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Open PhD Position

(Research Group in Sustainable and Renewable Electrical Technologies, Department of Electrical Engineering, University of Cadiz, Spain)

Project information

Title:	Dynamic modelling and intelligent control of energy communities in active distribution networks (ConEC)
Project ID:	PID2024-156036OB-C32
Funding organization:	Ministry of Science, Innovation and Universities
Position:	Funded open PhD student
Principal investigators:	Prof. Dr. Luis M. Fernández-Ramírez Prof. Dr. Pablo García Triviño
Expected start date:	September/October 2026
Contract duration:	4 years
Location:	Research Group in Sustainable and Renewable Electrical Technologies, Department of Electrical Engineering, University of Cadiz ▪ Higher Technical School of Engineering of Algeciras (ETSIA), Avda. Ramón Puyol, s/n. 11202 Algeciras (Cádiz), Spain ▪ UCA-SEA Innovation Center, Avda. de la Hispanidad (Llano Amarillo), s/n. 11202 Algeciras (Cádiz), Spain
Salary:	First and second year: 19 k€. Third year: 20 k€. Fourth year: 25 k€.

Requirements

Degree:	A Master degree (or equivalent) in Electrical Engineering, Energy Systems, Power Electronics, Control Systems, or a related field.
Experience:	▪ Training and experience in renewable energies, microgrids, power electronic converters and/or control systems. ▪ Experience in the use of simulation and control software, such as MATLAB, Python, OPAL, Siemens PLCs, etc., applied to renewable energies, microgrids, and power electronic converters. ▪ Experience in experimental implementation and laboratory validation (hardware-in-the-loop, HIL, and power-hardware-

	in-the-loop, PHIL, testing technologies) of renewable energy sources, microgrids, power electronic converters and/or control systems.
Language:	▪ Proficiency in English (written and spoken). ▪ Knowledge of Spanish is valuable but not essential.
Other soft skills:	▪ Communication & teamwork: Ability to collaborate in multidisciplinary environments. ▪ Critical thinking & problem-solving: Analytical approach to complex challenges. ▪ Proactivity: Self-motivated and capable of taking initiative. ▪ Resourcefulness: Ability to work independently and find effective solutions. ▪ Adaptability: Willingness to learn and adjust to new research methodologies.

Project summary

Smart energy systems emerge as a solution for decarbonizing the electricity sector through optimal integrating renewable energy tecnologies (RETs), energy storage systems (ESSs) and electric vehicles (EVs). Moreover, typical passive users are evolvingtowards active players providing flexibility and further capabilities to the system, thus increasing its versatility and manageability. In this context, **two main agents** can be highlighted: 1) **Active Distribution Networks (ADNs)** transform traditional power distribution with two-way power flow, integration of distributed energy resources (DERs) like RETs and ESSs, and advanced control systems for real-time monitoring. They optimize power flow, ensure grid stability, and leverage smart grid technologies for communication and automation. ADNs improve power quality, reliability, efficiency, grid flexibility, and reduce emissions. 2) **Energy communities (ECs)** are key to sustainable, decentralized energy systems. By involving citizens and using DERs like rooftop solar, ESS, and EVs, ECs boost RET adoption, efficiency, sustainability, resilience, and consumer empowerment. Their success depends on social engagement, supportive policies, market structure, and technical solutions aligned with grid stability.

To increase the level of cooperation between these two agents, it is necessary to enable the proper interaction channels. ECs (an aggregation of electricity users) empower final residential users to partake actively in and operation. Thus, a cooperative environment between ECs and ADNs is possible and feasible if suitable coordination tools and mechanisms are enabled.

In this context, ConEC project will develop new solutions for designing, sizing, modelling, and intelligent real-time control of ECs in ADNs. Self-adjust/adaptive and predictive controls, combined with generation and consumption forecasting, will target ECs, their converters, and interconnected ECs in ADNs, aiming to enhance efficiency, stability, flexibility, grid integration, grid services, and costs. The specific objectives and main contributions are:

1) Development of novel design and techno-economic sizing methods using HOMER and MATLAB for ECs with innovative control strategies.

2) Implementation of dynamic equivalent models of ECs and ADNs suitable for dynamic response analysis, control system design and practical implementation.

3) Design and experimental implementation of intelligent real-time control systems for ECs in ADNs using adaptive and predictive techniques with generation and consumption forecasting to reduce variability, complexity, and unpredictability of EC operations, improving economic benefit, efficiency, operability, and resilience. The goal is to maximize RET use, minimize losses, extend equipment lifespan, and decrease CO_2 emissions, with validation on real microcontrollers in a lab under normal and fault conditions, using hardware-in-the-loop (HIL) and power-hardware-in-the-loop (PHIL) testing technologies, such as OPAL-RT OP45120/OP4512 units for real-time HIL emulation of ADNs and ECs, and Cinergia PHIL units (power converter as power amplifier), and microcontrollers (Siemens PLC, Raspberry Pi, or dSPACE MicroLabBox) for control system implementation.

Planned training activities:

The candidate will be incorporated in the Research Group in Sustainable and Renewable Electrical Technologies – SURET (TEP-023 in the Andalusian Plan of Research, Development and Innovation – PAIDI; website: https://tep023.uca.es/en), led by Prof. Dr. Luis M. Fernández-Ramírez (Stanford's Top 2% Most Cited Scientist) and composed by 8 PhD members, 2 PhD collaborators, 1 research fellow and 10 PhD students.

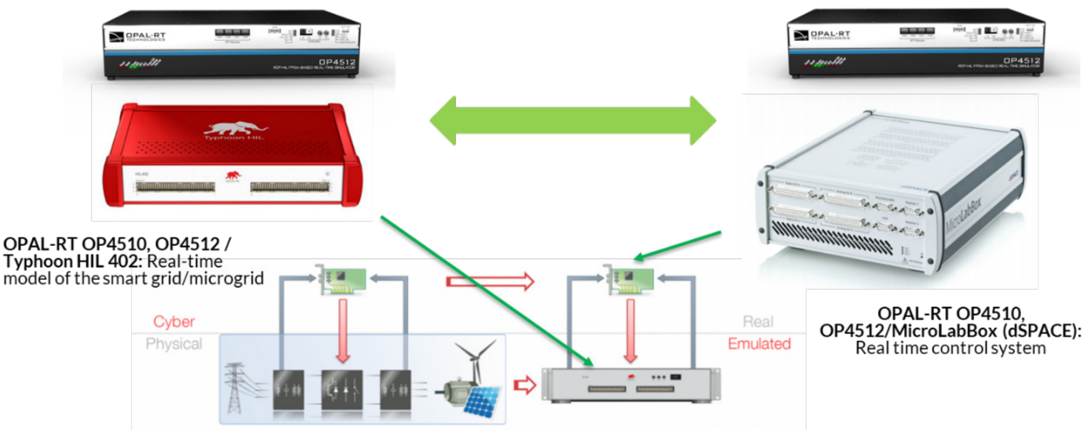
The research group has over 20 years of experience in design, sizing, dynamic modelling, control, optimal operation and energy management of microgrids with RETs, ESSs, green hydrogen, EVs and charging stations, operating in distribution networks. In their research, they have utilized software such as MATLAB and HOMER, experimental equipment including OPAL-RT and Typhon real-time simulators, Cinergia PHIL units, and microcontrollers like MicroLabBox, Siemens PLCs or Raspberry Pi. In this project's thematic area, this team has secured 8 research projects through competitive regional, national, or international funding calls. The team has published more than 70 papers in Web of Science-Journal Citation Report journals and more than 50 papers in international conferences. They have supervised 13 doctoral theses (2 extraordinary awards, 2 international mentions, and 2 international joint supervision).

The predoctoral candidate will enroll in the Ph.D. Program in Sustainable and Energy Engineering from the University of Cadiz. As a doctoral student, the candidate will benefit from a training program designed to foster both technical and soft skills, aiming to complete the minimum of 600 training hours required to obtain the doctoral degree and conduct research in their thesis field. Furthermore, the program encourages students to plan predoctoral stays in prestigious foreign research centers, taking advantage of the program's international character to earn the "International Mention" for their PhD. Specifically, the research group maintains excellent relationships with universities such as the University of Porto (Portugal), Cardiff University (UK), Politecnico di Milano (Italy), University of Bayreuth (Germany), Federal University of Ceará (Brazil), and Technological University of Pereira (Colombia), among other.

Available research facilities

All new solutions developed in this project for the control and operation of Energy Communities (EC) operating within Active Distribution Networks (ADN) will be experimentally validated at the SURET group laboratory. To this end, the laboratory is equipped with various power and digital devices that replicate the operating conditions of the electrical system. Specifically, the laboratory comprises the following elements:

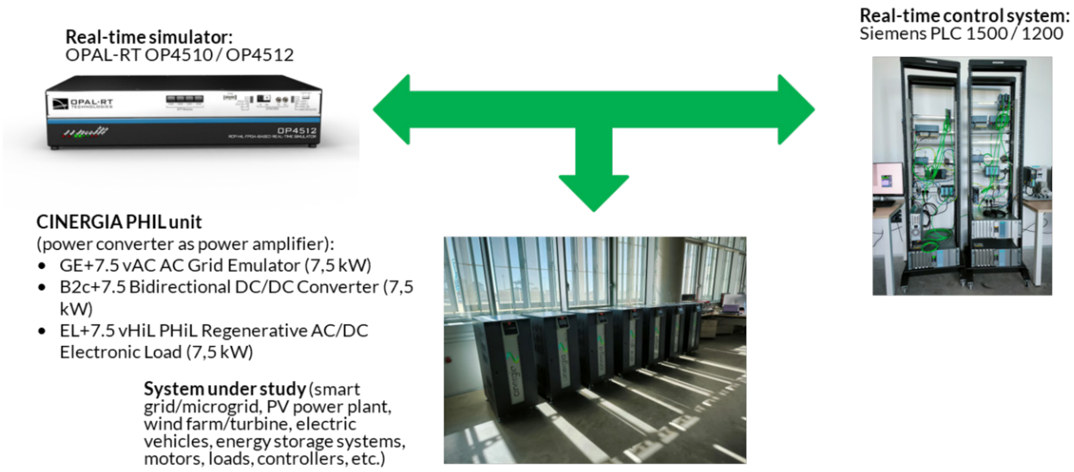
1) **Hardware-in-the-Loop (HIL) testing technologies:** Based on OPAL-RT and Typhoon HIL real-time simulators, as well as microcontrollers such as MicroLabBox, Siemens PLCs, and Raspberry Pi. These are used for the experimental real-time implementation and evaluation of solutions for smart grids, microgrids, industrial equipment, and motor drives.



2) **Industrial energy management/control/operation system development platform:** Platform based on Siemens industrial PCs/PLCs, which is designed for developing controllers, diagnostic systems, and process, energy management/control/operation algorithms aimed at improving the operability and energy efficiency of a wide variety of applications in industry, smart grids, and microgrids.

3) **Power hardware-in-the-loop (PHIL) platform:** Platform dedicated to the design and experimental evaluation of smart cities, smart grids, and microgrids featuring renewable energy, energy storage, hydrogen systems, and electric vehicles. The facility includes the following power equipment to emulate systems such as PV power plants, wind farms, and motors, enabling the real-time evaluation of control and operation solutions:

- GE+7.5 vAC AC Grid Emulator (7,5 kW)
- B2c+7.5 Bidirectional DC/DC Converter (7,5 kW)
- EL+7.5 vHiL PHiL Regenerative AC/DC Electronic Load (7,5 kW)



Relevant publications of the research group

1) Pablo Horrillo-Quintero, Pablo García-Triviño, David Carrasco-González, Luis M. Fernández-Ramírez. "**Optimal Control Strategy Based on Differential Evolution Algorithm for Seamless Transition Between Islanded and Grid-Connected Operation Modes in Microgrid Clusters**". *Expert Systems with Applications (Elsevier)*, vol. 297, part B, Article Number: 129461, 1-Feb-2026. Impact Factor WOS-JCR-SCI (2024)=7.5. Quartil Q1. https://doi.org/10.1016/j.eswa.2025.129461

2) Pablo Horrillo-Quintero, Pablo García-Triviño, David Carrasco-González, Raúl Sarrias-Mena, Marcos Tostado, Francisco Jurado, Luis Sainz Sapera, Luis M. Fernández-Ramírez. "**Adaptive Multi-objective Real-Time Hierarchical Control for Isolated Microgrid Clusters Utilizing an Enhanced Particle Swarm Optimization Strategy to Optimize Costs and Emissions**". *Electric Power Systems Research (Elsevier)*, vol. 250, Article Number: 112169, Jan-2026. Impact Factor WOS-JCR-SCI (2024)=4.2. Quartil Q2. https://doi.org/10.1016/j.epsr.2025.112169

3) Pablo Horrillo-Quintero, Iván De la Cruz-Loredo, Pablo García-Triviño, Carlos E. Ugalde-Loo, Luis M. Fernández-Ramírez. "**Impact of thermal stores on multi-energy microgrids with multi-layer dynamic control architecture**". *Sustainable Energy, Grids and Networks (Elsevier)*, vol. 42, article number: 101667, June 2025. Impact Factor JCR-SCI (2024)=5.6. Quartil Q1. https://doi.org/10.1016/j.segan.2025.101667

4) David Carrasco-González, Raúl Sarrias-Mena, Pablo Horrillo-Quintero, Francisco Llorens-Iborra, Luis M. Fernández-Ramírez. "**Design and Raspberry Pi-based implementation of an intelligent energy management system for a hybrid AC/DC microgrid with renewable energy, battery, ultracapacitor and hydrogen system**". Computers and Electrical Engineering (Elsevier), vol 123, part D, article number: 110253, April 2025. Impact Factor WOS-JCR-SCI (2024)=4.9. Quartil Q1. https://doi.org/10.1016/j.compeleceng.2025.110253

5) Ehsan Hosseini, Pablo Horrillo-Quintero, David Carrasco-González, Pablo García-Triviño, Raúl Sarrias-Mena, Carlos Andrés García Vázquez, Luis M. Fernández Ramírez. "**Reinforcement Learning-Based Energy Management System for Lithium-Ion Battery Storage in Multilevel Microgrid**". *Journal of Energy Storage (Elsevier)*, volumen: 109, article number:115114. February 2025. Impact Factor JCR-SCI (2024)=9.8. Cuartil Q1. Tercil T1. https://doi.org/10.1016/j.est.2024.115114

6) Ehsan Hosseini, Pablo García-Triviño, Pablo Horrillo-Quintero, David Carrasco-González, Carlos Andrés García Vázquez, Raúl Sarrias-Mena, Higinio Sánchez-Sainz, Luis M. Fernández-Ramírez. "**A Novel Reinforcement Learning-Based Multi-Objective Energy Management System for Multi-Energy Microgrids Integrating Electrical, Hydrogen, and Thermal Elements**". *Electric Power Systems Research (Elsevier)*, vol. 242, article number: 111474, May 2025. Impact Factor WOS-JCR-SCI (2024)=4.2. Quartil Q2. https://doi.org/10.1016/j.epsr.2025.111474

7) Pablo Horrillo-Quintero, Iván De la Cruz-Loredo, Pablo García-Triviño, Carlos E. Ugalde-Loo, Luis M. Fernández-Ramírez. "**A Real-Time Combined Dynamic Control Framework for Multi-Energy Microgrids Coupling Hydrogen, Electricity, Heating and Cooling Systems**". *International Journal of Hydrogen Energy (Elsevier)*, vol. 106, pp. 454-470, March 2025. Impact Factor JCR-SCI (2024)=8.3. Quartil Q1.

https://doi.org/10.1016/j.ijhydene.2025.02.005

8) Pablo Horrillo-Quintero, Pablo García-Triviño, Carlos E. Ugalde-Loo, Ehsan Hosseini, Carlos Andrés García Vázquez, Marcos Tostado, Francisco Jurado, Luis M. Fernández Ramírez. "**Efficient Energy Dispatch in Multi-Energy Microgrids with a Hybrid Control Approach for Energy Management System**". *Energy (Elsevier)*, vol. 317, article number: 134599. 15 February 2025. Impact Factor JCR-SCI (2024)=9.4. Quartil Q1. https://doi.org/10.1016/j.energy.2025.134599

9) Ehsan Hosseini, Pablo Horrillo-Quintero, David Carrasco-González, Pablo García-Triviño, Raúl Sarrias-Mena, Carlos Andrés García-Vázquez, Luis M. Fernández-Ramírez. "**Optimal Energy Management System for Grid-Connected Hybrid Power Plant and Battery Integrated into Multilevel Configuration**". *Energy (Elsevier)*, vol. 294, article number: 130765. 1-May-2024. Impact Factor JCR-SCI (2024)=9.4. Cuartil Q1. Tercil T1. https://doi.org/10.1016/j.energy.2024.130765

10) Pablo García-Triviño, Laís de Oliveira-Assís, Emanuel P. P. Soares-Ramos, Raúl Sarrias-Mena, Carlos A. García Vázquez, Luis M. Fernández Ramírez. "**Supervisory Control System for a Grid-Connected MVDC Microgrid Based on Z-Source Converters with PV, Battery Storage, Green Hydrogen System and Charging Station of Electric Vehicles**". *IEEE Transactions on Industry Applications*, vol. 55, no. 2, pp. 2650-2660. March-April 2023. Impact Factor JCR-SCI (2023)=4.2. Quartil Q1. https://doi.org/10.1109/TIA.2022.3233556