) and was supported by the AAE (Andalusian Energy Agency).

During the event, the presentation of the IMPROVEMENT project was made and, specifically, the important role within the project occupied by the Lisbon pilot plant was highlighted, as well as its contribution as a space for the development and integration of renewable heat and cold generation systems in a microgrid for the conversion of an existing public building into one of zero energy balance.

Photo 2. Awareness Raising Event in Lisbon — group photo.

The days, which had a large influx of public, highlighted the role of renewable energies and their integration into public buildings as a tool for achieving greater energy efficiency and conversion into zero energy buildings (nZEB).

Finally, it should be noted that this event coincided with the celebration of the last technical days of IMPROVEMENT partners, also held in Lisbon on 26 and 27 October. A meeting held with the objectives of sharing learning between the pilot plants in Lisbon and Puertollano, and evaluating the status of final deliverables showing the results of the project to facilitate other public buildings their transformation into energy efficient buildings. More information here.

During these days, technical workshop was held to exchange information on the pilot plants of Improvement (Lisbon and Puertollano) and review the status of pilot projects.

The follow-up workshop of IMPROVEMENT partners took a technical approach to share learning between the pilot plants in Lisbon and Puerto Llano. In addition, the status of the final deliverables that show the results of the project was evaluated, in order to facilitate other public buildings their transformation into buildings with almost zero energy consumption (NZEB). More information here.

28-29/11/2022. HYBRIDO/PUERTOLLANO (SPAIN)/ AWARENESS RAISING EVENT IN SPAIN.

Improvement has organised a new event within the framework of the Interreg IMPROVEMENT Awareness Day, under the slogan "Quality and continuity of supply through hybrid energy storage systems in public buildings". It is a new dissemination act, the third planned within this communication plan, which took place last November 28 in Puertollano (Spain) and was carried out both in face-to-face and online format.

The event had the support and active participation of the National Hydrogen Center (CNH2), in addition to the presence of different partners and entities associated with the project such as the Hospital Comarcal de la Axarquía and Nec Renewables. Also, the event also involved leading companies such as Asime, Ingho FM, Sistrol and Geothermal Energy. To this is added the innovative incorporation of the Madrid Health Service, with a relevant intervention in the Green Hydrogen Pilot Project in the Hospital of the Community of Madrid.

The event consisted of a total of three sessions composed of different presentations that showed the importance of the

integration of renewable energy into public buildings, especially in the case of hospitals, as a key point for achieving sustainable and energy efficient buildings. Likewise, a group dynamic was carried out as the final closing of the day, aimed at the active participation of the attendees and evaluation of the progress and results collected throughout the day.

For its part, IMPROVEMENT was presented by Jesús Martin, responsible for the Project Management Unit of the CNH2, exposing the main advances of the project, the latest achievements and the results obtained from hydrogen technologies, among other aspects. In addition, the pilot plant of Puertollano, managed by the CNH2 and an essential part of the IMPROVEMENT project, was presented, as well as the different activities and lines of research that are developed in it and that seek the integration of combined microgrids of cold, heat and energy. with functionalities to improve the energy quality for the rehabilitation of public buildings with critical loads for their conversion into buildings of zero energy balance (nZEB).

During the day a guided tour was made to the facilities of the pilot plant of Puertollano. An opportunity that allowed attendees to know the different fields of action and lines of application in which they have been working since the beginning of the project. More information here.

Photo 3. Puertollano Improvement Meeting at CNH2 Pilot area, and group photo.

28-29/11/2022. HYBRIDO/PUERTOLLANO (SPAIN)/ EIGHTH MEETING OF THE TECHNICAL AND MANAGEMENT COMMITTEE OF IMPROVEMENT

Meeting of IMPROVEMENT Work Package Leaders to make technical and project development decisions. Specifically, the status of the different work packages was analysed for the completion of the project, scheduled for March 2023 and, specifically, the final event that will take place in Seville.

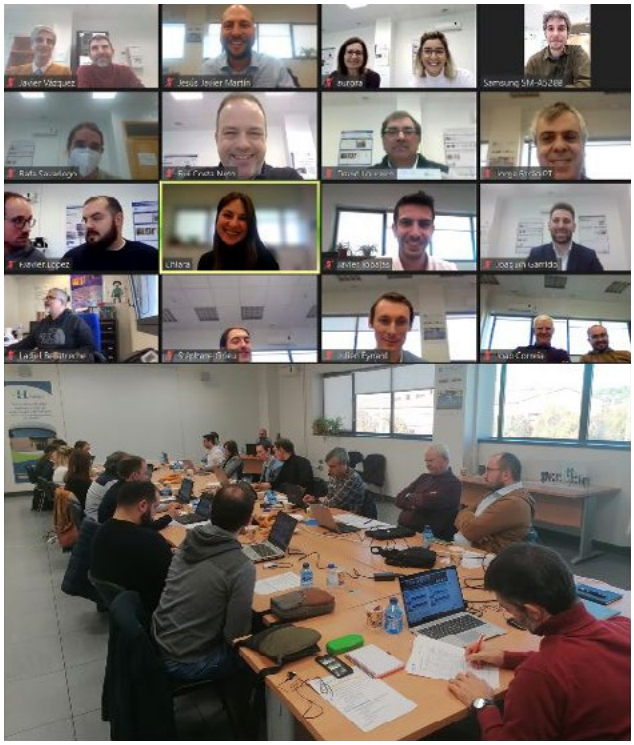

Photo 4. Eighth meeting of the Technical and Steering Committee.

2. CONFERENCES AND PRESENTATIONS OF IMPROVEMENT

The evolution of the project was presented in the following events:

17/10/2022. 48TH ANNUAL CONFERENCE OF THE INDUSTRIAL ELECTRONICS COMPANY IEEE, IECON 2022.

Francisco Javier LoPesca-Alcolea of the University of Castilla La Mancha (UCLM), partner of the IMPROVEMENT project, presents thepublication "Using resonant términs in a 2DOF control scheme for the current control of an active power filter" that includes the results of the IMPROVEMENT Project.

20/11/2022. 3 RD INTERNATIONAL CONGRESS OF POTENCE, ENERGY AND ELECTRIC INGENIERY, FOR 2022

Rafael Savariego (UCO), partner of the IMPROVEMENT project, presents "Integration of CCHP Microgrids in NZEB with Critical Loads under high PQR Requirements, a Position Paper".

17/12/2022. IEEE INTERNATIONAL CONFERENCE ON BIG DATA, IEEE BIG DATA 2022

Florian Chauvet, Ladjel Bellatreche and Carlos Augusto Santos Silva from the Institute Superior de l'Aeronautique de l'Espace (ENSMA), partner of the IMPROVEMENT project, presents "AI Approaches for Electricity Price Forecasting in Stable/Unstable Markets: EU Improvement Project" including the results of the IMPROVEMENT project.

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3. PILOT PLANT AT PUERTOLLANO FOR RENEWABLE GENERATION SYSTEMS

This pilot installation consists of a microgrid that integrates different electrical and thermal generation and storage devices, the latter both in the form of heat and in the form of cold.

The elements that make up the facilities are:

- 100 kW photovoltaic plant
- 30 kW fuel cell
- 60 kW alkaline electrolyser
- Hydrogen storage park with 8 300 l to 10 bar and 800 l to 200 bar
- Gel batteries with a total capacity of 156 kWh
- Heat storage in an inertia tank with phase change material
- Cold storage in inertia tanks
- Geothermal installation with 50 kW heat pump and 6 geothermal exchange wells.

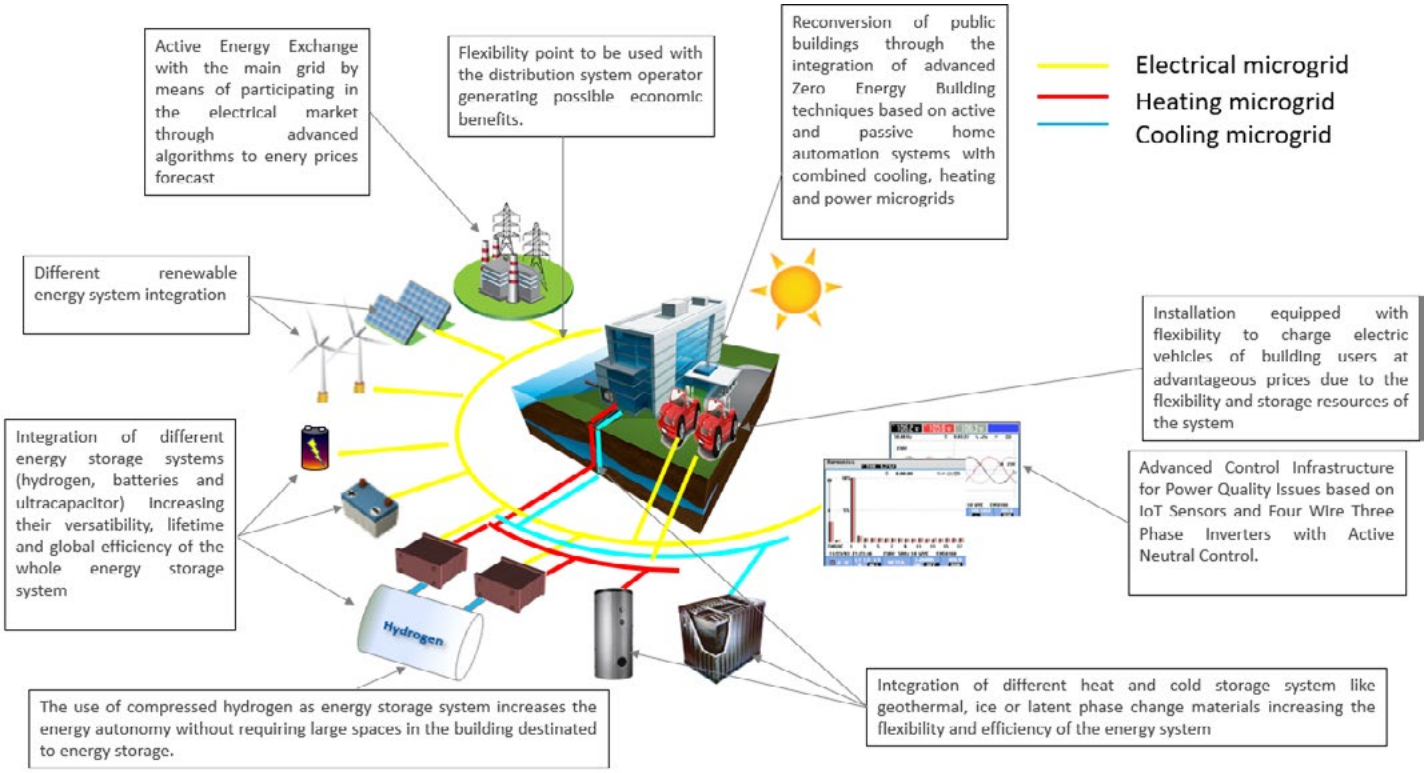
The solar plant produces electricity, a part of it is directly consumed in the building, while production surpluses that are not consumed at the moment are stored, first in the batteries and when those are full, these surpluses are used to produce green hydrogen in the electrolyser. Hydrogen can be stored in the long term and used either to refuel hydrogen vehicles from the centre's own mobile fleet, or to produce electricity through the fuel cell to power the center when there is no sun.

On the other hand, the waste heat generated by the electrolyser is stored in the tanks for this purpose, to support the heating of the building. The installation of geothermal heat pump, which is powered by the electricity produced by the microgrid itself, produces heating in winter and cooling in summer with very high yields. In addition, thermal accumulation makes it possible to prioritise the operation of the heat pump when the electrical production is more economical (direct photovoltaic production), storing the heat to be used when the electric production is more expensive (for example by using hydrogen previously accumulated in the fuel cell).

It should be noted that the optimisation of the management of these systems is part of the knowledge that has developed in the IMPROVEMENT project.

More information on:

https://www.improvement-sudoe.es/microgrids-based-nzeb-spain-pilot-plant/



General scheme of operation of the system

4. INTERVIEW THREE QUESTIONS TO PARTNERS

Jesus J. Martin
Head of Programmes, Projects and Communication of CNH2

Jesús Javier Martín Pérez, received his title of Mining Engineer specialising in Energy and Fuels in 2006, from the Polytechnic University of Madrid (UPM) obtaining Master's Degree in Renewable Energies, Hydrogen and Fuel Cells from the Menéndez Pelayo International University in 2010. Since 2016, he is an expert in European Project Management by the UPM and he made an Advanced University course in Energy Efficiency from Catholic University of Avila in 2019.

With more than 17 years of experience, his professional career has always been linked to research related to renewable energy and energy efficiency sector. He started his professional development working in different companies related to the promotion of R&D&I energy area and as a Technical Project Advisor in the Spanish Science and Innovation Ministry.

In 2008, I took part of the first engineers chosen to launch the Spanish National Hydrogen Centre (CNH2) in Puertollano (Ciudad Real, Spain). Since then, he has worked on issues of testing, characterisation and validation of hydrogen technologies in isolated systems with cogeneration and trigeneration for domestic use or refuelling systems, social perception and currently in the coordination, communication and management of projects. Since 2020, he is the responsible of Management Project Unit and promoted as Head of Programmes, Projects and Communication Unit.

He has also collaborated in the management and implementation of equipment, laboratories and facilities in the CNH2 funded by European and Development and Research Funds (ERDF) granted to Singular Scientific-Technical Facilities (2014-2016). And he was the responsible of the management of the project 'Consolidation and improvement of the scientific-technical infrastructure of the National Hydrogen Centre' funded by ERDF-JCCM (2018-2022). Since 2017, he is charge of the Secretary of the Spanish Standardisation Technical Committee CTN 222 "Fuel Cell Technologies" and participates as a member in CTN 181 "Hydrogen Technologies" and CTN-UNE 216/GT 2 "Climate Change". He has collaborated in the definition of the new European programme (2021-2027) of Clean Hydrogen Partnership (CHP) and in the review of Spanish Hydrogen Roadmap in 2020.

He has participated in more fifteen innovative European and National projects in collaboration with companies and research centers such as PSE H2RENOV, National Programme (NP) GEBE, NP ENHIGMA, NP TOGETHER, NP SHINE-FLEET, ERASMUS+ project "Manufacture of a kart with alternative energies", FP7 HYACINTH, FCH2JU H2PORTS, horizon 2020 MACBETH, Horizon 2020 ARENHA as a Communication and Dissemination responsible, FCH2JU GREEN HYSLAND, FCH2JU FCH2RAIL, CHP HYPOP and scientific dissemination projects approved by the Spanish Foundation for Science and Technology (Scientific Culture and Innovation Unit, UCC+I-CNH2). Since 2019, he is the coordinator of the IMPROVEMENT project from South-West European Territorial Cooperation Programme (SUDOE).

WHAT WERE THE REASONS WHY NATIONAL HYDROGEN CENTER DECIDED TO PARTICIPATE IN THE IMPROVEMENT PROJECT?

The CNH2 is a Spanish national research and development centre at the service of the society to optimise hydrogen and fuel cell technologies and promote their applications. For these reasons, CNH2 carries out activities based on the execution of R&D+i projects on subjects such as hydrogen production and storage, hydrogen conversion into energy or integration of systems and operation of installations.

In Europe, the buildings are going on being a central part of our daily lives being responsible for 40 % of our energy consumption due to heating, cooling, ventilation, hot water and lighting, and 36 % of greenhouse gas emissions. Improving energy efficiency in buildings so you have a key role to play in achieving the ambitious goal of carbon-neutrality by 2050, set out in the European Green Deal.

On the one hand, various storage technologies can reduce the gap that exists between the time at which the energy generated by renewable sources is at its peak, and the time at which is needed by consumers. Moreover, some multiple technologies for thermal energy storage could be used in building structures through for example by thermally activated building systems. Besides the use of external heat storage systems in buildings, such as solar collectors at the facade or suspended ceilings, their integration in the construction elements is also possible. They can be installed in the internal and external walls, as well as in the ceiling and floor constructions in the interest of taking advantage of the thermal mass provided by these elements and enhance their energy storage capabilities. Differential storage methods include total heating and cooling demand of the building in question, occupancy, am-

bient conditions, space available, potential impacts in the building's structure, etc.

Moreover, in the building sector, the interest in energy self-sufficient buildings that feature energy storage capacities has grown in the last period integrating renewable energies into the buildings. But problems related to integrate distributed energy resources in environments and the maintenance of the supply in buildings with high-tech equipment considered as "critical loads" must be taken in account. The extreme sensibility of these equipment to power disturbances for sanitary reasons in hospitals and for security reasons in military facilities, railways stations or airports... involve that power quality and continuity of supply should be considered as fundamental aspects to solve with the autonomy that, for example, hydrogen could provide.

On the other hand, South-West European Territorial Cooperation Programme (SUDOE) supports regional development projects to improve the efficiency energy in buildings in SUDOE area with some Differentiating characters and characteristics. This type of facility is Characterised by high energy consumption for heating in the winter months and air conditioning in the summer months.

CNH2 has a platform for the development and testing of hydrogen-based systems applied in the field of the microgrids and smart grids. So, this platform integrates the hydrogen as energy carrier with other energy storage solutions such as batteries and ultracapacitors. It is open to integrate new microgrids components and develop advanced Energy Management Systems.

For all these reasons, CNH2 decided to propose a new project to the INTERREG SUDOE programme in 2018 with the support of other eight entities from Spain, Portugal and France. The main goal is to convert existing public buildings into Zero energy buildings (nZEB) by integrating combined cooling, heating and power microgrids with neutral clamped inverters using hybrid energy storage systems which will guarantee power quality and continuity of service of environments with critical loads while increasing the energy efficiency in this kind of buildings.

WHAT WILL THIS PROJECT BRING TO SPAIN AND TO CNH2?

Improvement Sudoe project looks for showing how different energy innovative techniques and technologies used individually and new power electronics and algorithm developed can be used together in a new concept called "IMPROVEMENT system" to improve the energy efficiency in buildings and maintain the power quality and continuity of electrical supply.

In SUDOE area, is Characterised by having a high renewable resource (solar and wind) which must be integrated in buildings with thermal and energy disruptive storage technologies (Phase Change Material, ultracapacitors, batteries and hydrogen cycle). Also, using passive and active techniques (solar collectors at the facade, suspended ceilings...) where their integration in existing buildings and the construction elements is also possible. All these kinds of techniques and technologies must be driven to manage the electrical and thermal and power energy to optimise their use and solve specific problems with critical loads to ensure always the quality and continuity of the service.

With this project, CNH2 seeks to demonstrate that hydrogen is an interesting option as storage system, given its energy density allows for long periods of energy autonomy to other options and is able to answer quicker regarding to possible power disturbances in the grid than others. An improvement of energy performance of buildings, along with reducing carbon emissions, would yield important benefits to building such as improved durability, reduced maintenance, greater comfort, lower costs, increased habitable space, increased productivity and improved health and safety.

Improvement Sudoe project objectives are completely in line with the current National Integrated Energy and Climate Plan (PNIEC) (2021-2030) of Spain and their National Hydrogen Roadmap (October 2020).

WHAT IS THE CURRENT STATUS WITH NZEB AND HYDROGEN IN SPAIN AT THE MOMENT?

Because of their low energy efficiency, buildings are currently responsible for more than 30 % of global world energy consumption and account for one-third of direct and indirect dioxide of Carbone and particulate matter emissions. Buildings are long-term durable goods; Hence, their contributions to future energy consumption and emissions are a key aspect to investigate and support the renovation of old buildings and apply different measures in the construction sector.

Up-to-date, electricity in buildings is mostly provided by fossil-fuel-based central power plants and distribution systems. In recent years, more renewable or distributed generation has been encouraged and adopted worldwide. 'Nearly Zero Energy Buildings' means a building that has a very high energy performance. The almost zero of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby. Furthermore, European legislation obliges member states to establish minimum energy efficiency requirements for buildings to achieve optimum levels of costs versus energy demand reduction. These requirements are reviewed every five

years and represent categories of buildings based on their energy levels (demand and generation).

For instance, over 50 % of existing public buildings in Spain were constructed before 1980, a time when building codes had no energy efficiency requirements. Moreover, in the following years in Spain there was a construction boom of buildings but elsewhere, policy-makers should have a deep taking decisions to implement corrective strategies to better the real energy efficiency and energy consumption in the buildings. It may also be useful for countries and regions in south-west Europe that share a similar situation and have the same climatic characteristics as Spain.

In Spain, the Technical Building Code (RD 314/2006) aims to unify the energy efficiency regulations of buildings. Energy efficiency legislation in Spain is based on RD 235/2013 on energy certification of buildings. Also, Spanish legislation on renewable energies has been extensively developed in the Technical Building Code DB-HE. In addition, each Regional Government can legislate and impose more restrictions on the installation of renewable energy. In order to reach the objective of decarbonisation by 2050 set in Spain, on 1 June 2021 the regulation on the basic procedure for the certification of energy efficiency of buildings was updated by RD 390/2021.

Regarding to hydrogen, the European Commission has set out plans for the energy system of the future and published the European hydrogen strategy with a strong focus on an “energy efficiency first” principle. Heat-pumps in buildings are explicitly mentioned as an example how to increase the use of green electricity being the focus of the hydrogen strategy on “sectors that are not suitable for electrification”. In December 2019, the EU Commission presented its plan for a European Green Deal, which foresees a carbon neutral Europe by 2050. For this reason, will be promoted the creation of markets and infrastructure for hydrogen in the EU.

In 2020 the Spanish Hydrogen Roadmap was published for first time. This roadmap also places an emphasis on industrial policy, highlighting the technical potentials offered by hydrogen. However, it does not address in detail the use of hydrogen in the building sector (heating pumps). From 2030 onwards, hydrogen-based heating solutions may become competitive but not today. Nevertheless, with this project is tried to decide if the use of hydrogen in buildings as energy storage to buildings with high-tech considered equipment critical loads is or not relevant.

One of CNH2 mission is to collaborate with the society and European entities in energy efficient, renewable hydrogen-based, circular economy and decarbonised solutions.

5. TECHNICAL PUBLICATIONS FROM PARTNERS

We would like to share with the IMPROVEMENT community some publications done so far:

1. 12/05/2022. LNEG. Integration of a renewable-based energy system in a micro-grid and energy efficiency solutions in public buildings.
2. 20/06/22. LNEG. Combined integration of cooling, heating, renewable energy storage in a public building – IMPROVEMENT SUDOE project.
3. 06/07/2022. UCLM. Discrete control with nested regulators for the current injected into the grid with a single-phase inverter and an LCL filter.
4. 24/09/2022. UPDV. A Survey of Recent Advances in the Smart Management of Microgrids and Networked Microgrids
5. 20/10/2022. UCLM. Use of Resonant Terms in a 2DOF Control Scheme for the Current Control of an Active Power Filter
6. 21/10/2022. UPDV.Comparison between Time- and Observation-Based Gaussian Process Regression Models for Global Horizontal Irradiance Forecasting
7. 25/10/22. OH, UCO. Load Scheduling Strategy to Improve Power Quality in Electric-Boosted Glass Furnaces
8. 25/10/2022. CNH2. Integration of combined heat, cold and electricity microgrids into zero-consumption public buildings under high quality criteria and continuity of supply
9. 18/11/2022. UCO. Integration of CCHP microgrids in NZEB with critical loads under high PQR requirements, a position paper.

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

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

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