CIESOL

Solar Energy Research Center

ANNUAL REPORT 2023

CIESOL

Solar Energy Research Center

Joint Center UAL - PSA CIEMAT

More info:

www.ciesol.es - www.ciesol.com

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1. EXECUTIVE OVERVIEW

1.1 PRESENTATION AND WELCOME

The Solar Energy Research Center, CIESOL, is a joint center of the University of Almería and the Almería Solar Platform, which develops new applications of solar energy. Both researchers from the Solar Platform and from the University work at the center, joining forces to get the most out of solar radiation, ranging from energy use, water treatment and the study of air conditioning and comfort in the building.

At the center we develop, at an international level, research, transfer, dissemination and training on various aspects of solar energy.

We collaborate with companies and institutions in our desire to serve society. In the field of training, we are proud of the Official Master's Degree in Solar Energy, a clear example of the understanding between the two institutions that make up CIESOL (https://www.ual.es/estudios/masteres/presentacion/7106).

1.2 CENTER DESCRIPTION

The CIESOL is located in a building located on the campus of the University of Almería specifically designed for the study of the use of solar radiation in buildings. Thus, in addition to laboratories, scientific equipment and pilot plants, the center itself is a scientific facility.

We have an area of about 1,700 m^2, with a 200 m^2 warehouse and a 300 m^2 courtyard, 1 workshop, an outdoor laboratory, 3 cold storage chambers, 1 weather station, 8 laboratories, 5 offices, 1 dining room, 1 study room, 1 work room and a classroom and meeting room. The solar heating and cooling system covers most of the demand of the center, the building is designed to employ passive strategies and maximize solar resources. We have advanced equipment to carry out our research projects, as reflected in section 2, where we expose the infrastructures in detail.

During 2023, 97 researchers have participated in projects and contracts assigned to CIESOL (56 men and 41 women), 39 of them (21 men and 18 women) with permanent location in their laboratories and offices throughout this period. The activities of these researchers have been framed in 26 projects of official competitive calls (National Research Plan and Andalusian Program of Incentives for Knowledge Agents), 7 contracts with companies and institutions, 22 European projects and 7 networks.

On the other hand, the units have had 13 stays by international researchers from 7 different countries, Brazil, France, Cuba, Panama, Portugal, Mexico and Greece. Also, 10 CIESOL's researchers have spent time abroad in countries such as Japan, the Netherlands, France, Italy, Chile, the USA, Norway and Portugal.

1.3 LINES OF WORK IN THE CENTRE

What does CIESOL do?

We work in different areas, all of them focused on the knowledge of solar resources and their various applications, which can be classified into two lines: one related to the energetic use of solar radiation, and the other to the development of solar technologies for water treatment.

Convinced of the importance of preserving the environment, CIESOL carries out research in two areas that are essential for life, water and energy, united by the use of solar radiation.

How is CIESOL advancing in the use of energy?

The first thing we need to know in order to use solar energy is its availability, which is why we are researching new methods to evaluate and predict the solar resource and the optimisation of sky cameras to track and predict cloud cover.

Also important is the monitoring, modelling and automatic control of solar installations, with very different scales, from large solar thermal plants to produce electricity, to electric vehicles powered by solar energy using the photoelectric effect, better known as photovoltaic energy.

NAVE CIESOL – Solar cooling installation

In addition, solar thermal energy makes it possible to produce what is known as "solar cooling" by means of phase change, compression and decompression systems. Research is being carried out on "solar air conditioning", the CIESOL building being an example of this. Work is being carried out on the design and optimisation of solar cooling and heating plants, both for domestic and industrial use, with particular emphasis on energy efficiency and comfort control in buildings. The introduction of smart energy grids is also a very significant savings factor.

Research is also being carried out on the development of new water-soluble, photochemically active substances with the aim of paving the way for new, more environmentally sustainable photovoltaic cells.

How is CIESOL making progress in water treatment?

We must protect the water resource, which is as necessary as it is scarce, and whose value for life increases the better its quality. To this end, CIESOL is developing new clean technologies for decontamination based on solar irradiance, both for toxic water that cannot be treated by conventional biological methods and for treated wastewater, which still contains small amounts of persistent pollutants that affect the aquatic environment.

Among the solar methods of wastewater treatment, a new process based on microalgae is gaining ground, using photosynthesis to decontaminate, with less energy consumption and producing biomass that is useful for other industrial sectors.

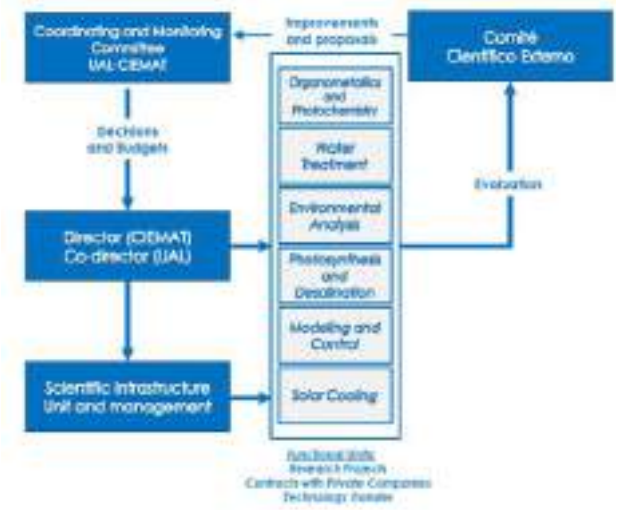
CIESOL TESTING SPACE - Water Experimentation Facilities

Once treated, the water can be put to a new use, especially for irrigation. For this purpose, pathogenic micro-organisms still remaining in the water must be inactivated. Disinfection by solar photocatalysis of treated water is proving to be particularly efficient. In all these processes, the study of the influence of the treatments on the quality of the treated water and the evaluation of the impact of their use play a crucial role. The development of advanced chemical analysis methods is necessary to measure the presence of pollutants at very low concentrations, down to one billionth of a gram per litre (nanogram/litre). But when water scarcity is pressing, desalination is needed to generate new fresh water. Desalination of seawater, or brackish water, using solar energy is a much-needed alternative. In this regard, the combination of membrane distillation, which requires less heat input than other processes, and the use of solar energy to provide the heat is seen as an alternative solution to conventional technologies.

1.4 CENTER ORGANISATION

How does Ciesol work?

Functional structure of CIESOL is made up of a Coordination and Monitoring Committee, CCS, the highest decision-making and management body, a Management Team and a set of 6 Functional Units that bring together researchers from both institutions in different specific thematic areas. It should be noted that CIESOL has an External Evaluation Committee, CEE, with four members of recognized prestige and national and international impact, which annually assesses and supervises the scientific production of its different functional units as well as the development of the center. There is also a Scientific and Management Infrastructure Unit, made up of specialist technicians, who are in charge of the maintenance and operation of the center's equipment.



Functional organigram of CIESOL

Who is the Coordination and Monitoring Committee and what does it do?

The Coordination and Monitoring Committee, CCS, is made up of two researchers from the UAL, one of whom is the Vice-Rector for Science Policy, and two researchers from the PSA, one of whom is the Director of the Almeria Solar Platform. Currently, the CCS is made up of José Antonio Sánchez Pérez (Vice-rector for Science Policy) and Manuel Berenguel, researcher for the UAL, and Julián Blanco (Director of the Plataforma Solar de Almería) and Eduardo Zarza for the PSA, the latter until 18 October 2023, when, due to his retirement, he was replaced by Diego Alarcón Padilla from the PSA.

The Coordination and Monitoring Committee is responsible for ensuring the good governance of the Research Center and its main function is to evaluate and monitor the progress of the center's activities and their adaptation to the planned objectives.

Who is the Management Team and wha does it do?

The Management Team consists of a director and a deputy director, belonging to UAL and PSA (and vice versa). During 2023 José Luis Casas López has replaced José Antonio Sánchez Pérez as director of CIESOL, as the latter has been appointed as Vice-Rector for Science Policy at the University of Almeria. The deputy director is Sixto Malato Rodríguez, from the PSA. They are responsible for the allocation of space and resources to the different projects and working groups, the supervision of the technical staff, the maintenance of CIESOL and, in general, everything that affects the day-to-day running of the centre.

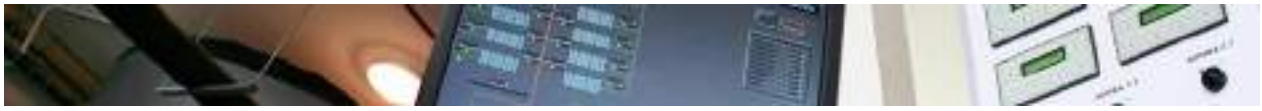
Who is the External Evaluation Committe (Scientific Committe) and what does it do?

The External Evaluation Committee, CEE, is composed of Ana María Amat Payá, Professor at the Polytechnic University of Valencia, Ángela Fernández Curto, Deputy Deputy Director General of Large Scientific and

Technical Infrastructures (Ministry of Science and Innovation, Government of Spain), David Serrano, Director of IMDEA ENERGÍA in Madrid and Professor at the Rey Juan Carlos University and Carlos Bordons Alba, Professor of Systems Engineering and Automation at the University of Seville.

The EWC is responsible for evaluating the scientific quality of CIESOL and proposing actions for improvement. Its functions include the evaluation of work proposals and strategic lines of action for CIESOL, new projects or collaborations, as well as the scientific evaluation of the work carried out. The EWC meets once a year with CIESOL researchers, visits their facilities and issues a report on their activity.

What are the Functional Units of CIESOL?



Solar Resource and Solar Cold. Its main activity is the evaluation and prediction of the solar resource, being its main researchers Joaquín Alonso Montesinos (UAL) and Jesús Ballestrín Bolea (PSA). It also works on remote sensing and optimization of sky cameras, as well as the design and optimization of solar heating and cooling plants. Trigeneration.

Modelling and control. Led by Manuel Berenguel Soria (UAL) and Lidia Roca Sobrino (PSA), the group works on the modelling and control of solar thermal plants, photoreactors and photobioreactors, while studying energy efficiency and comfort control in buildings, including smart energy grids.

Organometallics and photochemistry. Led by Antonio Manuel Romerosa Nievas (UAL) and Christoph Richter (DLR-PSA), it is working on the development of new homo and hetero-nuclear ruthenium complexes soluble in water and with photocatalytic activity in processes for the synthesis of high added value molecules as well as in new photovoltaic cells.

Water regeneration. It focuses its activity on the study of solar photocatalysis for the decontamination of toxic water and the elimination of micropollutants and disinfection of treated water (regeneration). The main researchers are José Antonio Sánchez Pérez (UAL) and Inmaculada Polo López (PSA).

Environmental Analysis. It is focused on the development of advanced analytical methods in complex effluents and their application to the monitoring of organic micropollutants as well as the identification of transformation products generated during water treatment. The main researchers are Ana Agüera López (UAL) and Isabel Oller Alberola (PSA).

Desalination and photosynthesis. The group develops two parallel lines of work, desalination and water treatment using membrane systems as well as the production of microalgae and products of interest. The main researchers are José M. Fernández Sevilla (UAL) and Guillermo Zaragoza del Águila (PSA).

1.5 ACTIVITIES OF THE CENTRE IN 2023

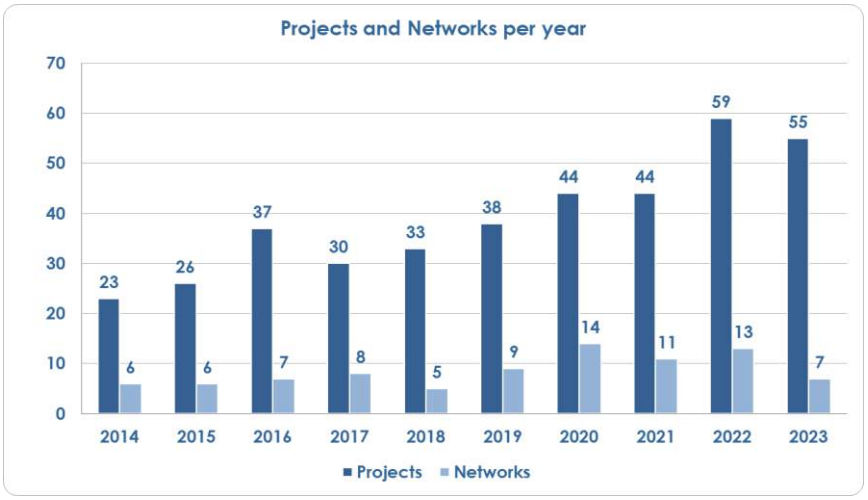
1.5.1 Staff

During 2023, Enrique García Campos in the Energy Area and Irene Fernández Gómez in the Dissemination and Transfer Area have joined the centre as staff.

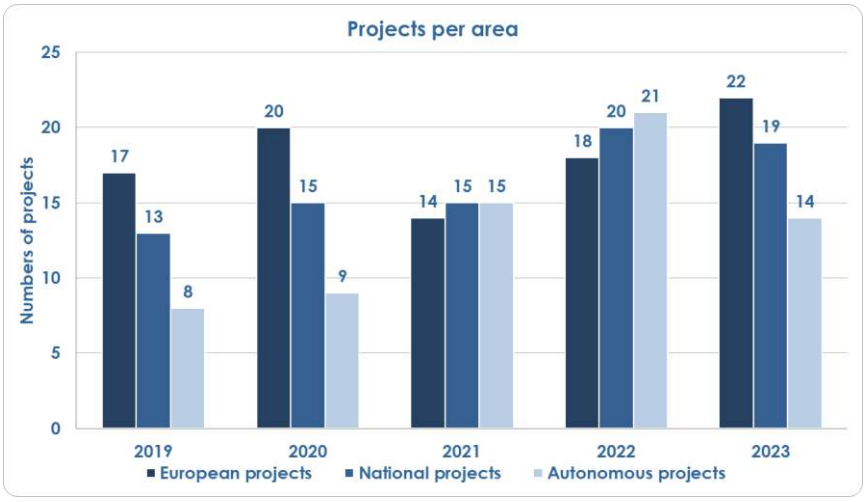
Likewise, during the year 2023, 6 extracurricular internships have been offered, one for each functional unit, for undergraduate and master's degree students with the intention of promoting initiation in research in the field of CIESOL, these internships are generally established for a duration of 6 months and on an annual basis. These internships have had a cost of 10000€ per year and their incorporation has taken place at the beginning of 2024.

1.5.2 Projects

Ciesol has maintained its research activity in 2023 through 55 research projects in progress. The figure shows the evolution of the number of projects over the last ten years, with an average of 40 projects being carried out per year, with an upward trend in the last three years. In terms of networks, we have participated in 2 national and 5 international networks.

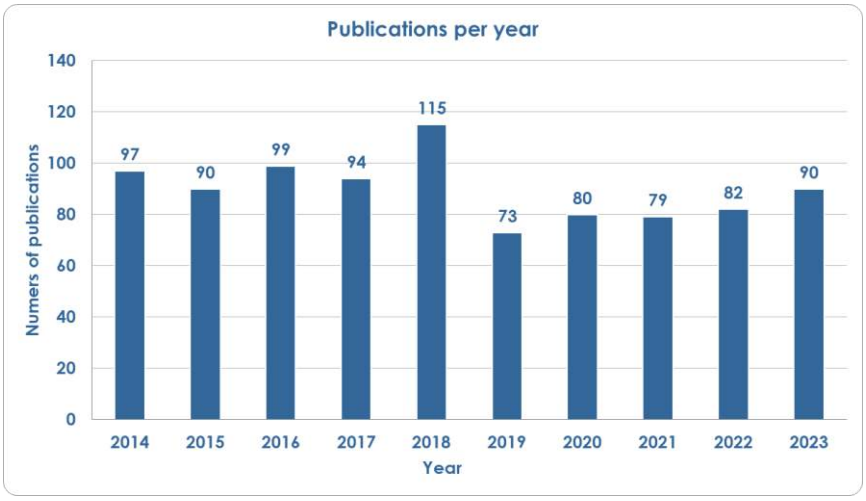


As for the distribution of the 55 projects, 22 were European projects, 19 were national projects and 14 were regional projects.

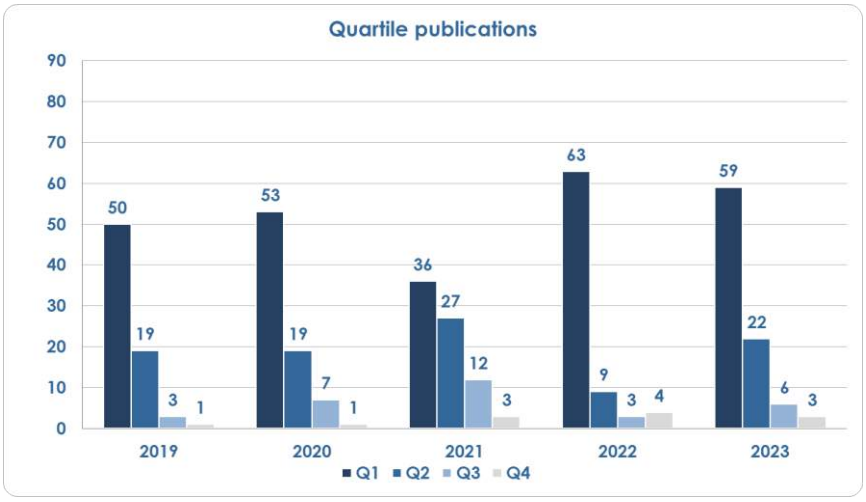


1.5.3 Scientific production

CIESOL's scientific production during 2023 has maintained the trend of recent years with a total of 90 articles indexed in the JCR. The figure shows the evolution of the number of international scientific publications in JCR over the last eight years. It shows an average of 98 articles per year.



The quality of the scientific production can be assessed on the basis of the indexation of the journals in which they have been published. In this sense, 66% have been published in Q1 journals, 24% in Q2 journals, 7% in Q3 journals and only 3% in fourth quartile journals. With regard to internationalisation, 40 articles have international affiliation, which represents 44% of the total, highlighting the international nature of the centre.

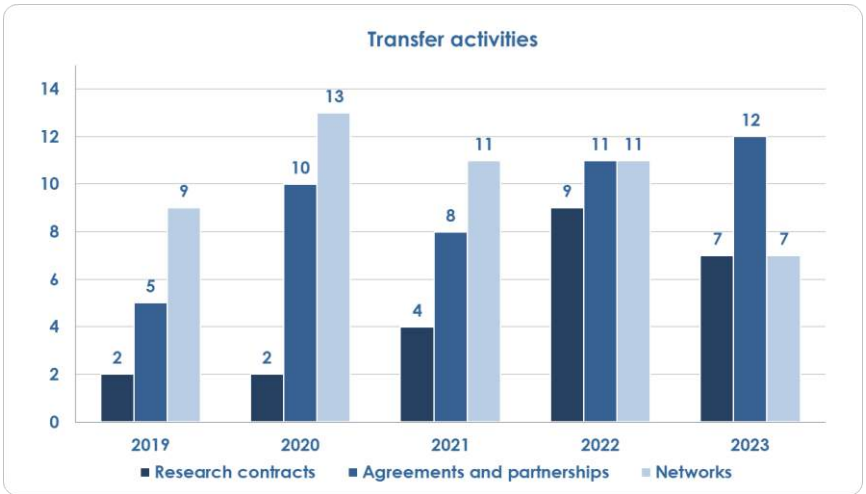


All units have participated in national (35) and international (58) congresses and scientific meetings with a total of 145 contributions. With regard to doctoral theses, a total of 9 doctoral theses were defended in 2023.

1.5.4 Dissemination and transfer activities

In terms of dissemination and outreach activities, Ciesol has been present in the media through various activities (a dozen appearances in the press) and has participated in the organisation of a large number of courses and conferences, as shown in the activity of the different functional units.

With regard to participation in contracts (7), agreements (12) and networks (7), during 2023, CIESOL has maintained its continuous and consolidated activity over time, as can be seen in the following graph.



1.5.5 University Chairs linked to CIESOL

AQUALIA University Chair - Integrated water cycle

The Aqualia Chair of the Integral Water Cycle is aligned with the UN Sustainable Development Goals, especially with SDG 6, on the availability and sustainable management of water and sanitation, and with SDG 17 in the search for partnerships between institutions and companies. The purpose of this Chair is to establish channels for the joint implementation of dissemination, research and transfer activities in the field of the integral water cycle.

https://catedraaqualia.eu/

Its Advisory Committee is made up of:

- Director: Ana María Agüera López – Professor of Analytical Chemistry, University of Almeria.
- Co-director: José Vicente Colomina – Director of Aqualia's Andalusia III Office.
- Co-director: Frank Rogalla – Director I+D+I of Aqualia.
- Secretary: Laura Piedra Muñoz – Full Professor in Applied Economics, University of Almeria.
- Vowel: José Antonio Otero Moreno – Manager of Aqualia Almería.
- Vowel: Zouhayr Arbib – Aqualia Sustainability Area Manager.
- Vowel: Francisco G. Acién Fernández – Professor of Chemical Engineering, University of Almeria.
- Vowel: José Luis Casas López – Professor of Chemical Engineering, University of Almeria.

Biorizon Biotech University Chair - Agricultura Regenerativa en 4.0

The Biorizon Biotech-UAL Chair on "Regenerative Agriculture in 4.0" seeks to deepen knowledge and promote both the transfer and generation of knowledge in the field of microalgae, other microorganisms and natural solutions, relying on the technification, digitisation and automation of processes. In this way, it aims to contribute to the development of the concept of Regenerative Agriculture in a connected environment, as a solution for sustainable environmental, social and economic development. The aim of this Chair is to establish channels for dissemination, research and transfer activities in the field of microalgae and other microbial and biological solutions for regenerative agriculture in a digital environment. https://www.catedrabiorizonual.com/

Its Governing Committee is made up of:

- Director: José Luis Guzmán Sánchez – Professor, University of Almeria.
- Co-director: Joaquín Pozo Dengra – Director I+D of Biorizon Biotech.
- Secretary: Francisco de Asís Rodríguez Díaz – Professor, University of Almeria.

Its Advisory Board is also made up of:

- Manuel Berenguel Soria – Professor, University of Almeria.
- Francisco G. Acién Fernández – Professor, University of Almeria.
- Fernando Román Ranchal – Biorizon Biotech President's.
- Ricardo García Lorenzo – Director of Cajamar Innova and Deputy Director of Innovation Agro.

Kimitec University Chair -Farm to fork

The Kimitec - From Farm to Fork Chair of the University of Almeria aims to contribute to the development of a safe, healthy and environmentally sustainable agri-food system as well as to the fulfilment of the Sustainable Development Goals (SDGs). This mission is materialised in three main lines of action: a) Society, addressing activities that enable the creation of social value and contribute to different communities, in addition to those related to the agri-food sector; b) Training and development of talent in R&D&I, with the aim of promoting the training and development of research talent, including the development of doctoral theses in the field of action of the Chair; and c) Dissemination and transparency, addressing activities of scientific dissemination, dissemination and communication of the results of the activities carried out within the framework of the Chair.

Its Governing Committee is made up of:

- Director: María del Mar Gálvez Rodríguez, Full professor in the area of Business Organisation.
- Secretaria: Antonia Estrella Ramón, Full professor in the area of Marketing and Market Commercialisation.
- Codirector: José Manuel Martos Romero, E-learning Training Specialist (Training area).

Its Advisory Board is made up of:

- Julián Sánchez-Hermosilla López, Professor in the area of Agro-forestry Engineering.
- José Luis Casas López, Professor in Chemical Engineering
- Paola Haro Vera: R&D SubArea Manager (Head of the Microalgae Area
- David Haigh Florez: R&D Subarea Manager (Head of Upcyclin)

1.5.6 Master's Degree linked to CIESOL

Máster in Solar Energy

The Official University Master's Degree in Solar Energy aims to provide specialised, high-level training in Solar Energy and its multiple applications, oriented towards the labour market. Part of the content of the Master is oriented towards research activities in solar energy, as well as learning how to plan and develop R&D projects and publications.

This Master has a high practical content. As a result, students acquire both scientific and engineering training, which allows them to access PhD programmes and the industrial sector.

Enrolment and students

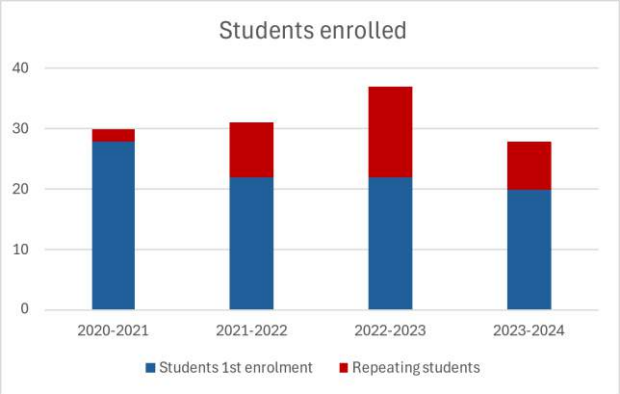
The average number of students enrolled in the first year of the master's degree over the last 4 years has been 23, with an average entry mark of 7.2. The average number of students enrolled per academic year is 33, with an average duration of 1.2 years. The access studies have been, in this order, degrees in Industrial Engineering (Electrical, Mechanical, Electronic and Chemical), Environmental Sciences, Physics and Chemistry.

With regard to the origin of the student body, the high percentage of foreign students, around 80%, is noteworthy. This percentage is mainly made up of students from Latin American universities.

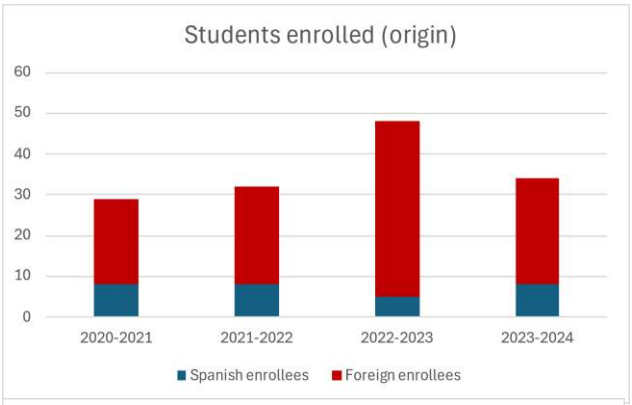
The gender gap has been narrowing over the last three academic years, with a minimum value in the 2023-2024 academic year, with a parity percentage of 83%.

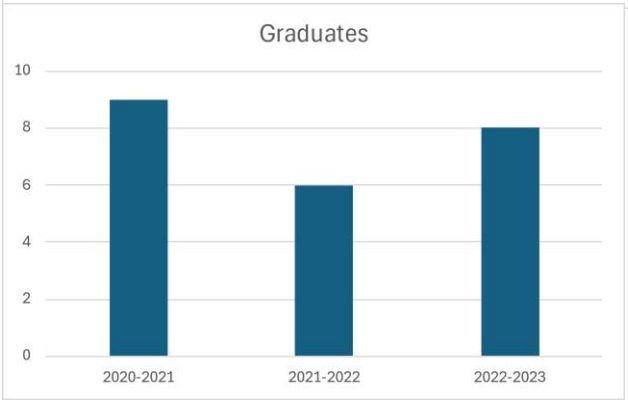
Academic quality and employability:

The average number of students graduating from the Master's in the last 3 editions is 7.7 graduates/course. The average success rate (credits passed/credits taken) is 97%. Satisfaction with the teaching quality of the average student body, evaluated by means of surveys, gives an average score of 4.7 out of a maximum score of 5 over the last 3 academic years.



With regard to labour market insertion, the data corresponding to graduates in the last academic year analysed, i.e. the academic year 2022-2023, is 56%. An analysis of labour market insertion through the unemployment rate (unemployed graduates/graduates) extended to the two years following the completion of studies yields a value of 0, i.e. a situation of full employment for graduates in the academic year 2021-2022. With regard to the types of jobs held and activities carried out by Master's graduates, it is worth noting that 40% of the contracts are related to pre-doctoral fellowships, research projects or doctoral studies. The remaining percentage corresponds to technical positions in engineering companies related to the development of solar photovoltaic projects.





Scholarship programme and external internships:

Although the master's degree does not have a specific subject on work placements in companies, students on the master's degree are eligible for extracurricular grants managed by the UAL University Employment Service through the ICARO platform. In the 2022-2023 academic year, 3 students of the master's degree have been able to carry out this type of internship, 2 of them at the CIESOL research centre and the third at a consultancy on energy projects linked to a group of agricultural cooperatives.

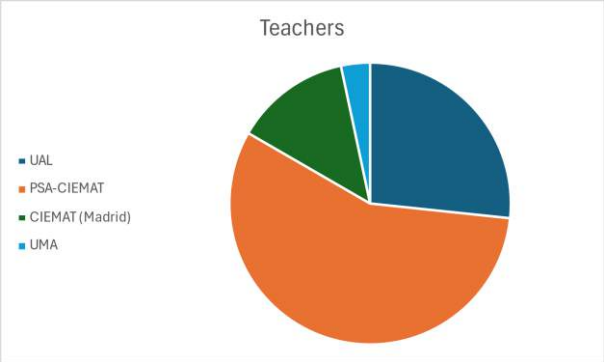
In addition to the scholarships and tuition grants from the national and regional governments, it is worth highlighting the agreement with the Carolina Foundation, which provides funds, from the 2022-2023 academic year, to finance 2 Latin American students, with the particularity that the call for the 2024-2025 academic year is for female students.

A student has also received a scholarship for the academic year 2023-2024 through the international mobility programme between Andalusian universities and institutions belonging to the Ibero-American University Association of Postgraduate Studies (AUIP), forming part of the 'Line of Action 3: Scholarships and Mobility

Grants for Postgraduate Studies' of the AUIP Action Plan 2024-2026 for the development of postgraduate studies (Masters, Doctorate, Specialisation) in the Ibero-American sphere.

Teachers:

The teaching staff of the master's degree in Solar Energy in the 2023-2024 academic year is made up of a total of 28 lecturers. Of these professors, 22 are external professors, of which 17 are researchers at the Plataforma Solar de Almería, 4 work at the headquarters in Madrid of the Centro de Investigaciones Medioambientales y Tecnológicas, the organisation to which the Plataforma Solar de Almería belongs and, finally, 1 research professor from the Department of Mechanical, Thermal and Fluids Engineering of the University of Malaga. The 6 professors belonging to the University of Almeria belong to the areas of Chemical Engineering, Systems and Automation Engineering, Applied Physics and Materials Science and Metallurgical Engineering. Two of these professors of the University of Almeria are University Professors and the rest belong to the body of University Professors. Of the professors belonging to CIEMAT, OPI (Public Research Organisation), all have a permanent link to this organisation and 14 of them belong to the scale of Senior Scientists of Public Research Organisations.



With regard to the research quality of the master's degree lecturers, the average number of six-year research periods among the professors teaching on the master's degree is 5.8, while the average number of full university lecturers is 3.8. Also noteworthy is the appearance of 5 lecturers linked to the master's degree in the 2023 edition of the World's Top 2% Sicentist Ranking prepared by Stanford University in the areas of Chemical Engineering and Automation and Automatic Control.

2. WHAT DOES CIESOL OFFER – SCIENTIFIC AND TECHOLOGICAL INFRASTRUCTURES AND CAPACITIES

2.1 ACTIONS IN 2023

In 2023, several improvements were made to the Research Centre's infrastructures.

On the one hand, laboratory 7 has been fitted out as a working laboratory (previously it was a room with tables and chairs used to house interns and students during their stay at the Centre). This laboratory, mainly run by the Desalination and Photosynthesis Group, has been used for cosmetics and functional food, with pilot equipment for the recovery of proteins and bioactive compounds from microalgae and for the preparation and analysis of functional foods..

In laboratory 1 we have installed two ion chromatographs on loan from the Plataforma Solar de Almería that will allow us to extend the range of analysis in ion chromatography, going from only analysing certain anions to being able to analyse cations and oxo-anions.

On the other hand, in the ground floor hall, several laboratory tables have been installed to increase the available working areas.

A new filtration plant has also been installed in the hall for the pre-treatment of wastewater for subsequent treatment by photocatalytic processes. The plant consists of four filters in series from 100 to 0.5 microns. It has two 300-litre tanks (one for raw water and the other for treated water) and a treatment capacity of up to 3,000 litres per hour.

Finally, we have continued to equip the building's meeting room, installing a new screen, a new projector, an integrated audio system and a meeting area at the back.
We are in the process of installing a camera and a microphone in order to be able to organise videoconferences.

The solar cooling system has been overhauled and flow meters that capture the flow of water used to air-condition the building and sensors that measure the temperature of the fluid have been replaced.

Flowmeters

Temperature sensor

2.2 FACILITIES AND INFRASTRUCTURES IN THE AREA OF CHEMICAL ENERGY UTILISATION

XcelVap.

The XcelVap automated evaporation system is a system that provides rapid and gentle evaporation of up to 54 sample extracts varying in size (up to 200 ml). Evaporation is carried out by a combination of constant heat, controlled gas bubbling and active venting of solvent vapours. With the XcelVap system, reproducible extracts for chromatographic analysis (GC/MS, LC/MS, GC, LC) can be prepared in less time and with less need for attention, improving laboratory productivity.

Micromolar photochemical system.

The micromolar photochemical reactor is a system that allows the controlled irradiation of a small volume of a reactive chemical system, both homogeneous and heterogeneous, using sunlight or, in its absence, artificial halogen lamps as a source of radiation. This avoids any disturbance of the reaction medium and constantly monitors all external parameters that may influence the reaction.

Spectrophotometers.

- Fluoromax-4 Horiba Jobin Yvon Fluorometer
- JASCO V650 UV-Vis spectrophotometer
- Hach Lange UV-Vis spectrophotometer

Monochromator-coupled deuterium lamp.

It is mainly used to study light-mediated reaction mechanisms, identification of intermediate species and reaction kinetics.

Reaction carrousels.

The reaction carousels consist of twelve teflon-lidded tubes for working in various reaction atmospheres, with a coolant at the top of the tubes for liquid condensation. The working temperature ranges from room temperature up to 300ºC. Each tube is shaken individually. They are mainly used for catalytic studies by varying reaction atmosphere, reaction time and reaction temperature.

High-sensitivity fluorometer with temperatura control.

The instrument allows the fluorescent characteristics of both a solution and a solid to be determined at different temperatures in the near IR to near UV range. It allows the determination of all optical parameters of a sample as well as the lifetime of excited states in the pico-second range.

Cyclic volta-amperometry.

It allows the study of the redox properties of a solution and of the different solutes in it. The instrument available consists of a thermostatised chamber and a whole battery of possibilities that allow a detailed study of how a sample exchanges electrons.

AB SCIEX QTRAP 5500.

This is a hybrid linear ion trap-quadrupole mass spectrometer coupled to ultra-high resolution liquid chromatography. It provides excellent sensitivity in full scan, MS/MS and MS3. It is applied to the

determination of organic micropollutants (pesticides, emerging contaminants, etc.) present in wastewater samples and other environmental matrices, as well as their monitoring during degradation tests.

TripleTOF™ 5600+.

This system allows the determination of the exact mass of the analysed compounds, which facilitates the structural characterisation and identification of unknown compounds, such as transformation products of pollutants in water treated for decontamination. It also allows scanning analyses for the preliminary identification of thousands of pollutants in environmental samples, thus characterising the type and degree of contamination of the samples.

Agilent 8890 gas chromatograph coupled to Agilent 7010B triple quadrupole mass spectrometer (GC-QqQ-MS/MS) with high performance GERSTEL autosampler.

It allows the analysis of low/medium polarity volatile organic compounds, thus completing the range of compounds that can be analysed in the Environmental Analysis laboratory. It is especially applicable to the determination of trace levels of pollutants such as synthetic fragrances, pesticides, PAH, THM, etc.

EXION ultra-pressure liquid chromatograph (UHPLC) coupled to a triple quadrupole mass spectrometer (SCIEX 7500).

This state-of-the-art mass spectrometer enhances the performance of the QTRAP 5500 LC/MS/MS, providing excellent sensitivity for ultra-traces analysis of organic contaminants, in many cases without the need for sample pre-treatment. This improves the accuracy of analysis by avoiding losses in the extraction process, in turn minimising the cost and time of analysis.

Automated solid phase extraction (SPE) equipment Dionex AutoTrace 280.

This system automates the laborious process of solid phase extraction (SPE). It is designed for the extraction of trace level organic compounds from water or aqueous matrices. It allows analytes to be concentrated from large sample volumes (20 ml to 4 l). The system allows simultaneous analysis of up to 6 samples, minimising manual operation errors and operator exposure to both samples and extraction solvents.

Ion chromatograph (Metrohm 881 Compact IC Pro).

This chromatograph allows the precise analysis of anions or cations in concentrations from µg/L to g/L, with detection limits <1 µg/L. This system is essential for the characterisation of aqueous effluents with which the experiment is carried out, since the presence of certain cations such as phosphates and chlorides affect the water decontamination processes carried out (Fenton and solar photo-Fenton processes).

Total organic carbón analysers (TOC).

This equipment allows the determination of dissolved carbon and nitrogen. In the laboratory it is used for the determination of organic and inorganic carbon and dissolved nitrogen in liquid wastewater samples to assess their purification when oxidative treatment is applied.

Atlas Suntest cPS+ solar simulator.

This device simulates the solar spectrum, allowing experimentation on a laboratory scale, making it essential in initial tests prior to pilot scale.

Pilot plant.

We have four pilot plants for the treatment of contaminated water using the photo-Fenton process. They operate with direct solar irradiation and have radiometers to record the incident radiation in each case.

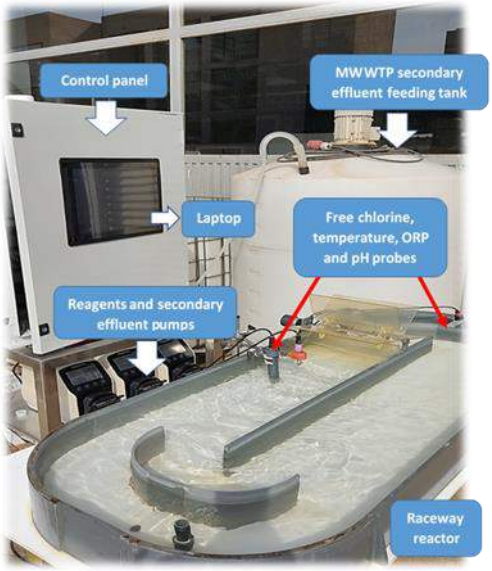
Bioreactors.

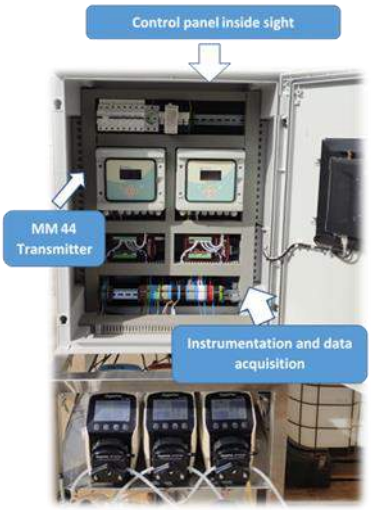
They are used to simulate the different biological processes of water purification:

- Flat membrane (MBR)
- Hollow fibre (MBR)
- Biological reactor batch (SBR)
- Membrane biological reactor SiClaro® 8PE of Martin Systems AG

Solar Photo-Fenton Experimental Automatic System.

The solar photo-Fenton experiments are carried out in pilot plant scale raceway reactors. A SCADA system monitors and controls the entire functioning of the process in real time.





Filtration plant.

It is intended for the pre-treatment of wastewater for subsequent treatment by photocatalytic processes. The plant consists of four filters in series from 100 to 0.5 microns. It has two 300-litre tanks (one for raw water and the other for treated water) and a treatment capacity of up to 3,000 litres per hour.

2.3 INSTALACIONES E INFRAESTRUCTURAS DEL ÁREA DE APROVECHAMIENTO ENERGÉTICO DE LA ENERGÍA SOLAR

Solar termal power plant. Solar heating/cooling system.

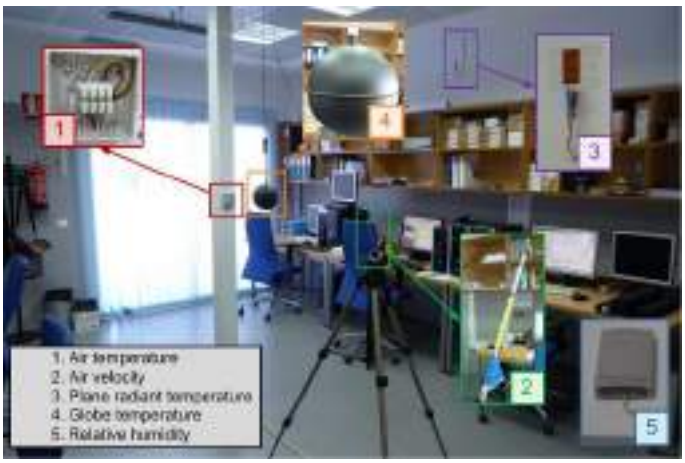
The installation has a collector field which is responsible for collecting the energy from solar radiation to heat water which is stored in tanks, this water can be used in the cooling system or for phytosanitary purposes.

Solar collector field

Yazaki adsorption machine and hot water storage tanks

Building monitoing system.

We have a system that monitors the thermal comfort in our facilities.



Comfort monitoring infrastructure in CIESOL laboratories and SCADA monitoring system screen and actuator examples.

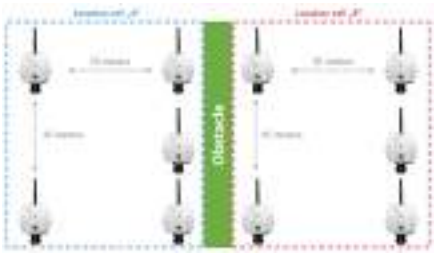
Ultra Wide Band (UWB) component system for real-time location system solution.

Different rooms on the ground floor and first floor of the building have a system of ultra-wideband components for locating the building's users in real time. This system is made up of radio beacons anchors, which form an internal network apart from CIESOL's own, through which they send the location data of the users, and tags, which the user carries in their pocket or strapped to their wrist, which communicate with these beacons and by means of triangulation of the beacons located in a room allow them to know in real time where the user of the tag is in real time.

Anchors

Tags

Internal network



Triangulation

Charging point for electric vehicles.

The centre has an alternative current charging point for electric vehicles on the west side of the courtyard. This charging point is connected to a row of photovoltaic panels which feeds the charging point. In the event that there is not enough radiation to cover the demand of the connected car, the charging point will be powered by the batteries of the building's microgrid, thus avoiding the consumption of energy from the grid.

Charging point for electric vehicles

Consumption/production profile

Load simulator.

The Modelling and Control functional unit also has a test bench where the behaviour of some of the elements of an energy district can be simulated, with which some of the control and energy management strategies can be tested. The aim is to replicate the elements that consume, store and produce electrical energy. There is also a test bench for the electric car, which is currently located in CITE IV for space reasons. This test bench is used to characterise the propulsion system of a light electric vehicle.


Load simulator (left). Charging station for electric vehicles (right)

Inverters.

The Modelling and Control functional unit has three inverters, one of them manages the row of photovoltaic panels and feeds laboratory 6 and the electric vehicle charging point, another inverter manages two panels that are on the highest part of the roof, and simulates an isolated network, with a specific load of an air conditioner. A Fronius Symo Gen 24 8.0 has also been incorporated with a 9.3 kWp photovoltaic plant.


Plant for the use of renewable energies for agricultura, Project AGROCONNECT.

The infrastructure project AgroConnect (EQC2019-006658-P): Sustainable, Autonomous, Connected and Open Intensive Cultivation System, is distributed in:

- Storage system.

A server for simulation and a storage service for the data collected. The monitoring and control system installed on a desktop PC with NAS data server and CLOUD server infrastructure; and the aerial monitoring system (dron Mavic Air).

- Weather measurement stations.

A set of commercial weather stations: one outdoor and 6 indoor:

Outdoor weather station (DeltaOhm Srl): consisting of a base unit (HD35APW) to which the data collected by two loggers are fed: HD35EDM…TC y HD35EDW 1NB…F TCV.

To HD35EDM...TC are connected the LPPYRA03, HD54.3, HD2015R, HP3517TC2 and HD54.D sensors, while to HD35EDW 1NB...F TCV is connected a single LP 35 PAR sensor, having an integrated CO2 sensor.

Generic schematic of base unit connected between data loggers and PCs

Indoor weather station 1 (DeltaOhm Srl): consisting of a base unit (HD35APW) to which the data from 5 loggers are fed: HD35EDWSTC, HD35ED1NTC, HD35EDWRTC, HD35EDW1NLTC and HD35ED1NB.

Indoor weather station 2 (CAMPBELL): consisting of a base unit CR310 to which the following sensors are directly connected: HC2A-S3 T/HR probe, CS655, SKP215 and CS301.

Data logger CR310

Indoor weather station 3 (LIBELIUM): consisting of a base unit that doubles as the SA-XTR 4G EU/BR v2 recorder to which the various sensors are connected.

Example data logger

Indoor weather station 4 (LABFERRER/ METER): consisting of a ZL6 base unit to which an SQ-110 sensor and an ATMOS41 weather station/ recorder are connected.

Unidad Base ZL6.

Indoor weather station 5 (HOPU): consisting of a Smart Spot Core base unit, which includes an internal CO2 sensor. It receives data from a TEROS 11 sensor and two SP-421 and SHT35-DIS loggers.

Reverse osmosis plant (RO).

The RO has a specific consumption of 3 kWh/m^3, which is fed directly by seawater, and can generate 11 m^3 of desalinated water per day. This water is stored in a 100 m^3 tank. In addition, the RO unit generates 22 m^3/h of brine which is stored in a 50 m^3 tank and used to feed the membrane distillation system.

Membrane distallation plant (MD).

This system is an MD unit capable of generating 6 m3/day of distilled water. The MD unit requires a continuous heat source for proper operation. It is the second water generation system that uses membrane distillation technology to desalinate the brine generated from reverse osmosis with solar energy support.

Solar photovoltaic power plant.

A photovoltaic generation installation with electrical storage capacity for the complementary supply of the irrigation, desalination, climate control and other electrical consumption systems of the experimental greenhouse. It is composed of two 18-module photovoltaic panel units (LONGI LR4-72 HPH 450W) with an electricity generation capacity of 16.2 kW, two Fronius Symo Gen24 8.0 Plus inverters and two batteries (Battery-box premium HVM 22.1), for electricity storage with a capacity to store 44.2 kWh.

Solar termal power plant.

It is composed of 30 collector modules with a generation capacity of 92 kW, it has a 3000 l storage tank.

Sistema de acondicionamiento térmico.

A thermal conditioning system (heating and cooling) to control the climate inside the greenhouse.

Thermal conditioning system

System for storage and re-injection of CO_2 from combustion.

A system for storing and re-injecting CO_2 from the combustion of biomass in the boiler for crop improvement trials.

Humidification system.

Humidification installation. System designed to increase the humidity and decrease the temperature in the greenhouse.

Liquefied gas carbonic enrichment system.

Increases the CO_2 concentration in the greenhouse

Fertigation system.

An irrigation unit of the SC800 series equipped with a mixing tank and an automatic Venturi injection system, which in the greenhouse will divide its action into two irrigation sectors by means of two valves. To satisfy the demand for water and nutrients, the greenhouse is equipped with a fertigation system using a dripper.

Greenhouse system.

The centre of the installation is an experimental greenhouse of 1900 m^2 located in the IFAPA centre next to the University of Almeria (Almeria, Spain). The greenhouse is divided into two sectors of equal size and is equipped with a multitude of systems that allow a great deal of control over the growing conditions.

Open and scalable system for monitoring, efficient energy management and comfort control of the unique and strategic CIESOL building.

The infrastructure project awarded by the Junta de Andalucía consisted of three lots with the aim of renewing all the hardware and software of the acquisition system of the CIESOL research centre, as well as including new technologies such as IoT, Cloud or Big Data that were not available at the time of its initial development.

Both the hardware and software that monitors the solar cooling installation have been renewed. To this end, all the old SAUTER and National Instruments components have been migrated to their Schneider Electric equivalents. An acquisition system has been created based on new IoT and Cloud technologies for data collection and storage, for which a NAS server has been purchased where this data will be stored periodically. With regard to the hardware dedicated to data acquisition, all the PLCs that collected the data from the different sensors in the installation have been renewed.

PLCs of Schneider Electric. New acquisition application and server to store the data.

Meteosat satellite station.

The reception of images from the METEOSAT geostationary satellite is carried out thanks to the configuration and adaptation of a system installed on the roof of the CIESOL building, where every 15 minutes a map of the globe is obtained from a spatial view.

Radiometric station.

Direct, diffuse and normal radiation are measured with a frequency of 1 minute thanks to the two-axis solar tracker (2AP Sun Tracker - Kipp & Zonen) composed of a pyrheliometer (CH 1 Kipp & Zonen) and two pyranometers (CMP 11 Kipp & Zonen). In addition, 2 pyranometers (CMP 11 Kipp & Zonen) have been installed to measure the radiation in inclined plane having the same inclination of the solar field, together with 2 pyranometers measuring the normal GHI radiation (1 CMP 11 and 1 SMP6 from Kipp & Zonen).

Installation of Campbell CR100X Datalogger for the correct and accurate reading of DNI DHI and GHI radiation data from the solar tracker, allowing the measurements to be recorded in the control SCADA.

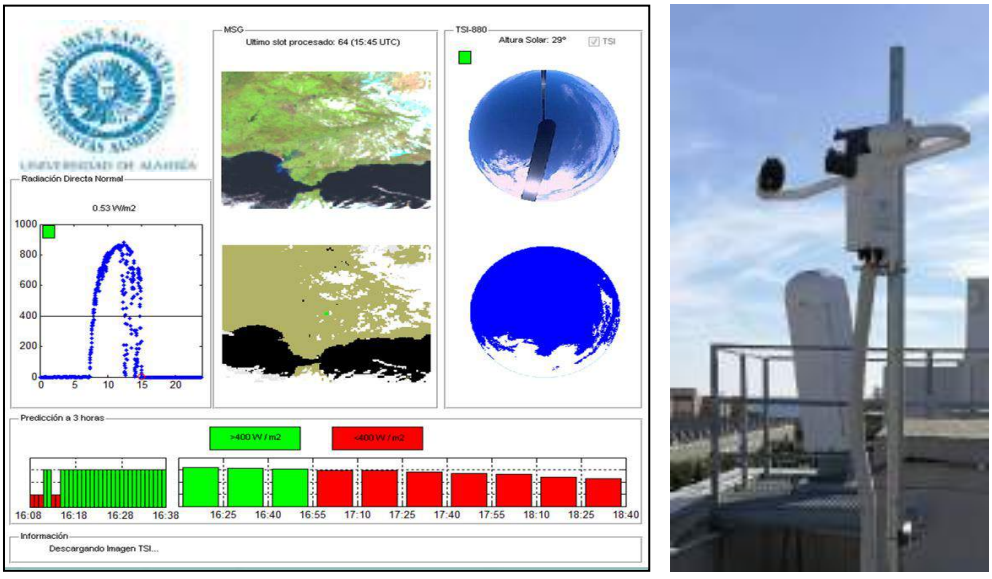
Sky camera system.

The view of the sky from a terrestrial point of view is provided by a system of sky cameras of different types, structure and operation. With them, the passage of clouds can be characterised, and their images have allowed and are allowing meteorological developments in the prediction of cloudiness and solar radiation in the short term.

Cloud prediction system. Real-time cloud prediction up to 3 hours ahead, using satellite imagery and sky cameras.

Precipitation measurement system.

The Lambrecht meteo rain gauge allows the recording of the amount of rainfall as well as the intensity of the rainfall in each time interval.



Atmospheric characterisation and visibility measurement system.

The VAISALA CL-51 ceilometer and the Visibilimeter Biral SWS-250 form an innovative and precise system for characterising the lower layers of the atmosphere. Their mission is mainly to discover clouds and atmospheric pollutants at wavelengths of 910 and 840 nm, respectively, one of them vertically and the other horizontally, thus having an exhaustive control of what happens on the surface of CIESOL.

Station for measuring dust deposition on photovoltaic panels.

In order to characterise dust deposition on photovoltaic panels, a widely monitored measuring station has been set up to evaluate soiling losses and to correlate them with meteorological variables.

Solar food chambers.

In the CIESOL patio there are three food chambers that are solar-powered for refrigeration. The compression refrigeration cycle is driven by photovoltaic panels, and can be used for direct cooling of a chamber, for storing thermal energy in a tank filled with phase change material nodules, or in eutectic panels. The system can also be connected to the solar-powered absorption chiller that provides cooling at CIESOL. There is also a control room adjacent to the three chambers, and the entire system is monitored and can be controlled online.

Particulate matter and air quality measurement station.

The AEROQUAL AQS1 is a particulate air meter that allows us to detect PM10 PM2.5 or TSP particles simultaneously, as well as Nitrogen Dioxide (NO2) and Ozone (O3). It can obtain air quality information at one minute intervals.

3. ACTIVITIES IN CIESOL

3.1 ACTIVITIES IN ORGANOMETALLIC CHEMISTRY AND PHOTOCHEMISTRY

3.1.1 Description of the Research Group

This unit was constituted in 2023 by 10 members (3 university professors, 2 postdoctoral researcher, 1 postdoctoral research professor and 3 predoctoral researchers) and is made up of staff from the Research Group "Coordination/Organometallic Chemistry and Photochemistry" (FQM-317) belonging to the Department of Chemistry and Physics of the University of Almeria, which in turn is made up of members of the University of Almeria, La Laguna, Cádiz and by a researcher from the German Aerospace Center - Plataforma Solar de Almería (DLR-PSA-CIEMAT), now Director of the company Solarway SLNE. The group maintains permanent exchanges with other PAI (Andalusian Research Plan) groups as well as with other groups from CIESOL and other Andalusian universities. The unit has not stopped growing both in projects (regional, national and international) and in scientific production (more than 260 articles in international impact chemical journals). His initial interests, the synthesis of metal catalysts for the mediation of photochemical reactions in water, have been extended to other areas such as the photo-generation of hydrogen, the transformation of small molecules by solar radiation and the fight against cancer through photoactivation with visible light of metal compounds, which makes them useful in photoactive therapy. which consists of the compounds being inert in the dark and anti-cancer under visible radiation.

3.1.2 Strategic lines

The main strategic lines of the group within the CIESOL Joint Centre are the following:

- Development of new water-soluble homo and heterometallic complexes with photocatalytic activity in processes of synthesis of high value-added molecules such as hydrogen from water and visible-solar radiation.
- Transformation of white phosphorus into red, using solar energy as an energy source.
- New photoactivatable anticancer agents useful in photoactive therapy, where compounds are inert in the dark and active under visible radiation

3.1.3 Main researchers

Antonio Manuel Romerosa Nievas (ORCID ID = 0000-0002-6285-9262; Scopus Author ID 6603792206)

Antonio Romerosa was born in Granada (Spain) in 1964. He graduated in 1987 (University of Granada) and received his PhD (Autonomous University of Barcelona) in January 1992. In the same year he carried out a postdoctoral stay at the former CNR ISSECC, now ICCOM CNR, (Florence, Italy), before becoming full professor (1997) and professor (2009) of the area of inorganic chemistry at the University of Almería (Spain). His main lines of research are aimed at homogeneous catalysis and organometallic chemistry in water, phosphorus chemistry, inorganic photo-chemistry, bioinorganic chemistry and natural stones. He is the author of more than 166 international articles, 15 Spanish and international patents and more than 265 presentations at national and international conferences. He has been responsible for more than 23 national, regional and European research projects, as well as directed 21 doctoral theses, and is currently directing 3 more. He is responsible for the group of the Junta de Andalucía FQM-317.

Christoph Richter (ORCID ID = 0000-0001-8386-1882; Scopus Author 55439554100)
He received his PhD in Physical Chemistry from the University of Cologne in 1993. In 1994 he began working in the Department that DLR (German Aerospace Center) has in the Almería Solar Platform (PSA-CIEMAT), in Spain; The largest test center for research and development in high-temperature solar concentration technologies. Initially he worked as a project manager in the area of solar chemistry, in the development of projects on the photochemical applications of solar energy in water purification and in fine chemical synthesis. He currently works on different aspects of the operation of solar thermal plants, including heat storage, cooling and environmental impact, and is responsible for DLR's administration and infrastructure department in Almeria. Since March 2008 he has been the Secretary-General of SolarPACES. In 2011 he founded the company Solarway SLNE with special dedication to the management of SolarPACES and its annual international conference. Since June 2022 he has left his position at DLR and is dedicated as director of Solarway to SolarPACES, in addition to continuing to participate with his company Solarway in research projects.

3.1.4 Summary of the functional unit's activities carried out in CIESOL during 2023

The group has continued its renewal with the incorporation of new members thanks to youth employment contracts, pre-doctoral students, various undergraduate and master's students and foreign postdoctoral visitors. We have continued with the training of doctors, the publication of articles in the best journals in the area of chemistry, inorganic chemistry and materials. It is noteworthy that two of its members have obtained their doctorates, joining the teaching staff of the University as temporary substitute professors.

3.1.5 Collaboration with other CIESOL Research Groups during 2023

During 2023, the unit has collaborated with the Water Regeneration unit, and it is intended to collaborate with units of the solar platform for the design and use of suitable reactors to develop photochemical reactions under inert conditions.

3.1.6 Human resources of the Research Group

Stays of CIESOL researchers in other centres:

- Jose Manuel Veiga del Pino. Aoyama Gakuin University, Japan (15/05/2023-15/09/2023).

Students in curricular internships:

- Paula Morales Martínez. Bachelor's Degree in Chemistry (26/11/2022-03/02/2023).
- Carlos Morillas Cano. Bachelor's Degree in Chemistry (28/11/2022-12/02/2023).
- Álvaro Martínez Aguilera. Master's Degree in Advanced Chemistry Laboratory (03/11/2022-31/01/2023).

3.1.7 Summary tables of scientific production

The scientific production of the functional unit during 2023 is summarised in the following tables containing the number of indexed articles, participation and contributions to congresses, organisation of congresses, book chapters, as well as theses defended and in progress. The complete production can be consulted in the corresponding Annex at the end of this report.

Number of Article	Number of articles in each quartile				Number of articles with international collaboration
	Q1	Q2	Q3	Q4	
4	4				1

Congresses attended	2
Contributions to congresses	-
Oral	1
Posters	1
Congress organization	-
Book Chapters	-
Doctoral theses defended	2
Doctoral theses in progress	-

3.1.8 Members of the Research Group

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Researcher
Director Solarway SLNE
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Pablo Antonio Lorenzo Luis

Professor of Inorganic Chemistry
Univ. La Laguna

Isaac de los Rios Hierro

Professor of Inorganic Chemistry
Univ. Cadiz

Ismael Diaz Ortega

Postdoctoral Researcher
UAL

Franco Scalambra

PhD Researcher
UAL

Cristóbal Saraiba Bello

PhD Researcher
UAL

Sonia Mañas Carpio

PhD Researcher
UAL

Belén López Sánchez

Predoctoral Researcher
UAL

José Manuel Veiga del Pino

Predoctoral Researcher
UA

Andrés Alguacil Alarcón

Predoctoral Researcher
UAL

3.1.9 Projects in force during 2023

	Started in 2023	Started before 2023
European projects		
National projects		
Regional projects		2

3.1.9.1 Projects under implementation started before 2023

3.1.9.1.1 Heterometallic Complexes as Antiproliferative Agents: Moving Toward New Cancer Drugs

Participants:
Research Group "Coordination Chemistry, Organometallic and Photochemistry". University of Almería (FQM-317)
Contacts:
A. Romerosa Nievas (romerosa@ual.es)
Funding source:
Projects of Excellence Junta de Andalucía (PY20_00791)
Expected duration:
05/10/2021 – 30/06/2023
Situation:
In development.
Summary

The group focuses on the synthesis of novel water-soluble heterometallic compounds and their applications as photoactive anticancer agents.

The objectives are to search for new water-soluble compounds with novel properties that are useful as anticancer drugs under visible-solar irradiation.

3.1.9.1.2 Production and Storage of Hydrogen Catalyzed by Photoactivated Metal Complexes.

Participants:
Research Group "Coordination Chemistry, Organometallic and Photochemistry". University of Almería (FQM-317)
Contacts:
A. Romerosa Nievas (romerosa@ual.es)
Funding source:
University of Almeria-FEDER (UAL2020-RNM-B2084)
Expected duration:
01/11/2021 – 30/06/2023.
Situation:
In development.
Summary

The group focuses on the photocatalytic production of hydrogen from water mediated by water-soluble metal complexes.

Develop a practical process for producing water hydrogen induced by solar radiation.

3.1.10 Transfer and Ancillary Activities.

Collaboration with programmes (ERASMUS, STUDY ABROAD,...)

Academic mobility coordinators:

- Universidad de la Frontera (CL Frontera01), Chile. 2018
- University of Isfahan (IR Isfahan01), Iran. 2019
- University of Guadalajara (MX Guadalajara01), Mexico. 2021

Socrates-Erasmus Collaborations

- Université Paul Verlaine (France)
- University of Copenhagen (Denmark)
- The Royal Veterinary and Agricultural University (Denmark)
- University of Stavanger (Norway)
- University of Ferrara (Italy)

- University of Firenze (Florence, Italy)
- Universidade Nova de Lisboa (Portugal)
- Universidade Tecnica de Lisboa (Portugal)
- Polytechnic Institute of Bragança (PBRAGANC01) (Portugal)
- Babes-Bolyai University (RO CLUJNAP01), in Romania, in the area of Chemistry. Erasmus+ Programme
- University of Isfahan, IRAN, (IR ISFAHAN01), Chemistry. UALMUNDO Programme (Erasmus World, 2020-2021).
- University of Guadalajara (MX Guadalajara01, Mexico, Chemistry. UALMUNDO Programme (Erasmus World).
- Konrad Lorenz University Foundation (Colombia). from 2014-2015
- University of Isfahan (IR Isfahan01), Iran. From 2019

Collaboration with other centres

- ICOOM-CNR (Florence, Italy)
- Universidade de Lisbona (Portugal)

Patents

Antonio Manuel Romerosa Nievas, Franco Scalambra, Belen López Sánchez. Transformation of the pheromone 3-methyl-2-cyclohexen-1-ol in the presence or absence of [RuClCp(PTA)2] and [RuCp(H2O-kO)(PTA)2]CF3SO3. APPLICATION REQUEST: EP23382785.6 (300490379) (28 July 2023)

3.1.11 Training and Outreach Activities.

Organization of Courses

- Crystallization Contest at School (Almería Section), 2023 Edition. Almeria, April 21, 2023. Directors: Franco Scalambra, Antonio Manuel Romerosa Nievas.
- XXIV Summer Course of the University of Almería 2023: "Almeria: a green hydrogen hub". 13/07/2023.

Other training and outreach activities

- Researchers' Night. University of Almeria. Almeria, 2023.

3.1.12 Projects requested during 2023

- **Light and metals against cancer (LMAC).**

  Ministry of Science, Innovation and Universities Knowledge Generation Projects 2023. PI: Antonio Manuel Romerosa Nievas

3.1.13 Others

Final degree projects:

- Development of new compounds with water-soluble lanthanides: study of their solar photochemical and photocatalytic properties. Moreno Vera, Victoria. Degree: Bachelor's Degree in Chemistry (2009

Plan). Final Degree Project. 22/02/2023. Tutor(s): Antonio Manuel Romerosa Nievas, Ismael Francisco Díaz Ortega.

- Catalytic Olefin Metathesis In Aqueous Environment: Advances, Challenges and Perspectives. César Fernández Sánchez. Bachelor's Degree in Chemistry (2009 Plan). Final Degree Project. 08/11/2023. Tutor(s): Antonio Manuel Romerosa Nievas, Franco Scalambra.

Master's Degree Final Projects:

- Study of the catalytic isomerization of branched allyl alcohols and characterization of a reaction intermediate. Judit Cano Asensio. Master's Degree in Advanced Chemistry Laboratory. Master's Degree Final Project. 24/02/2023. Tutors: Antonio Manuel Romerosa Nievas, Franco Scalambra.
- Study of the catalytic activity of water-soluble complexes of Ru(II) for the photoisomerization of hex-1-en-3-ol in water Master in Advanced Chemistry Laboratory. Juan José Burgos Morata. Master's Degree Final Project. 24/02/2023. Tutor(s): Antonio Manuel Romerosa Nievas, Franco Scalambra. Qualification:

Doctoral theses in the process of being carried out

- José Veiga del Pino (Superisores: Antonio Romerosa, Franco Scalambra)
- Álvaro Martínez Aguilera (Superisores: Antonio Romerosa, Franco Scalambra)
- Fernando Bonilla (Superisores: Antonio Romerosa, Franco Scalambra)

3.2 ACTIVITIES OF ENVIRONMENTAL ANALYSIS UNIT

3.2.1 Functional unit description

The Functional Unit is made up of researchers from the Department of Chemistry and Physics of the University of Almería and the Solar Water Treatments Unit of the Plataforma Solar de Almería (CIEMAT). Collaboration between both centres began in 1996, when the first joint work was published. Since then, the group has been actively involved in national and international projects and has more than 60 joint publications. Currently, members of both centres are part of the research group "Environmental Analysis and Water Treatment (FQM-374)" of the Andalusian Research Plan (PAI).

3.2.2 Main research lines

The activity of the group focusses on the development, optimization and analytical assessment of advanced wastewater treatment processes applied to complex effluents to achieve their regeneration and enable their reuse. The strategic lines of action include the following:

- Development of advanced analytical methods for the characterization of complex effluents and their application to the monitoring of organic microcontaminants during wastewater treatment to ensure their elimination.
- Identification of transformation products generated during wastewater treatment and establishment of degradation routes.
- Study of the influence of treatments on the quality of reclaimed water and evaluation of the impact of its reuse in agriculture and the environment.

3.2.3 Main researchers

Ana Agüera López (ORCID ID: 0000-0003-2649-6772; Scopus Author ID: 6701415534).
Full professor at the University of Almeria. Degree in Chemistry (1987). Ph.D. in Chemistry (1995). She is responsible for the group 'Environmental Analysis and Water Treatment' (FQM-374) of the Andalusian Research Plan. She has more than 30 years of experience in the development and validation of analytical methods, based on the use of chromatographic techniques coupled to mass spectrometry, for the analysis of organic contaminants in foods and environmental matrices. She has participated in 40 national and international competitive research projects, 13 of them as principal investigator. She is co-author of 2 patents and 180 scientific publications in indexed international journals (h-index = 67, March, 2024). She has co-supervised 10 doctoral theses and participated in more than 180 conference communications. She is the author of 3 books and 12 book chapters and has participated in the organisation of 8 international conferences.

Isabel Oller Alberola (ORCID ID: 0000-0002-9893-6207; Scopus Author 8415190600)
Researcher in the Solar Treatment of Water Unit at the Plataforma Solar de Almería (CIEMAT), degree in Chemical Engineering (2002) and Ph.D. in Chemical Engineering (2008). It has more than 20 years of experience in the field of industrial and urban wastewater through advanced oxidation processes and their combination with physicochemical pretreatment systems, as well as advanced biological treatments. She has developed this activity through her participation in various national and European R&D Projects (5th, 6th & 7th EU FP, H2020, HE). Within her scientific production, it is worth mentioning that she is the author and coauthor of 4 books at national publishers and co-author of 21 book chapters at international publishers. In addition, she is coauthor of 174 publications in international scientific journals with an impact index and more than 190 contributions to international Conferences and Symposiums to date (December 2023). In addition,

she has participated as a teacher in national and international courses related to Advanced Wastewater Treatment. H-index (December 2023): 50.

3.2.4 Summary of the functional unit's activities carried out in CIESOL during 2023

During 2023, the Environmental Analysis Unit has completed its contribution to the European project PANIWATER (Horizon Europe Programme) in collaboration with India, through the analysis and monitoring of micropollutants and disinfection by-products in samples from the demonstration-scale plant built in India, which uses a UV/H2O2 for the treatment of WWTP effluents. This project ends on 31 January 2024.

Throughout this year, the final tasks of the NAVIA national project have been addressed. The determination of the reaction intermediates of the contaminant sulfamethoxazole has been carried out throughout the application of a new glass wool photocatalyst with TiO2 developed by the UPV on a laboratory scale.

In the DIGITI4WATER project, work has been done on the collection of physical-chemical data and the presence of micropollutants in real effluents from several WWTPs in the province of Almería, to generate an open database that allows feeding machine learning models that are being developed within the framework of the project.

A greater number of water reclamation facilities are being monitored in the MODITRAGUA project to generate a broader database that allows defining a decision support system on the most suitable treatment for elimination of micropollutants and pathogens present in this type of water. The MODITRAGUA project also includes the chemical and microbiological evaluation of a selected group of drinking water treatment stations. The project pays special attention to the formation of disinfection products derived from the chlorination processes applied. For this reason, the analytical capacity of the laboratory has been expanded for the determination of different groups of these compounds.

The ANDROMEDA project began in September 2023. It is focused on the determination and degradation of persistent and mobile organic compounds (PMOCs). A fast and simple method has been developed and validated for the determination of per- and polyfluoroalkylated substances (PFAS), which includes the 21 for which there is regulation. Similarly, a list of other unregulated PFAS and PMOCs has been prepared for their evaluation by applying a "suspect screening" analytical strategy.

In the AQUAENGRI project, the environmental analysis unit has defined the antibiotics and problem contaminants that will be evaluated throughout the project, for elimination using different oxidation technologies, due to their presence in real fish farm wastewater.

In the PHOENIX and ANUKIS projects, the validation of the developed technologies has continued. The Environmental Analysis Unit has contributed to determining their efficiency in the degradation of micropollutants.

The difficulties found in the PNFR reactor operated within the framework of the PureAgroH2O project, as a consequence of the characteristics of the treated water, suggested the need to couple a filtration stage prior to loading the reactor. A filtration system that reaches up to 1 ug has been designed and purchased and is currently in operation.

Additionally, the activity related to the detection and quantification of contaminants of emerging concern has been maintained along the treatment line proposed in the AQUACYCLE project. A demonstration-scale treatment plant has been installed in the Blanca WWTP (Murcia). The plant consists of an anaerobic biological system, followed by two wetlands (vertical and horizontal) and a raceway-type solar photoreactor. Monitoring of these contaminants has also been carried out in the wetlands themselves, analysing the substrate, roots, and plants.

Finally, it is worth highlighting the group's participation in the service provision contract between CIEMAT and the company SYNGENTA S.L., for the determination and monitoring of the pesticide Azoxystrobin in real wastewater from the treatment of bananas in the post-processing/post-harvest stage and prior to the packaging for marketing.

3.2.5 Collaboration with other Functional Units of CIESOL during 2023

Activity	Organometallics and Photochemistry	Environmental Analysis	Water Regeneration	Modelling and Control	Solar Resources and Solar Cooling	Desalination and Photosynthe
Papers			10			
Projectss			11	4		1

In 2023 the collaboration with the Water Regeneration Unit has been maintained, with joint projects: LIFE PureAgroH2O (LIFE17 ENV/GR/000387), LIFE ULISES (LIFE18 ENV/ES/000165), LIFE PHOENIX (LIFE19 ENV/ES/000278), ANUKIS (PDC2021-121772-I00), NAVIA (PID2019-110441RB-C31) and recently with ANDROMEDA project (PID2022-140875OB-C31).

There is also collaboration with the Modelling and Control Unit (INTEGRASOL, ULISES, PHOENIX and MODITRAGUA Project). We also collaborate with the Desalination and Photosynthesis Unit within the framework of the INTEGRASOL project.

3.2.6 Human resources of the Research Group

Stays and visits at CIESOL:

- Dra. Jany Hellen Ferreira de Jesús. University of Sao Paolo, Brasil (desde el 07/04/2023 al 24/05/2023).
- Dña. Kyriaki Anagnostopoulou. Aristotle University of Thessaloniki, Grecia (01/09/2023-01/10/2023).
- Dra. Dimitra Lambropoulou. Aristotle University of Thessaloniki, Grecia (12/09/2023-19/09/2023).

Stays of CIESOL researchers in other centres:

- Dña. Eva Jambrina Hernández. Wageningen Food Safety Research (WFSR), Wageningen University Wageningen, Países Bajos (15/08/2023 al 15/12/2023).

Students in curricular practices:

- José Javier Flores. Degree in Chemistry (28/11/2022-10/02/2023).
- Paula Morales Martínez. Degree in Chemistry (28/11/2022-03/02/2023).
- Vanesa Rubira Cantón. Degree in Chemistry (29/11/2022-10/02/2023).

3.2.7 Summary tables of scientific production

The scientific production of the functional unit during 2023 is summarised in the following tables containing the number of indexed articles, participation and contributions to congresses, organisation of congresses, book chapters, as well as theses defended and in progress. The complete production can be consulted in the corresponding Annex at the end of this report.

Number of articles	Number of articles in each quartile				Number of articles with international collaboration
	Q1	Q2	Q3	Q4	
11	10	1	-	-	4

Congresses attended	8
Contributions to congresses	17
Oral	11
Posters	6
Congress organization	1
Book Chapters	-
Doctoral theses defended	1
Doctoral theses in progress	7

3.2.8 Members of the Research Group

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Research Professor
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Patricia Plaza Bolaños

Professor
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Ana Ruiz Delgado

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Ricardo Sánchez

Hired doctor
CIEMAT-PSA

Kelly Johana Castañeda

Predoctoral student
CIEMAT-PSA

Azahara Martínez García

Predoctoral student
CIEMAT-PSA

Eva Jambrina Hernández

Predoctoral student
UAL

Flor Ximena Cadena Aponte

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Predoctoral student
CIEMAT-PSA

Joyce Gloria Villachica

Predoctoral student
CIEMAT-PSA

Agustín M. París Reche

Predoctoral student
UAL

Sara Guerrero Benítez

Investigo Program
UAL

3.2.9 Proyects in force during 2023

	Started in 2023	Started before 2023
European projects		6
National projects	2	4
Regional projects		3

3.2.9.1 Projects under implementation started in 2023

3.2.9.1.1 Advanced tertiary treatments based on combined reduction/oxidation processes and novel photocatalytic materials applied to the simultaneous disinfection and removal of persistent and mobile compounds in urban wastewater (ANDROMEDA)

Subproyect 1: Analytical determination and removal of mobile and persistent organic compounds in urban wastewater by means of new advanced reduction treatments and LED photoreactors (PID2022-140875OB-C31).
Subproyect 2: Advanced tertiary treatments of reduction/oxidation (solar) for the simultaneous elimination of pathogens, genes and persistent and mobile compounds in urban wastewater. (PID2022-140875OB-C32).

Participants:

"Environmental Analysis" functional unit
"Water Regeneration" functional unit

Contacts:

Subproyect 1:
A. Agüera (aaguera@ual.es)
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Subproyect 2:
I. Polo (inmaculada.polo@psa.es)
I. Oller (isabel.oller@psa.es)

Funds:

Ministry of Science and Innovation. Knowledge Generation Projects 2022.

Time Period:

01/09/2023- 31/08/2026

Current Situation:

In progress

Summary:

The ANDROMEDA project is focused on the removal of the so-called persistent and mobile organic chemicals (PMOCs) in reclaimed water with special emphasis on PFAS per- and polyfluoroalkyl substances), with well-documented hazardous effects on environment and human health. The discharge of PFAS into the aquatic environment is a threat to the quality of our water resources. They are highly polar (mobile in water) and can pass through wastewater treatment plants, subsurface environments, and also drinking water treatment processes. Therefore, its elimination has been in the spotlight of the European Commission, which proposes its inclusion in updated lists of water pollutants to be more strictly controlled in surface waters and groundwater. The main objectives of the project are:

1) Development of target, suspect, and non-target analytical methodologies to identify PFAS and other relevant PMOCs in UWWTP effluents; to evaluate the PMOC removal efficiency of the proposed treatments; to identify the main transformation products generated; and to provide estimations about environmental ecotoxicity and risk to human health of the identified compounds.

2) Assessment of novel advanced processes based on the best performing and most promising oxidative/reductive photocatalytic materials developed in ANDROMEDA for the simultaneous disinfection of UWWTP effluents and decontamination at pilot plant scale via the design, construction and testing solar/LED reactors. The ANDROMEDA project will also include the comparative assessment with

ozonation (as conventional and widely employed tertiary treatment) and the catalytic and solar photocatalytic ozonation (as novel ozone based AOP).

3) Propose the most efficient treatment strategy for UWW reclamation and reuse based on the novel treatments developed and tested at pilot scale in the project.

3.2.9.1.2 Sustainable management of water from phytosanitary treatments. SYNGENTA ESPAÑA S.A.U (Service provision contract)

Participants:
"Environmental Analysis" functional unit
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Funds:
SYNGENTA ESPAÑA S.A.U.
Time Period:
01/01/2023- 31/01/2024
Current Situation:
Finalized
Summary:

The objective of this contract has been the investigation, by the Solar Water Treatments Unit of the PSA-CIEMAT and the Environmental Analysis Unit of CIESOL, of the most appropriate technology for the removal of phytosanitary products present in banana washing water. Specifically, the environmental analysis group has carried out the analysis, in real water samples, of the degradation of the contaminant Azoxystrobin.

3.2.9.2 Projects under implementation started before 2023

3.2.9.2.1 Reclamation of urban wastewater by the integration of solar technologies based on microalgae (secondary treatment) and photo Fenton (tertiary treatment) (INTEGRASOL)

Participants:
"Water Regeneration" functional unit
"Desalination and photosynthesis" functional unit
"Environmental Analysis" functional unit
"Modeling and control" functional unit
Contacts:
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Funds:
Ministry of Science and Innovation. Projects of ecological transition and digital transition 2021 (TED2021-130458B-I00).
Time Period:
01/12/2022-30/11/2024
Current Situation:
In progress
Summary:

The starting hypothesis of the INTEGRASOL project is that it is possible to develop efficient and robust wastewater treatment processes based on solar technologies (microalgae and solar photo Fenton) to produce microalgae biomass and water ready to reuse, more sustainably and efficiently than using conventional technologies. Although both technologies have been widely studied in a separate way, their combination has not been tested until now and some aspects regarding the operational conditions need to be studied focused on, in the case of wastewater treatment priority by (i) maximising the wastewater treatment capacity, (ii) by minimising the energy consumption and reagent consumption, (iii) by guaranteeing compliance with the strict discharge regulations (REGULATION (EU) 2020/741), as well as (iv)

reliable operation in real conditions. In the case of microalgae biomass and reusable water, priority is given by (i) optimising the quality of produced biomass to produce biostimulants/biopesticides and (ii) guaranteeing compliance with regulation for water reuse in agriculture.

The main objective of the INTEGRASOL project is the development of a combined WWT process based on microalgae secondary treatment and solar photo - Fenton process as tertiary treatment operated in continuous-flow mode for UWW reclamation. To this end, the project will focus on the adaptation of the secondary treatment conditions operation to obtain an effluent with the better characteristics possible to be treated by solar photo Fenton in a raceway pond reactor operating in continuous flow. In this sense, the operation conditions will focus on the maximization of the water treatment capacity and minimising the concentration of ammonium, phosphates, and carbonates in the secondary effluent. Raceway pond reactors will be used for both treatment steps, although in the case of secondary treatment with microalgae, membranes will be used to improve the treatment capacity and to reduce the concentration of ammonium, phosphates, and carbonates in the secondary effluent. The use of membranes will also allow to operate with independence at different values of hydraulic residence time and cellular residence time. The technical assessment will be based on the simultaneous analysis and monitoring of different water quality indicators, including: i) E. coli and total coliforms (commonly defined in UWW guidelines), ii) antibiotic resistant bacteria and iii) organic microcontaminants (OMCs), some of them already included in the Proposal for a Regulation of the European Parliament and the Council on minimum requirements for UWW reuse.

3.2.9.2.2 Upgrading wastewater treatment plants by Low-cost Innovative technologies for energy Self-Sufficiency and full recycling. (LIFE ULISES, LIFE18 ENV/ES/000165)

Participants:

"Water Regeneration" functional unit
"Environmental Analysis" functional unit
"Modeling and control" functional unit

Contacts:

J. L. Casas López (jlcasas@ual.es)

Funds:

LIFE Environment and Resource Efficiency, EU. (LIFE18 ENV/ES/000165)

Time Period:

July 2019 – July 2022.

Current Situation:

Finalized

Summary:

The LIFE ULISES project aims to improve conventional reclamation processes through a set of innovative technologies that allow the production of value-added resources from wastewater, such as vehicular biofuels, agricultural biofertilizers, and water suitable for reuse. The project seeks to reduce energy consumption and the carbon footprint associated with water treatment, increasing the efficiency of a conventional wastewater treatment plant (WWTP) by integrating different technologies in each of the main lines (water, gas, and mud).

During the project, the following low-cost technologies will be implemented at the El Bobar WWTP (Almería):

- Biogas enrichment with the ABAD Bioenergy® system to produce a renewable biofuel for vehicles. (Aqualia, Energylab)
- PUSH anaerobic pretreatment combined with advanced aeration control to reduce energy consumption by half in the purification process. (Aqualia)
- Photo-Fenton solar disinfection treatment to produce regenerated water to reuse in irrigation. (Ciesol - UAL)

- Mud enzymatic hydrolysis treatment to obtain a quality agricultural biofertilizer (CETIM, Aqualia)
- Struvite recovery system of concentrates by means of direct osmosis-based process (CETIM)

All these innovative technologies will reduce the electrical consumption of the El Bobar sewage plant and, therefore, minimise its environmental impact and carbon footprint.

3.2.9.2.3 Pollutant Photo-NF remediation of Agro-Water (LIFE PureAgroH2O, LIFE17 ENV/GR/000387)

Participants:
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"Water Regeneration" functional unit
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Funds:
LIFE Environment and Resource Efficiency, EU. (LIFE17 ENV/GR/000387)
Time Period:
July 2018 – December 2024
Current Situation:
In progress
Summary:

The key objective of the LIFE PureAgroH2O project is to develop and demonstrate a novel purification system for the sustainable management of the end-of-the-pipe wastewater effluents generated in the fruit industry, the prevention of losses of various inorganic and organic contaminants to the environment, and the recycling / reuse of the purified water. To achieve the objective, a patented water purification system with the ability to effectively recycle 15 m3 / day.

Real agro-wastewater will be developed and commercialised. The novel photo-NF reactor (PNFR) system integrates synergistically state-of-the-art technologies such as nanofiltration (NF) with photocatalysis, resulting in applicability extension, minimisation of the operational cost and limitation of the carbon and environmental footprint. Innovative single-walled carbon nanotube (SWCNTs) photocatalytic membranes and vis-light active TiO2 nanostructures (VLA-TiO2) integrated in PNFR are expected to bring: i) 60% reduction in transmembrane pressure (energy efficiency), ii) significant extension of the process lifetime (2-fold) and iii) enhanced rejection performance (+99.5%) and 95% waste reduction.

3.2.9.2.4 Urban wastewater reclamation by Novel mAterials and adVanced solar technologies: assessment of new treatment quAlity Indicators (NAVIA)

Participants:
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"Water Regeneration" functional unit
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Funds:
Agencia Estatal de Investigación, Programa Estatal de I+D+i Orientada a los Retos de la Sociedad, convocatoria 2019. Ministry of Science and Innovation.
Time Period:
01/06/2020-31/05/2023. Extended until December 31, 2023.
Current Situation:
Finalized
Summary:

The main objective of the NAVIA project is the development of novel photocatalysts and new technologies based on solar advanced oxidation processes operated in continuous-flow mode for UWW reclamation. Novel heterogeneous photocatalysts prepared anchoring semiconductors or organic dyes on silica spheres,

solar photo-Fenton mediated by new iron sources at circumneutral pH, solar-Cl2 and solar assisted peroxide processes will be assessed at three technological level (lab scale, batch-wise pilot scale and continuous flow photoreactors at pilot plant scale). The technical assessment will be based on the simultaneous analysis and monitoring of different water quality indicators, including: i) E. coli and total coliforms (commonly defined in the UWW guidelines), ii) coliphages (somatic coliphages (SOMCPH) and F-specific RNA bacteriophages (FRNA)), iii) antibiotic resistant bacteria and genes (ARB&ARG) and iv) organic microcontaminants (OMCs), some of them already included in the Proposal for a Regulation of the European Parliament and the Council on minimum requirements for UWW reuse. Water quality indicators will be defined and assessed along the six-month operation of the selected reclamation technology at the pilot plant scale and continuous mode flow.

To achieve these goals, three research areas will be explored:

- The development of new heterogeneous photocatalysts with high efficiency for the decontamination and disinfection of urban wastewater.
- The development of new solar AOPs at pilot plant scale as tertiary treatments of real WWTP effluents.
- The development of effective and efficient solutions based on solar energy in continuous flow operation.

3.2.9.2.5 Innovative cost-effective multibarrier treatments for reusing water for agricultural irrigation (LIFE PHOENIX LIFE19; ENV/ES/000278)

Participants:

"Water Regeneration" functional unit
"Environmental Analysis" functional unit
"Modeling and control" functional unit

Contacts:

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Funds:

LIFE Environment and Resource Efficiency, EU. LIFE19 ENV/ES/000278

Time Period:

01/09/2020-29/02/2024

Current Situation:

In progress

Summary:

LIFE PHOENIX is a demonstrator project. It aims at the validation of a multiple barrier FPP with a set of 3ary technologies in 5 sites (3 for testing technologies for large-medium WWTPs, 2 for testing technologies for small WWTPs) and 1 replication site (small WWTP), arranged in a flexible way to allow any combination between them (Fig. 3). Although some of LIFE PHOENIX technologies have been already validated individually at TRL 5-6, LIFE PHOENIX will demonstrate them in an integrated and flexible solution in the form of a FPP, providing 130-240 m3/day of water for agricultural reuse (WWR-EU class A), and at a higher TRL of 7-8. LIFE PHOENIX technologies are tailored for the particularities of small or large-medium WWTPs. In the first case they include natural based and low-energy-low-maintenance treatments, while technologies for large-medium WWTPs are intensive and easily scalable.

Objectives:

- Demonstrate new cost-effective multibarrier treatments at TRL 7-8 for reusing 2ary effluents to meet WWR-EU quality for agricultural irrigation by a flexible pilot plant (FPP) with state-of-the-art and innovative technologies.

3.2.9.2.6 Demonstration of continuous solar photo-Fenton reactors for the regeneration of secondary WWTP effluents (ANUKIS)

Participants:
"Water Regeneration" functional unit
"Environmental Analysis" functional unit
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Funds:
Ministry of Science and Innovation. (PDC2021-121772-I00)
Time Period:
01/12/2021-30/11/2023.
Current Situation:
Finalized
Summary:

The general objective of the proposal is the construction of a demonstration-scale prototype of a solar photo-Fenton continuous reactor for WWTP secondary effluent reclamation and the protection of the technological knowledge destined for its commercial exploitation.

To this end, the following specific objectives will be addressed:

- Analysis of the technical and socio-economic viability of wastewater reclamation by the solar photo-Fenton process.
- Construction and operation of a demonstration-scale RPR prototype as tertiary treatment in a WWTP located in a rural area.
- Establishment of the procedure for technological knowledge protection.

Establishment of a business plan to transfer the technology to the water industry or create a spin-off.

3.2.9.2.7 Photo-irradiation and Adsorption based Novel Innovations for Water-treatment (PANI WATER)

Participants:
"Environmental Analysis" functional unit
"Water Regeneration" functional unit
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I. Oller (isabel.oller@psa.es)
Funds:
H2020 EU Program (Amendment Reference No AMD-820718-11)
Time Period:
01/02/2019-31/01/2024
Current Situation:
In progress
Summary:

Wastewater and drinking water in peri-urban and rural India is polluted by contaminants of emerging concerns (CECs) such as pesticides, pharmaceutical and personal care materials, or antibiotics. The EU-funded PANI WATER project aims to expand and confirm six prototypes that remove CECs and other pollutants from wastewater. The project will be implemented on site and in relation to local stakeholders. In fact, PANI WATER puts a particular emphasis on understanding the social context in which the technologies will be potentially deployed, and it will review possible social and health impacts to provide quality analyses. It will also support wastewater treatment for the safe reuse of water in agriculture, in related industries, and public water structures. The main objectives of the project can be summarized as follows:

- Development of advanced analytical methods to characterize complex effluents and their application to the monitoring of organic micropollutants during wastewater treatment to ensure their elimination.
- Identification of transformation products generated during wastewater treatment and establishment of degradation routes.
- Study of the influence of treatments on the quality of reclaimed water and evaluation of the impact of its reuse in agriculture.

3.2.9.2.8 Photoreactor for disinfection and removal of contaminants of emerging concern in treated water (AT21)

Participants:
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Funds:
Consejería de Universidad, Investigación e Innovación. Junta de Andalucía. Call 2021.
Time Period:
01/09/2021-31/05/2023
Current Situation:
Finalized
Summary:

Taking into account that Regulation (EU) 2020/741 will apply from June 2023, water regeneration facilities, in service for years, must improve their treatment systems or incorporate new treatments to comply with the new quality requirements. In this sense, the photo-Fenton process stands out as a very effective tertiary treatment both in the elimination of micropollutants and in the inactivation of microorganisms. Regarding the source of UV radiation, there is growing interest in the use of light-emitting diodes (LEDs) as an alternative to mercury lamps. This system has significant advantages such as low power consumption, long lifespan, high spectral purity, uniform illumination, energy efficiency, and flexible configuration. The bacterial inactivation efficiency of LED systems depends on the wavelength and spectral distribution of the light source. Today, UVC treatment is widely applied, mainly in drinking water disinfection devices and small household systems, as UVC irradiation effectively eliminates fungi, yeasts, viruses, and bacteria, without chemical residues, corrosion, or harmful additives. UVC-LED technology is booming and 254nm LEDs are available today, although their cost is not yet competitive. Taking into account the promising results obtained on a laboratory scale by the research team, pioneering in the UVC-LED-278/Fe3+–NTA/H2O system, this project addresses for the first time the design, operation and evaluation of a photoreactor prototype for photo-Fenton at neutral pH with Fe3+–NTA under UVC-LED radiation at 278 nm for the tertiary treatment of wastewater, complying with the quality requirements established in Regulation (EU) 2020/741.

3.2.9.2.9 Monitoring and diagnosis of the purification and reclamation of urban wastewater in regions with water stress and development of sustainable alternative treatments to chlorination (MODITRAGUA)

Participants:
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Funds:
Junta de Andalucía. Research projects oriented towards the challenges of Andalusian society.
Time Period:
02/12/2022-31/12/2025
Current Situation:
In progress.
Summary:

The general objective of MODITRAGUA is to propose solutions to face the challenges of the urban water cycle, making it possible to build more resilient cities through sustainable management of water resources. In this context, MODITRAGUA is focused on:

- The follow-up and monitoring of different Residual Water Regeneration Stations (ERAR) and Potable Water Supply Points (PAAP) in the province of Almería, in order to assess their status according to chemical and microbiological quality parameters, as well as the degree of compliance with the new quality regulations for reclaimed water and water for human consumption. In this monitoring, special emphasis will be placed on the presence of chlorinated disinfection by-products and the presence of a genomic trace of the Sars-Cov-2 virus, two current challenges in terms of water quality and of high social concern.
- Proposition for alternative processes/treatments to chlorination for efficient and viable urban wastewater reclamation, guaranteeing the sustainability of the urban water cycle, adaptation to climate change, and ensuring the quality of reclaimed water for its safe use in agricultural irrigation practices.
- Development of a novel Computer Decision Tool using automatic learning techniques that allows, based on physicochemical and microbiological parameters, to anticipate the need to apply alternative techniques to chlorination or indicate the minimum concentrations necessary to carry out chlorination actions on safe way.

3.2.9.2.10 Towards improving the Resilience of the Urban Water Cycle through the implementation of digital tools based on "Machine Learning" models and Water Regeneration Technologies (DIGI4WATER).

Participants:
"Environmental Analysis" functional unit
"Water Regeneration" functional unit
"Modelling and Control" functional unit
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Funds:
Ministry of Science and Innovation. Call 2021 - 'Green Transition and Digital Transition Projects' (TED2021-129969B-C31)
Time Period:
01/12/2022-30/11/2024
Current Situation:
In progress
Summary:

The main objective of DIGIT4WATER is to create the bases for the implementation of a decision and technology design support tool based on machine learning models. Such models will be fed by an open database on physicochemical characteristics of raw MWWTP influent and effluent, as well as advanced regeneration tertiary treatments tested at laboratory and pilot plant scale for compliance with the new European regulation (EU 2020/741) on water reuse. Special attention will be paid to the elimination of ARB & ARGs as well as the DBPs prevention commonly produced in conventional disinfection processes. A Decision Support Tool (DST) and an Early-Warning System (EWS) will be also designed based on the models developed.

The main objective of the DST is to design advanced tertiary treatment techniques for water treatment facilities, selecting the most adequate parameters. The EWS is intended to create alarms when the quality of reclaimed water is below the minimum legal and sanitary requirements depending on the final reuse purposes.

3.2.9.2.11 PARTICIPATION – SFERA III Solar Facilities for the European Research Area

Participants:
CIESOL
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Contacts "Environmental Analysis" functional unit
Ana Agüera (aaguera@ual.es)
Funds:
European Commission-DG RTD Horizon 2020 Framework Programme H2020-INFRAIA-2018-2020 (H2020-INFRAIA-2018-1)
Time Period:
January 2019 – December 2023
Current Situation:
Finalized
Summary:

SFERA III is a Horizon 2020 project funded under the Research Infrastructure Programme. The consortium is coordinated by CIEMAT-PSA and made by a total of 15 partners from 9 EU member countries. The project runs from January 2019 to December 2023 and will receive a 9,103 M€ EC grant over these 5 years.

The overall objective of this project is to carry on with the work done during the past 8 years in the SFERA 1 and SFERA 2 projects and reinforce the sustainability of the activities of the European Advanced Concentrating Solar Power research infrastructures.

Those activities will include (i) networking activities to further develop the cooperation between the research infrastructures, the scientific community, industries and other stakeholders; (ii) transnational access activities aiming at providing access to all European researchers from both academia and industry to singular scientific and technological solar research infrastructures; and (iii) joint research activities whose sole purpose is to improve the integrated services provided by the infrastructure.

3.2.9.2.12 Revaluation of different wastewaters through technologies that improve the water-renewable energy-food nexus (AQUAENGRI)

Participants:
"Environmental Analysis" functional unit"
Contacts:
S. Malato (smalato@psa.es)
A. Agüera (aaguera@ual.es)
Funds:
Ministry of Science and Innovation. Knowledge Generation Projects 2021.
Time Period:
01/06/2022- 31/08/2025
Current Situation:
En curso
Summary:

The main objective of the AquaEnAgri project is to eliminate barriers to the implementation of an aquaponics system by minimizing water consumption and/or being able to be fed with regenerated water. This project is coordinated by the UPV (Alcoy Campus) and CIEMAT and the URJC are the two

remaining subprojects. The activities carried out by CIEMAT and the Environmental Analysis Unit of CIESOL in this project include i) the research of advanced oxidation processes for the regeneration of urban wastewater treated and its reuse in aquaculture, ii) the production of solar photocatalytic hydrogen using the organic content of WWTP effluents, iii) the use of aquaculture and hydroponic effluents as a sacrificial agent, iv) evaluation of the processes applied for the elimination of pathogens in aquaculture and at the entrance to hydroponic systems.

3.2.9.2.13 Towards increasing the sustainable treatment and reuse of wastewater in the Mediterranean region (AQUACYCLE)

Participants:
"Environmental Analysis" functional unit"
Contacts:
I. Oller (ioller@psa.es)
A. Agüera (aaguera@ual.es)
Funds:
ENI CBC "Mediterranean Sea Basin Program-EU".
Time Period:
01/09/2019- 31/10/2025
Current Situation:
Finalized
Summary:

The main objective of the AQUACYCLE project is to change the current paradigm of wastewater reuse in the MENA region through 3 municipal action plans. Eco-innovative technologies (anaerobic digestion, artificial wetland, solar treatment) have low operation and maintenance cost, as they use less chemicals, run on renewable energy, biogas and fertilizer are produced, and the artificial wetland will prosper as an ecological tourist attraction, in addition to being a climate change mitigation technology. The environmental analysis group has been in charge of monitoring the contaminants of emerging concern present in the wastewater throughout the entire proposed treatment train, as well as inside the wetlands.

3.2.10 Transfer and Complementary Activities

Collaboration with programs (ERASMUS, STUDY ABROAD,…)

Erasmus agreement with the University of Salerno, Italy.

Collaboration with other centers

Research stay of Dr. Jany Hellen Ferreira de Jesús from 04/07/2023 to 05/24/2023, to work on the Research Project entitled "Correlation of the matrix effect, the degradation pathways and the toxicity of antibiotics during the heterogeneous photo-Fenton process under solar irradiation".

3.2.11 Training and Dissemination Activities

Course Organization

"The path to sustainability in the water sector: intelligent management and energy efficiency". Almería, from July 12 to 13, 2023.

Other training and dissemination activities

- European Night of Researchers, Almería, Spain, 2023.
- International Day of Girls and Women in Science, Almería, Spain, 2023.

- "Contaminants of emerging concern. Analytical strategies", in the Postgraduate Course "Advanced Oxidation Processes for Detoxification and Disinfection of Water", Faculty of Exact Sciences of the University, National La Plata, Argentina, 2023.2023.
- Water/wastewater treatment by AOPs: organic pollutants degradation and effluent toxicity, in the 1st Latin America School on Environmental Applications of Advanced Oxidation Processes, Santiago de Cali, Colombia, 2023.
- Water reuse, at the III Energy, Environment and Health Conference. Liquid sustainability, Motril, Granada, Spain, 2023.

3.2.12 Projects requested during 2023

- **An integrated database to identify transformation products of organic contaminants in water.** WATER 4 ALL, Water security for the planet, JOINT TRANSNATIONAL CALL 2023, María Ibañez Msrtín (Universidad Jaume I, Castellón).
- **Evaluation and identification of transformation products generated by different advanced treatment processes: screening in effluents and aqueous matrices of environmental relevance.** Convocatoria CNPq/MCTI N° 10/2023 - Vía B - Grupos Consolidados (Brasil). Carla Sirtori (Universidad Federal de Santa María, Brasil).

3.2.13 Others

Final degree projects:

- José Javier Flores Morales (Degree in Chemistry). Analysis of antibiotics in wastewater using liquid chromatography coupled to tandem mass spectrometry.
- José Vicente González García (Degree in Chemistry). Determination of antibiotics in tomato leaves irrigated with regenerated water using liquid chromatography coupled to mass spectrometry.

Doctoral theses in progress:

- Azahara Martínez (Supervisors: Inmaculada Polo and Isabel Oller).
- Eva Jambrina (Supervisors: Patricia Plaza and Samira Nahim Granados).
- Alba Hernández Zanoletty (Supervisors: Inmaculada Polo López and Isabel Oller).
- Joyce Gloria Villachica Llamosas (Supervisors: Sixto Malato and Alba Ruiz).
- Kelly Joahana Castañeda (Supervisors: Sixto Malato and Inmaculada Polo López).
- Agustín Manuel París Reche (Supervisors: Patricia Plaza and Ana Agüera).
- Flor Ximena Cadena Aponte (Supervisors: Ana Agüera and Patricia Plaza).

Awards obtained during 2023

- Flor Ximena Cadena Aponte. 3rd Award for the best oral presentation entitled "Advancing Photocatalytic Nanofiltration System for the Treatment and Sustainable Use of Wastewater in the Agri-Food Industry." XII Research Symposium in Experimental Sciences, Almería.
- The LIFE Ulises Project has been awarded in the XXVII edition of the Andalusia Environment Awards, which awards the Ministry of Sustainability, Environment and Circular Economy

3.3 ACTIVITIES OF ADVANCED WATER REGENERATION TECHNOLOGIES

3.3.1 Functional unit description

In 2023, the Functional Unit was made up of 13 researchers, including two university professors, one researcher contracted by OPI, one university lecturer, one doctor contracted in charge of a project, two PhDs contracted by CIEMAT-PSA, one doctor contracted by the Andalusian Regional Government PAIDI2020, four pre-doctoral researchers and one technician, as detailed in section 3.3.8. The group works on the decontamination of water contaminated with persistent toxins, elimination of micropollutants and disinfection of treated water for reuse. It has advanced analytical equipment located in laboratories 1 and 2 of the centre, as well as pilot plants for biological and photochemical water treatment, in the building and in the test yard.

3.3.2 Main research lines

Study of solar photocatalysis for the elimination of toxic substances and water disinfection, as well as its combination with advanced biological methods. The strategic lines of action are:

- Application of solar photo-Fenton to the decontamination of toxic waters.
- Application of solar photo-Fenton to the elimination of micro-pollutants in purified water.
- Application of solar photo-Fenton to the disinfection of purified water (regeneration).
- Water regeneration by means of photo-Fenton assisted by UV LED radiation
- Water regeneration by concentrated solar radiation
- Combination of solar photo-Fenton with membrane bioreactors (pre- and post-treatment)
- Optimisation of operation and development of new photo-Fenton technology
- Economy of water treatment processes

3.3.3 Main researchers

José Antonio Sánchez Pérez (ORCID ID: 0000-0001-5635-3137; Scopus Author ID 57195586656)

University Professor. Department of Chemical Engineering. Industrial Chemist (1988) and Doctor in Chemical Sciences (1992) from the University of Granada. He has participated in 26 national and international R&D projects, leading 13 of them, as well as in a dozen contracts with companies. He has supervised 19 doctoral theses in different fields such as microalgae biotechnology, fermentation of filamentous fungi and water treatment and is co-author of four patents and more than 190 scientific publications in international journals.

María Inmaculada Polo López (ORCID ID: 0000-0002-2505-721X; Scopus Author ID 26032688800)

OPI contract researcher. Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Plataforma Solar de Almería. Degree in Biology from the University of Granada in 2006 and PhD in Chemical Engineering from the University of Almeria (2012). She has participated in more than 25 national and international R&D projects, currently leading 2 of them. She has directed/co-directed three doctoral theses and is currently directing another four doctoral theses in progress in the field of solar water treatment and reuse. Author and co-author of more than 100 publications in international journals with high impact index, author of 1 book and co-author of 16 book chapters.

3.3.4 Summary of the functional unit's activities carried out in CIESOL during 2023

During 2023, work has been carried out on the UAL-Feder AQUELOO, Life Ulises, Life Phoenix, NAVIA (Challenges-AEI), ANUKIS (Proof of Concept-AEI) and Rayo (Junta de Andalucía) projects, as well as the Integrasol (TED2021-130458B-I00) and AT21 (Proof of Concept-Junta de Andalucía) projects. The operation of the solar photo-Fenton demonstration plant in which up to 24 m3/day of secondary effluent from the 'El Bobar' WWTP in the city of Almeria has been treated. It is a 100 m2 RPR (Raceway Pond Reactor) type reactor operated in continuous mode for the disinfection and elimination of emerging pollutants in secondary effluents for reuse in agriculture. The fluid dynamics of the reactor has been studied, as well as the treatment at acid pH with on-line acidification and neutralisation, achieving micropollutant removals of more than 80% and water disinfection levels that would allow its reuse for agricultural irrigation. Within the framework of the Rayo project, a prototype of a concentrating solar photoreactor has been installed at the El Bobar WWTP based on Fresnel technology. In the framework of the Phoenix project, a 37 m2 solar photo Fenton treatment plant has been installed at the El Toyo WWTP in the municipality of Almeria with a treatment capacity of 5.4 m3/h, and in the framework of the Anukis project, a 37 m2 solar photo Fenton treatment plant has been installed at the Uleila del Campo WWTP capable of treating around 7 m3/h (Figure 2.3.1.).

As for the work carried out at the centre's facilities, a photoreactor with UVC LED illumination at 276 nm has been set up and experimental studies have continued on RPR at pilot scale, analysing the effect of different variables of interest for the operation of the process, such as different sources of iron and oxidants.

In terms of mobility, during 2023 we have hosted Dr. Roberto René Moreno García in the framework of the ANUKIS project (PDC2021-121772-I00), from 10 November to 12 January.

a)  b)  c) 

Raceway-type photoreactors for the operation of the solar photo-Fenton process in continuous mode for the treatment of treated water, installed at the WWTPs of (a) 'El Bobar' in Almería, (b) 'El Toyo' in Almería and (c) Uleila del Campo.

3.3.5 Collaboration with other functional units of CIESOL during 2023

Activity	Organometallics and Photochemistry	Environmental Analysis	Water Regeneration	Modelling and Control	Solar Resources and Solar Cooling	Desalination and Photosynthe
Artículos		9		2		4
Proyectos		10		3		2

There is close collaboration with the 'Environmental Analysis' group, complementing and strengthening the main current lines of work, with which the NAVIA (PID2019-110441RB-C31 and PID2019-110441RB-C32), ANUKIS

(PDC2021-121772-I00), Life PureAgroH2O (LIFE17 ENV/GR/000387), Life Ulises (LIFE18 ENV/ES/000165) and Life Phoenix (LIFE19 ENV/ES/ES/000278) projects are shared. With the 'Modelling and Control' Unit, collaboration is being carried out for the implementation of control systems for the disinfection and decontamination process using solar photo-Fenton operated in continuous mode in the ANUKIS (PDC2021-121772-I00), Rayo (PY20_00786), Life Phoenix (LIFE19 ENV/ES/000278), Life Ulises (LIFE18 ENV/ES/000165) and Integrasol (TED2021-130458B-I00) projects. The 'Desalination and Photosynthesis' unit collaborates with the Rayo project (PY20_00786), dedicated to the evaluation of disinfection using concentrated solar energy, and Integrasol (TED2021-130458B-I00), focused on the coupling of water treatment using microalgae and solar photo-Fenton.

In the field of collaboration between units through the co-direction of doctoral theses, the defence of the thesis 'Use of greenhouse plant waste for heating and carbon enrichment', co-directed by Gabriel Acien Fernández (Desalination and Photosynthesis Unit) and Mª Guadalupe Pinna Hernández (Water Regeneration Unit), should be highlighted. Doctoral student: José Vicente Reinoso Moreno. Almeria, 28/04/2023, Excellent Cum Laude. Doctoral Programme in Biotechnology and Industrial Bioprocesses Applied to Agri-Food and the Environment.

3.3.6 Human resources of the Research Group

In 2023, researcher Elena Olivares left the group to join the company SANDO to complete a doctoral thesis in the field of business projects.

Stays and visits at CIESOL:

- Dr. Roberto René Moreno García within the framework of the ANUKIS project (PDC2021-121772-I00), 10 November to 30 January. Center for Applied Economic Research Studies, Faculty of Economic and Business Sciences, Universidad de Oriente, Cuba.

Stays of CIESOL researchers in other centres::

- Elizabeth Gualda Alonso. Pre-doctoral stay in Institut National of Recherche in Informatique et en Automatique (INRIA), Centre at Université Côte d'Azur (Sophia Antipolis, Niza, Francia), under the supervision of Dr. Olivier Bernard, from 18 September to 18 December.
- Paula Soriano Molina. Postdoctoral stay at the Environmental Sanitary Engineering Laboratory of the University of Salerno (Italy), under the supervision of Professor Luigi Rizzo, from 18 September to 18 December.

Students in curricular practices:

- Elena Olivares Ligero (02/11/2022 – 17/01/2023). Master's Degree in Chemical Engineering.
- Daniel Rodríguez García (02/11/2022 – 16/01/2023). Master's Degree in Chemical Engineering.
- Luis Francisco Simón Salvador (7/11/2022- 20/1/2023). Degree in Chemical Engineering.
- Paola Vico Aguilera (21/12/2022-10/02/2023). Degree in Chemical.
- Ana Isabel Segovia Morales (14/11/2022-24/02/2023). Degree in Chemical Engineering.
- Joel Gegenheimer (04/09/2023 – 22/12/2023). Master's Degree in Chemical Engineering (Erasmus).

3.3.7 Summary tables of scientific production

The scientific production of the functional unit during 2023 is summarised in the following tables containing the number of indexed articles, participation and contributions to congresses, organisation of congresses,

book chapters, as well as theses defended and in progress. The complete production can be consulted in the corresponding Annex at the end of this report.

Number of papers	Number of papers in each queartile				Number of papers with international collaborations
	Q_1	Q_2	Q_3	Q_4	
16	12	4	-	-	3

Congresses attended	14
Contributions to congresses	20
Oral	13
Posters	7
Congress organization	-
Book Chapters	-
Doctoral theses defended	1
Doctoral theses in progress	8

3.3.8 Members of the Research Group

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José Luis García Sánchez

Professor
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José Luis Casas López

Full Professor UAL
UAL

Paula Soriano Molina

PhD Research
UAL

María Guadalupe Pinna Hernández

PhD Research
UAL

Leila Samira Nahim Granados

PhD Research
CIEMAT-PSA/UAL

Guillermo Sánchez Cabrera

Technician contract
UAL

María Jesús Abeledo Lameiro

Doctor contract
CIEMAT-PSA

Elisabeth Gualda Alonso

PhD Student
UAL

Solaima Belachqer El Attar

PhD Student
UAL

Daniel Rodríguez García

PhD Student
UAL

Nerea López Serrano

PhD Student
UAL

3.3.9 Proyects in force during 2023

	Started in 2023	Started before 2023
European projects		4
National projects	1	4
Regional projects		2

3.3.9.1 Projects under implementation started in 2023

3.3.9.1.1 Advanced tertiary treatments based on combined reduction/oxidation processes and novel photocatalytic materials applied to the simultaneous disinfection and removal of persistent and mobile compounds in urban wastewater (ANDROMEDA)

Participants:

"Environmental Analysis" functional unit
"Water Regeneration" functional unit

Contacts:

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J.A. Sánchez Pérez (jsanchez@ual.es)
I. Polo (inmaculada.polo@psa.es)
I. Oller (isabel.oller@psa.es)

Funds:

Ministry of Science and Innovation. Knowledge Generation Projects 2022.

Time Period:

01/09/2023- 31/08/2026

Current Situation:

In progress

Summary:

The ANDROMEDA project is focused on the removal of the so-called persistent and mobile organic chemicals (PMOCs) in reclaimed water with special emphasis on PFAS per- and polyfluoroalkyl substances), with well-documented hazardous effects on environment and human health. The discharge of PFAS into the aquatic environment is a threat to the quality of our water resources. They are highly polar (mobile in water) and can pass through wastewater treatment plants, subsurface environments, and also drinking water treatment processes. Therefore, its elimination has been in the spotlight of the European Commission, which proposes its inclusion in updated lists of water pollutants to be more strictly controlled in surface waters and groundwater. The main objectives of the project are:

1) Development of target, suspect, and non-target analytical methodologies to identify PFAS and other relevant PMOCs in UWWTP effluents; to evaluate the PMOC removal efficiency of the proposed treatments; to identify the main transformation products generated; and to provide estimations about environmental ecotoxicity and risk to human health of the identified compounds.

2) Assessment of novel advanced processes based on the best performing and most promising oxidative/reductive photocatalytic materials developed in ANDROMEDA for the simultaneous disinfection of UWWTP effluents and decontamination at pilot plant scale via the design, construction and testing solar/LED reactors. The ANDROMEDA project will also include the comparative assessment with ozonation (as conventional and widely employed tertiary treatment) and the catalytic and solar photocatalytic ozonation (as novel ozone based AOP).

3) Propose the most efficient treatment strategy for UWW reclamation and reuse based on the novel treatments developed and tested at pilot scale in the project.

3.2.9.2 Projects under implementation started before 2023

3.3.9.2.1 Pollutant Photo-NF remediation of Agro-Water (LIFE PureAgroH2O LIFE17 ENV/GR/000387)

Participants:

Functional Units "Environmental Analysis" and "Water Treatments"

Contacts:

A. Agüera (aaguera@ual.es)

Funds:

LIFE Environment and Resource Efficiency, EU. (LIFE17 ENV/GR/000387)

Time Period:

July 2018 – Dicember 2021. Extended Dicember of 2023.

Current Situation:

In Progress

Summary:

LIFE PureAgroH2O is a demonstration project to develop a photocatalytic nanofiltration reactor (PNFR) using a previously developed and patented water purification device based on the use of advanced

photocatalytic monoliths and visible light activated photocatalysts (VLA) stabilised with porous polymeric fibre, which has been designed to effectively remove organic substances from wastewater. The innovation of the reactor lies in the synergy between two of the most efficient processes for the removal of pesticides from agricultural wastewater: nanofiltration (NF) and photocatalysis. This synergy provides a significant intensification of the process which, in turn, allows for a reduction in reactor size (investment costs) and a decrease in operational cost (running costs). The consortium aims to guarantee the autonomous operation of the process by providing a stable efficiency that will not depend on seasonal conditions (solar irradiation) and the composition of the agricultural wastewater. Additionally, the possibility of achieving a 60% reduction in the required transmembrane pressure allows for a significant extension of the lifetime of the process (2 times) and a higher efficiency in the removal of organic and inorganic pollutants (>99.5%).

The main objective of the LIFE PureAgroH2O project is the pilot scale application of Photocatalytic Nanofiltration for the treatment of wastewater produced at the facilities of the Agricultural Cooperative of Zagora, Greece, and Cítricos del Andarax S.A., in Almeria, Spain. The LIFE PureAgroH2O project aims to demonstrate to the agro-industrial sector - responsible for a significant percentage of water consumption worldwide - the potential of using Photocatalytic Nanofiltration technology at a commercial level, and thus contribute to the solution of important environmental, energy and social problems.

3.3.9.2.2 Upgrading wastewater treatment plants by Low cost Innovative technologies for energy Self-Sufficiency and full recycling. (LIFE ULISES, LIFE18 ENV/ES/000165)

Participants:

"Water Regeneration" functional unit
"Environmental Analysis" functional unit
"Modeling and control" functional unit

Contacts:

J. L. Casas López (jlcasas@ual.es)

Funds:

LIFE Environment and Resource Efficiency, EU. (LIFE18 ENV/ES/000165)

Time Period:

July 2019 – July 2022.

Current Situation:

Finalized

Summary:

The LIFE ULISES project aims to improve conventional reclamation processes through a set of innovative technologies that allow the production of value-added resources from wastewater, such as vehicular biofuels, agricultural biofertilizers, and water suitable for reuse. The project seeks to reduce energy consumption and the carbon footprint associated with water treatment, increasing the efficiency of a conventional wastewater treatment plant (WWTP) by integrating different technologies in each of the main lines (water, gas, and mud).

During the project, the following low-cost technologies will be implemented at the El Bobar WWTP (Almería):

- Biogas enrichment with the ABAD Bioenergy® system to produce a renewable biofuel for vehicles. (Aqualia, Energylab)
- PUSH anaerobic pretreatment combined with advanced aeration control to reduce energy consumption by half in the purification process. (Aqualia)
- Photo-Fenton solar disinfection treatment to produce regenerated water to reuse in irrigation. (Ciesol - UAL)
- Mud enzymatic hydrolysis treatment to obtain a quality agricultural biofertilizer (CETIM, Aqualia)
- Struvite recovery system of concentrates by means of direct osmosis-based process (CETIM)

All these innovative technologies will reduce the electrical consumption of the El Bobar sewage plant and, therefore, minimise its environmental impact and carbon footprint.

3.3.9.2.3 Regeneración de agua residual urbana mediante Nuevos materiales y tecnologías solares avanzadas: evaluación de nuevos Indicadores de calidad del tratamiento (NAVIA)

Participantes:
Unidad funcional de "Regeneración de aguas"
Unidad funcional de "Análisis ambiental"
Contactos:
J. A. Sánchez (jsanchez@ual.es)
A. Agüera (aaguera@ual.es)
Fuente de financiación:
Agencia Estatal de Investigación, Programa Estatal de I+D+i Orientada a los Retos de la Sociedad, convocatoria 2019. Ministerio de Ciencia e Innovación.
Duración prevista:
Junio 2020 – mayo 2023. Prorrogado hasta 31 de diciembre de 2023.
Situación:
Finalizado
Resumen:

NAVIA es un proyecto coordinado entre la Universidad de Almería (coordinador), la Plataforma Solar de Almería y la Universidad Politécnica de Valencia. El estrés hídrico es un problema mundial creciente, agravado por el cambio climático. España está especialmente amenazada por la escasez de agua y se prevé un deterioro de la disponibilidad de agua dulce en un futuro próximo. Entre las soluciones contra el estrés hídrico, la regeneración de aguas residuales urbanas (UWW) puede desempeñar un papel clave como fuente de agua no convencional, destinada al mayor consumidor de agua en España, el riego agrícola. Con este fin, los nuevos tratamientos terciarios deben resolver los principales desafíos de la reutilización del agua: calidad aceptable, bajo coste y sostenibilidad. El objetivo principal del proyecto NAVIA es el desarrollo de nuevos métodos de regeneración de UWW mediante el desarrollo de nuevos fotocatalizadores y tecnologías basadas en procesos de oxidación avanzada (AOP) solares, operados en flujo continuo en reactores de bajo coste. Para garantizar la calidad y la seguridad del agua reutilizada, los objetivos de los procesos serán la eliminación simultánea de patógenos microbianos, como E. coli, coliformes totales, colífagos (somáticos y bacteriófagos específicos de RNA), bacterias resistentes a los antibióticos y sus genes (ARB y ARG), y la eliminación de microcontaminantes orgánicos (OMC). El objetivo final es cumplir con la legislación española (RD 1620/2007) y las futuras regulaciones, como la reciente propuesta del Parlamento Europeo de febrero de 2019 (EC COM 337 final, 2018/0169). Finalmente, agrupando todos los datos obtenidos durante el proyecto, así como de la literatura más relevante, se seleccionarán nuevos indicadores fisicoquímicos, energéticos y microbiológicos como un conjunto de parámetros clave para un monitoreo simple, rápido y confiable del rendimiento de tratamientos de regeneración, con la intención generar una herramienta para la toma de decisiones del usuario final, especialmente desarrollada para el riego agrícola.

Se explorarán tres áreas de investigación distintas, aunque intercaladas:

- El desarrollo de nuevos fotocatalizadores heterogéneos con alta eficiencia para la descontaminación y desinfección de UWW. Se llevará a cabo la síntesis y caracterización de estos fotocatalizadores, tanto orgánicos como basados en semiconductores. Se evaluará su eficiencia y estabilidad frente a la degradación simultánea de los OMC y la inactivación microbiana, con

especial atención a la realización de estudios mecanísticos como base del modelado cinético de los procesos.

- El desarrollo de nuevos AOP solares a escala de planta piloto como tratamientos terciarios de efluentes reales de EDAR. La desinfección microbiana y la eliminación de OMC se evaluarán mediante tratamientos como el proceso foto-Fenton solar a pH neutro, tanto en modo discontinuo como continuo. Se analizarán nuevas fuentes de hierro junto con la utilización de agentes quelantes, así como los fotocatalizadores heterogéneos más eficientes obtenidos en (i). También se evaluará la irradiación solar con dosis bajas de oxidantes (PDS/PMS, H_2O_2 y HClO/ClO-) para la desinfección simultánea y la eliminación de la OMC.
- El desarrollo de soluciones eficaces y eficientes basadas en energía solar en operación de flujo continuo: se investigarán los efectos del tiempo de residencia hidráulico (30-60 min), y profundidad del líquido (5-10 cm) en la eliminación de los contaminantes objetivo (bacterias, ARB y ARG, colífagos, OMC), en los procesos desarrollados en i) y ii).

3.3.9.2.4 Innovative cost-effective multibarrier treatments for reusing water for agricultural irrigation (LIFE PHOENIX LIFE19 ENV/ES/000278)

Participants:

Functional Unit "Water Treatments"
Functional Unit "Environmental Analysis"
Functional Unit "Modeling and Control"

Contacts:

J. L. Casas (jlcasas@ual.es)

Funds:

LIFE Environment and Resource Efficiency, EU. LIFE19 ENV/ES/000278

Time Period:

01 September 2020 – 29 February 2024.

Current Situation:

In Progress

Summary:

The Life Phoenix project arises from the need to update wastewater treatment and reclamation systems due to the recent approval of the new Regulation (EU) 2020/741 of the European Parliament of 25 May 2020 on minimum requirements for water reuse. The project has a budget of more than 3 million euros. The international consortium, led by Aqualia FCC, is made up of 8 entities and includes international partners such as "Águas de Portugal" and the Dutch company MicroLAN; national partners such as CETIM and Newland EnTech; and Spanish public entities such as the University of Almeria, through the "Centro de Investigación de Energía Solar" (CIESOL) of Provincial Council and the "Confederación Hidrográfica del Guadalquivir" (CHG).

The Life PHOENIX project represents a clear case of technological adaptation to legislative requirements, and more specifically of existing purification and regeneration systems to the new Regulation (EU) 2020/741 of the European Parliament on minimum requirements for water reuse. From the point of view of the technology provided by the University of Almeria through CIESOL, Life Phoenix represents the leap in scale that the technology based on the photo-Fenton process operated in continuous mode in low-cost raceway type reactors needs in order to be able to study its definitive commercial implementation. Life Phoenix also represents the opportunity to take UV LED photo-Fenton technology from the laboratory to the pilot scale. The development of photo-Fenton technology for tertiary treatment of treated water may provide a solution for many sites where solar resources are not a constraint.

The University of Almeria, through the Solar Energy Research Centre CIESOL, is participating in the Life Phoenix project, the main objective of which is the regeneration of treated water by applying the photo Fenton process in continuous mode both in low-cost raceway reactors and in intensive reactors illuminated with UV LED technology. In order to energetically evaluate the different options, it is foreseen that all systems will be equipped with a constant supply of photovoltaic electrical energy. The participation of members of the Environmental Analysis group allows us to count on their extensive experience in the monitoring of emerging pollutants and their transformation products, which is why CIESOL assumes part of the analytical burden of the project.

The objectives and challenges faced by Life Phoenix are:

- To develop innovative urban wastewater reclamation solutions for small, medium and large wastewater treatment plants, adjusting the solutions to each specific case, depending on the size of the population, water quality and economic capacity. Tailor-made solutions will be developed for each population size, according to their needs, in order to achieve total sustainability, which translates into technical, economic and environmental viability.
- Quantify and eliminate emerging pollutants through advanced oxidation processes.
- Quantify and eliminate microplastics through advanced filtration processes.
- Design a transportable demonstration plant with more than 12 different technologies based on a flexible multi-barrier concept. Plug & play concept.
- Optimisation of irrigation through intelligent management.
- Diagnose the existing tertiary systems in the province of Almeria for their optimisation in order to meet the new quality requirements for agricultural use, feasibility of upgrading existing plants to meet the new requirements.
- Finally, to develop a diagnostic tool that will allow the selection of the best combination of technologies for each case, also mapping the tertiary treatments of existing wastewater treatment plants both nationally and internationally.

3.3.9.2.5 Demonstration of continuous solar photo-Fenton reactors for the regeneration of secondary WWTP effluents (ANUKIS)

Participants:

Functional Unit "Water Treatments"
Functional Unit "Environmental Analysis"

Contacts:

J. A. Sánchez (jsanchez@ual.es)
A. Agüera (aaguera@ual.es)

Funds:

Agencia Estatal de Investigación, Programa Estatal de I+D+i Orientada a los Retos de la Sociedad, convocatoria Pruebas de concepto 2021. Ministry of Science and Innovation.

Time Period:

Dicember 2021 – November 2023.

Current Situation:

In Progress

Summary:

Water scarcity is a growing problem in Spain, aggravated by the impacts of climate change, and Almeria is particularly threatened by water stress. Among the solutions to this problem, urban wastewater reclamation can play a key role as a source of non-conventional water for agricultural irrigation. New advances in treatments based on solar radiation are promoting their application for wastewater reclamation. Among them, the solar photo-Fenton process has demonstrated its effectiveness for wastewater disinfection and

micropollutant removal, due to the large amount of hydroxyl radicals (HO•) generated through the catalytic cycling of iron ions (Fe^{2+} y Fe^{3+}) activated by UV-vis radiation and their reaction with hydrogen peroxide. It is considered as a treatment with a lot of potential due to the abundance of iron in nature and its low toxicity, and that H_2O_2 is easy to handle and environmentally safe. As the fundamentals of the photo-Fenton process have been extensively studied in previous projects, the ANUKIS project addresses the need for new engineering developments in continuous flow photoreactors for urban wastewater disinfection and micropollutant removal, a pending subject for technology transfer to the water industry.
A demonstration plant will be built and will operate at the WWTP in Uleila del Campo, Almeria, a small rural town (750 inhabitants), which is operated by the company "Calares Obras Servicios y Medioambiente S.L.", which supports the project and is very interested in exploiting the results.
As for the socio-economic impact of the ANUKIS project, the WWTP currently discharges into the public water domain and tertiary treatment would allow the reuse of this water to irrigate olive groves or improve the recharge of the overexploited aquifer. Moreover, the replicability of the results in other water-stressed populations would promote reuse for irrigation, improve the benefits of agriculture and create new jobs by fixing the population in rural areas. In terms of technological maturity level, the proposal will start at TRL 5 and is expected to reach TRL 8. Thus, the ANUKIS project will demonstrate a new solar-based solution for the sustainable and safe production of reclaimed water for agricultural irrigation.
The general objectives of the ANUKIS project are the construction of a prototype, on a demonstration scale, of a continuous reactor for solar photo-Fenton to regenerate urban wastewater, as well as the protection of the knowledge acquired, in order to allow its commercial exploitation. The photoreactor will be a low-cost raceway pond reactor (RPR) with high treatment capacities (around 400 m^3/m^2 per day). To this end, the following specific objectives will be addressed:

- Analysis of the technical and socio-economic feasibility of wastewater reclamation using the solar photo-Fenton process.
- Construction and operation of a demonstration-scale RPR prototype as tertiary treatment in a WWTP located in a rural area.
- Establishment of the knowledge protection procedure.
- Establishment of a business plan to transfer the technology to the water industry or create a spin-off.

3.3.9.2.6 Water regeneration by concentrated solar power (RAYO)

Participants:

Functional Unit "Water Treatments"
Functional Unit "Desalination and Phostosynthesis"

Contacts:

J. L. Casas López (jlcasas@ual.es)

Funds:

Consejería de Conocimiento, Investigación y Universidad. Secretaría General de Universidades, Investigación y Tecnología. Junta de Andalucía. Convocatoria de subvenciones a «proyectos de I+D+i» universidades y entidades públicas de investigación. Modalidad RETOS.

Time Period:

05/10/2021-31/12/2022. Extended of Dicember 2023.

Current Situation:

In Progress

Summary:

On 25 May 2020, Regulation (EU) 2020/741 of the European Parliament on minimum requirements for water reuse was published, applicable from June 2023. This regulation aims to promote the reclamation of wastewater in Europe, mainly for agricultural irrigation, which is particularly important in Almeria, with a high

water deficit and an economy linked to intensive agriculture. In addition, it should promote the development of sustainable technologies that meet these requirements in an environmentally safe way. This proposal represents a paradigm shift in water disinfection using solar energy, such as the use of concentrated solar radiation. To date, research in this field has been carried out on static collection systems without active tracking of the solar position. On the one hand, in PET bottles for disinfection of water for human consumption in areas without direct access to drinking water; on the other hand, in tubular photoreactors with compound parabolic solar collectors (CPC), or open channel reactors (raceway pond reactor, RPR) using the photo-Fenton process that uses iron and hydrogen peroxide together with solar radiation. In this proposal, wastewater will be disinfected, for the first time, with concentrated solar energy, in tubular reactors located in the focal area of low-cost parabolic trough collectors with concentration factors between 3 and 5. This will operate at temperatures between 60-70C and UV irradiance up to 150W/m^2, accelerating the inactivation of micro-organisms and the degradation of emerging pollutants. In addition, special attention will be paid to the economics of the process, the impact of regeneration and the economic boost to agriculture focused on the use of renewable resources. This two-year project will lay the scientific and economic foundations for a new clean technology for the regeneration of agricultural irrigation water.

Objectives:

In this project, the disinfection of secondary WWTP effluents by means of concentrated solar radiation in photoreactors operated in continuous mode is being considered for the first time. The general objectives of the project, taking into account the available funding and the two-year duration, can be summarised as follows:

- Design and build a prototype solar photoreactor with concentration factors between 3 and 5, which can be operated in continuous flow.
- To study concentrated solar disinfection from a phenomenological and kinetic point of view. Determine the safe UV dose for all the pathogens contemplated in the new European regulation: E. coli, coliphages and spores of sulphate-reducing bacteria.
- To optimise the continuous operating variables of the photoreactor for the regeneration of wastewater on a pilot scale.
- To study the economic viability of the proposed new process and to investigate the potential of new reclamation technologies in the water market, their impact on the economic development of the region, with special reference to agriculture and tourism.

3.3.9.2.7 Photo-irradiation and Adsorption based Novel Innovations for Water-treatment (PANI WATER)

Participants:

Functional Unit "Water Treatments"

Functional Unit "Environmental Analysis"

Contacts:

A. Agüera (aaguera@ual.es)

I. Oller (isabel.oller@psa.es)

Frund:

Programme Horizonte 2020, EU (Amendment Reference No AMD-820718-11)

Time Period:

01/02/2019-31/01/2023

Current Situation:

In Progress (1° Annuality)

Summary:

Wastewater and potable water in peri-urban and rural areas of India are contaminated by contaminants of emerging concerns (CECs), such as pesticides, pharmaceutical and personal care materials or antibiotics.

The EU-funded PANI WATER project aims to scale up and confirm six prototypes that remove CECs and other pollutants from wastewater. The project will be implemented on site and in liaison with local stakeholders. Indeed, PANI WATER places particular emphasis on understanding the social context in which the technologies will potentially be deployed and will review potential health and social impacts to provide quality analysis. It will also support wastewater treatment for safe water reuse in agriculture, related industries and public water structures. CIESOL's activity focuses on the development, optimisation and analytical assessment of advanced wastewater treatment processes applied to complex effluents in order to achieve their regeneration and enable their possible reuse.

3.3.9.2.8 Photoreactor for disinfection and removal of contaminants of emerging concern in treated water (AT21)

Participante:

Functional Unit "Water Treatments"
Functional Unit "Environmental Analysis"

Contacts:

J.A. Sánchez Pérez (jsanchez@ual.es)

Funds:

Consejería de Universidad, Investigación e Innovación. Junta de Andalucía. Convocatoria 2021 de ayudas a actividades de transferencia de conocimiento entre los agentes del sistema andaluz del conocimiento y el tejido productivo

Time Period:

01/09/2021-31/05/2023

Current Situation:

In Progress

Summary:

Taking into account that Regulation (EU) 2020/741 will apply from June 2023, water reclamation facilities, in service for years, must improve their treatment systems or incorporate new treatments to meet the new quality requirements. In this sense, the photo-Fenton process stands out as a highly effective tertiary treatment both in the elimination of micropollutants and in the inactivation of microorganisms. Regarding the source of UV radiation, there is a growing interest in the use of light emitting diodes (LED) as an alternative to mercury lamps. This system has significant advantages such as low energy consumption, long lifetime, high spectral purity, uniform illumination, energy efficiency and flexible configuration.

The bacterial inactivation efficiency of LED systems depends on the wavelength and spectral distribution of the light source. Today, UVC treatment is widely applied, mainly in drinking water disinfection devices and small domestic systems, as UVC irradiation effectively eliminates fungi, yeasts, viruses and bacteria, without chemical residues, corrosion or harmful additives. UVC-LED technology is on the rise, and 254 nm LEDs are now available, although their cost is not yet competitive. Taking into account the promising results obtained at laboratory scale by the research team, pioneer in the UVC-LED-278/Fe^{3+}–NTA/H_2O, system, this project addresses for the first time the design, operation and evaluation of a prototype photoreactor for photo-Fenton at neutral pH with Fe^{3+}–NTA under UVC-LED radiation at 278 nm for the tertiary treatment of wastewater complying with the quality requirements established in Regulation (EU) 2020/741.

The general objectives of the proposal are the construction of a demonstration-scale prototype of a continuous UVC-LED photo-Fenton reactor for the regeneration of secondary WWTP effluents and the protection of technological know-how for its commercial exploitation. To this end, the following specific objectives will be addressed:

- Analysis of the socio-economic feasibility of wastewater reclamation using the UVC-LED photo-Fenton process.

- Design, construction and operation of a prototype UVC-LED photo-Fenton reactor on a demonstration scale as a tertiary treatment.
- Establishment of the technological knowledge protection procedure.
- Establishment of a business plan to transfer the technology to the water industry or create a spin-off.

3.3.9.2.9 Urban wastewater regeneration through the integration of solar technologies based on microalgae (secondary treatment) and photo-Fenton (tertiary treatment) (INTEGRASOL)

Participants:

Functional Unit "Water Treatments"
Functional Unit "Environmental Analysis"
Functional Unit "Modeling and Control"
Functional Unit "Desalination and Phostosynthesis"

Contacts:

J.L. Casas López (jlcasas@ual.es)

Funds:

Ministry of Science and Innovation. Green Transition and Digital Transition Projects 2021

Tiem Period:

01/12/2022-30/11/2024

Current Situation:

In Progress

Summary:

The new European Regulation on minimum requirements for water reuse (WWR-EU) establishes four quality classes of reclaimed water for agricultural irrigation and will enter into force in June 2023. Existing reclamation facilities, which have been in operation for years, will have to upgrade their treatment systems or incorporate new treatments to meet the new quality requirements. In addition to the regulated parameters, water reuse must consider organic micropollutants, anthropogenic, antibiotic resistant bacteria and antibiotic resistance genes, collectively designated as Pollutants of Emerging Concern. Their potential effects can be very serious: endocrine disruption, mutagenicity, antibiotic resistance, toxicity. Consequently, many researchers have emphasised the need to develop new tertiary treatments, alternatives to classical ones. Recently, treatments based on solar energy have been shown as sustainable and environmentally friendly strategies for the regeneration, disinfection and decontamination of wastewater, promoting the application of solar technologies for the removal of microorganisms and organic micropollutants. The solar photo-Fenton process is considered as an attractive oxidation system for wastewater treatment, due to the abundance of iron in nature and the inherent low toxicity, as well as the fact that H_2O_2 is easy to handle and environmentally safe. Its efficiency is based on the large amount of hydroxyl radicals (HO) generated by the catalytic cycling of iron ions (Fe^{2+} y Fe^{3+}) combined with hydrogen peroxide and UV-vis radiation. However, there are several compounds commonly present in secondary WWTP effluents that reduce the efficiency of the photo Fenton reaction, such as ammonium, a consumer of hydrogen peroxide, phosphates, a consumer of dissolved iron by precipitation and carbonates that act as HO sinks. In this sense, secondary wastewater treatment systems based on microalgae have been studied with great interest due to their known capacity to remove nutrients, C, N and P. During the last few years there has been a growing interest in this technology, specifically in the potential valorisation of the biomass produced for lower value applications such as energy, environment or agriculture, following the principles of the circular economy. Against this background, the main objective of the INTEGRASOL project is the development and evaluation of a combined wastewater reclamation process based on secondary treatment using microalgae and the solar photo-Fenton process as a tertiary treatment operated in continuous flow mode, in order to obtain reusable water and microalgae biomass. To this end, the project will focus on adapting the operating conditions of the secondary treatment to obtain an effluent

with the best possible characteristics to be treated by solar photo-Fenton in a raceway type reactor operated in continuous flow. The INTEGRASOL project represents the combination of the knowledge developed over the last 20 years by the research team in the fields of wastewater treatment with microalgae and water reclamation by solar photo-Fenton.

The general objective of the proposal is the evaluation of the combination of microalgae-based wastewater treatment with effluent regeneration by solar photo-Fenton in raceway pond reactors operated in continuous flow. For this purpose, the following specific objectives will be addressed:

- Optimise the operating conditions of the secondary treatment with microalgae to minimise the concentration of ammonium, phosphate and carbonate in the effluent. To this end, the effect of hydraulic residence time, cell retention time, biomass concentration and liquid depth on the removal of nutrients C, N and P and pollutants (bacteria, coliphages, organic micropollutants) will be studied.
- To evaluate the influence of the concentration of carbonates, ammonium and phosphates in the solar photo-Fenton reaction to establish their limiting concentrations for the combination of both processes, microalgae-based wastewater treatment and secondary effluent regeneration by solar photo-Fenton.
- To optimise the operating conditions of the tertiary treatment based on solar photo-Fenton in order to maximise the treatment capacity by minimising the consumption of reagents.
- To optimise the integration of the secondary treatment based on microalgae with the tertiary treatment based on solar photo-Fenton in order to maximise the treatment capacity and the productivity of the microalgae.
- To evaluate the presence of micropollutants in the different stages of the integrated process in both water and microalgal biomass, in order to determine the predominant removal mechanism.
- Evaluar desde un punto de vista tecnoeconómico y sustentable el proceso integrado y su posible implementación a escala real.
- Evaluate from a techno-economic and sustainable point of view the integrated process and its possible full-scale implementation.

3.3.9.10 Towards improving the Resilience of the Urban Water Cycle through the implementation of digital tools based on "Machine Learning" models and Water Regeneration Technologies (DIGI4WATER).

Participants:

"Environmental Analysis" functional unit
"Water Regeneration" functional unit
"Modelling and Control" functional unit

Contacts:

I. Oller (isabel.oller@psa.es)
I. Polo (inmaculada.polo@psa.es)

Funds:

Ministry of Science and Innovation. Call 2021 - 'Green Transition and Digital Transition Projects' (TED2021-129969B-C31)

Time Period:

01/12/2022-30/11/2024

Current Situation:

In progress

Summary:

The main objective of DIGIT4WATER is to create the bases for the implementation of a decision and technology design support tool based on machine learning models. Such models will be fed by an open database on physicochemical characteristics of raw MWWTP influent and effluent, as well as advanced regeneration tertiary treatments tested at laboratory and pilot plant scale for compliance with the new

European regulation (EU 2020/741) on water reuse. Special attention will be paid to the elimination of ARB & ARGs as well as the DBPs prevention commonly produced in conventional disinfection processes. A Decision Support Tool (DST) and an Early-Warning System (EWS) will be also designed based on the models developed. The main objective of the DST is to design advanced tertiary treatment techniques for water treatment facilities, selecting the most adequate parameters. The EWS is intended to create alarms when the quality of reclaimed water is below the minimum legal and sanitary requirements depending on the final reuse purposes.

3.3.10 Training and Dissemination Activities

As in previous years, the functional unit participated in the European Researchers' Night 2023, an activity carried out within the framework of the European science dissemination project OpenResearchers approved by the European Commission in the Marie Sklodowska-Curie call for actions.

With the aim of showing the work of female scientists and encouraging STEM vocations in girls, helping to close the gender gap in science, the functional unit has participated in outreach talks in secondary schools organised by the University of Almeria, through igUALdad (Rector's Delegation for Gender Equality).

Organisation of the Summer Course 'The path towards sustainability in the water sector: intelligent management, energy efficiency'. Almeria, from 11 to 13 July 2023. The course will deal with a very new and topical aspect, such as digitalisation and energy efficiency, which are key to promoting the sustainability of the integral water cycle. To this end, it will feature speakers of the highest quality from industry, academia and public management, with recognised national and international prestige. Debate will be encouraged with round tables to encourage audience participation and visits will be made to industrial and R&D&I facilities. The course boosts the internationalisation of the UAL, since its subject matter is of interest in regions of high water stress, such as the Mediterranean arc, and is clearly committed to sustainability and social responsibility when it comes to making use of a resource that is as scarce as it is essential for life. It is aimed at the general public, as well as university students, scientists, technicians and professionals related to the world of water.

Participation in the Science Week organised by the University of Almeria, from 13 to 17 November 2023, with the aim of bringing scientific and technological knowledge to students in the 4th year of ESO, Baccalaureate and Vocational Training in the province. We have also collaborated in the International Day of Girls and Women in Science (11 February 2023), carrying out educational activities at the Francisco Montoy Secondary School in El Ejido, Almeria.

Course Organisation

- Short-term trainings for technical staff and scientists (SFERA-III), Plataforma Solar de Almería, Almería, España, 25-27 Abril, 2023.
- Innovación y retos en la Depuración y Regeneración de Aguas Residuales en la Unión Europea" en el marco de las XV JORNADAS SOBRE LA UNIÓN EUROPEA. Almería, del 23 al 27 de octubre de 2023.

Other training and outreach activities

- Theoretical training on solar Photocatalytic Oxidation: Water disinfection. M.I. Polo-López .Workshop AQUACYCLE. Cross-border Know-how transfer. Training of trainers, Murcia, España, February 22-23, 2023. (Clase oral)

- Introduction to water pathogens and disinfection. M.I. Polo-López. Short-term trainings for technical staff and scientists (SFERA-III), Almeria, España, April 25-27, 2023. (Clase oral)
- Microbiological water quality monitoring by advanced methods. Toxicity and biodegradability monitoring. M.I. Polo-López, I. Oller. Short-term trainings for technical staff and scientists (SFERA-III), Almeria, España, April 25-27, 2023. (Clase oral)
- Proyecto AQUACYCLE. Tratamiento Sostenible y Reutilización de las Aguas Residuales en la Región del Mediterráneo. M.I. Polo-López. Jornada Reutilización del agua en agricultura: una visión desde andalucía experiencias compartidas, retos y recomendaciones desde el sector, Sevilla, España, 29 de junio de 2023. (Oral invitada)
- WebGIS como herramienta de apoyo a la decisión para el desarrollo de planes de acción para el reúso de efluentes tratados. M. I. Polo, S. Nahim. Tercera serie de Talleres para "stakeholders" proyecto AQUACYCLE. Planes de acción y de financiación en regeneración de agua residual tratada mediante un sistema de tratamiento Eco-innovador. (CIEMAT-WEBEX online), 6 de junio de 2023. (Clase oral)
- Desinfección de agua mediante tratamientos solares. S. Nahim Granados. Curso en Facultad de Ciencias Básicas de la Universidad de la Amazonia (8 h). Florencia, Colombia, 26 de octubre, 2023. (Clase oral)
- Water/wastewater disinfection by AOPs. S. Nahim Granados. 1st Latin America School on Environmental Applications of Advanced Oxidation Processes. Cali, Colombia, 30-31 October, 2023. (Clase oral)

3.3.11 Projects requested during 2023

- **New strategy to meet the challenges in wastewater reclamation: solar photo-Fenton combined with sodium hypochlorite in continuous flow (NEREIDAS).**

  Convocatoria 2022 - «Proyectos de Generación de Conocimiento». IP: Paula Soriano Molina.

3.3.12 Others

Final degree projects:

- Juan Manuel Hernandez Martínez (Degree in Industrial Chemical Engineering). Determination of haloacetic acid levels in wastewater treated by solar photo-Fenton with simultaneous addition of H2O2 and NaClO in raceway reactors.
- Hernandez Hoffman, Dario (Degree in Industrial Chemical Engineering). Design and optimisation of a microalgae drying process.

Master's final projects:

- Daniel Rodríguez García (Master's Degree in Chemical Engineering). Application of a mechanistic model as a decision-making tool for the operating conditions of a solar photo-Fenton demonstration plant for the removal of micropollutants.
- Elena Olivares Ligero (Master's Degree in Chemical Engineering). Removal of micropollutants in a solar photo-Fenton demonstration plant. Comparison of two operating strategies.
- Antonio Rodríguez Fábregas (Master in Solar Energy). On-line monitoring of physico-chemical and microbiological parameters in WWTP: present and future perspectives for regeneration and reuse in agriculture.

Doctoral theses in progress:

- Eva Jambrina Hernández (Supervisors: Patricia Plaza, S. Nahim Granados)
- Elizabeth Gualda Alonso (Directors: José Luis Casas López y Paula Soriano Molina)

- Solaima Belachqer El Attar (Directors: José Antonio Sánchez Pérez y Paula Soriano Molina)
- Daniel Rodríguez García (Directors: José Luis Casas López y José Luis García Sánchez)
- Azahara Martínez García (Directors: Inmaculada Polo e Isabel Oller)
- Kelly Johana Castañeda Retavizca (Directors: Sixto Malato e Inmaculada Polo)
- Alba Hernández Zanoletty (Directors: Isabel Oller e Inmaculada Polo)
- Isabel Cristina Espinoza Pavón (Directors: Inmaculada Polo)

Awards obtained during 2023

- Samira Nahim Granados. Best Doctoral Thesis Award. Chair of Water in Agriculture, Irrigation and Agri-food. University of Almeria. Call for applications 2022. Awarded on 5 June 2023.
- Daniel Rodríguez García. Special Commemorative Prize for the International Year of Basic Sciences for Sustainable Development (UN) of the 20th Archimedes Award for Introduction to Scientific Research (National Research Award) (Call for Entries 2022) (Date of publication: 2 August 2023).
- Samira Nahim Granados. Selection and assistance in the delegation of the Ministry of Science and Innovation of the Government of Spain as Young Researchers for their visit to the Joint Research Centre of the European Commission (JRC) in ISPRA, Italy. 13-15 November, 2023.
- Alice Ferreria. Prize for the best oral communication, competing for the PhD in Biotechnology and Industrial Bioprocesses Applied to Agri-Food and Environment in the XII RESEARCH SYMPOSIUM, organised by the Faculty of Experimental Sciences and held at the University of Almeria on 15 November 2023.
- Daniel Rodríguez García. Extraordinary End-of-Studies Award (MASTER - University of Almeria) (Course 2022/2023) (Date of publication of final decision: 18 December 2023).
- Daniel Rodríguez García. Best TFM Award in the Chair of Water in Agriculture, Irrigation and Agri-Food of the University of Almeria (Call 2023).
- SAN ALBERTO RESEARCH AWARDS 2023 for the best research articles within Q1 published in 2022. 250,00€. Faculty of Experimental Sciences of the University of Almeria. The University of Almeria awarded the San Alberto 2023 Research Prize to the article published under the title 'Large-scale raceway pond reactor for CEC removal from municipal WWTP effluents by solar photo-Fenton".
- SAN ALBERTO RESEARCH AWARDS 2023 for the best research articles within Q1 published in 2022. 250,00€. Faculty of Experimental Sciences of the University of Almeria. The University of Almeria awarded the San Alberto 2023 Research Prize to the article published under the title 'Mechanistic modeling of solar photo-Fenton with Fe3+-NTA for microcontaminant removal".

3.4 ACTIVITIES OF MODELING AND AUTOMATIC CONTROL

3.4.1 Functional unit description

Researchers from the "Automatics, Robotics and Mechatronics" group (TEP197, arm.ual.es) of the University of Almeria and the Almeria Solar Platform belong to this functional unit. The TEP197 group has among its fields of work modeling, control and robotics in agriculture, the application of solar energy in the water-energy-food nexus, the modeling and control of solar thermal plants, control and optimization in biotechnology and bioengineering, as well as education in automation, mechanization and robotics in general. Within the CIESOL building, the group also has a line of action linked to the applications of control systems to thermal, visual and air quality comfort and energy efficiency in buildings. The collaborative activities between the group and the PSA have been developed uninterruptedly over the last 25 years, with the participation of UAL researchers in the development of some of the SCADA (*Supervisory Control And Data Acquisition*) systems of test plants located in the PSA facilities being noteworthy.
For more information, please visit: https://arm.ual.es/arm-group/about-us/

3.4.2 Main research lines

The main strategic lines of the group within the CIESOL Joint Centre are the following:

- Modeling, control and optimization of solar thermal plants.
- Modeling, control and robotics in agribusiness.
- Modeling, control and optimisation in the water-energy-food nexus.
- Energy efficiency and comfort control in buildings.
- Engineering education.
- Modeling and control of photobioreactors.
- Control and optimization in solar desalination.
- Smart energy grids and electric vehicles.
- Industrial monitoring and communications systems.
- Artificial intelligence in solar energy applications.
- Predictive, hierarchical and robust control techniques.
- State estimators.

More detailed information can be found at the following links:
https://arm.ual.es/arm-group/research-lines/
https://arm.ual.es/arm-group/facilities-and-infrastructures/

3.4.3 Main researchers

José Domingo Álvarez (ORCID 0000-0003-2791-8105, Scopus Author ID 16303147700)

José Domingo Álvarez is an Associate Professor at the University of Almeria, Spain. He obtained a degree in Computer Engineering from the University of Almeria in 2003. Subsequently, in 2008 he obtained a PhD in Computer Engineering from the same university. During his postdoctoral stage, he was hired for three years in charge of the singular-strategic project of Bioclimatic Architecture and Solar Cooling (PSE-ARFRISOL). He then spent two years at the University of Seville through a Juan de la Cierva postdoctoral fellowship (2011 call). Subsequently, he enjoyed a Ramón y Cajal postdoctoral fellowship (2013 call) at the University of

Almeria. His main lines of research are focused on predictive control, repetitive control and classic PID control with practical applications to solar-based plants and energy efficiency in buildings. As a result of his work on these issues, in the last ten years he has co-authored the book Comfort Control in Buildings (Springer, 2014). He is co-author of 50 scientific publications in journals with an impact index and more than 60 papers accepted at national and international H-index conferences: 24 (Google Scholar), 19 (Scopus), 17 (WOS). In addition, he has been co-director of 3 doctoral theses on these topics and has participated in several R+D+i projects within the national and international scope with public and private funding.

Currently, he is a member of the research group 'Automatics, Robotics and Mechatronics' at the University of Almeria (code TEP-197 of the Andalusian Research Plan, http://arm.ual.es), member of the Spanish Committee of Automation (CEA). He has been part of the organizing committee of the XXVII Conference on Automation in 2006, the II National Symposium on Horticultural Engineering in 2016, and the XVI CEA Symposium on Control Engineering in 2018. He is a reviewer for more than 20 important international journals (with more than 100 reviewed papers), ANEP and ANECA. He has been coordinator of the Master's Degree in Solar Energy at the UAL, and is currently the director of the Smart-Campus secretariat of the university. He is also a member of: i) the editorial board of the journal 'Mathematical Problems in Engineering' (1.305 JCR index), ii) the topic committee of the journal 'Energies' (3.004 JCR index), iii) and reviewer of the RP2 panel of the COST (European Cooperation in Science and Technology) actions.

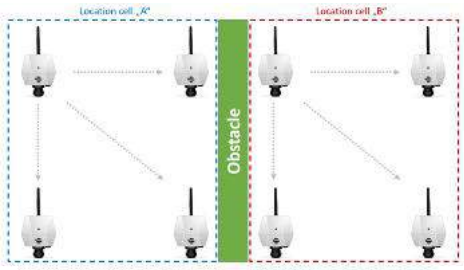
For more information, please visit: https://arm.ual.es/arm-group/people/jose-domingo-alvarez-hervas/

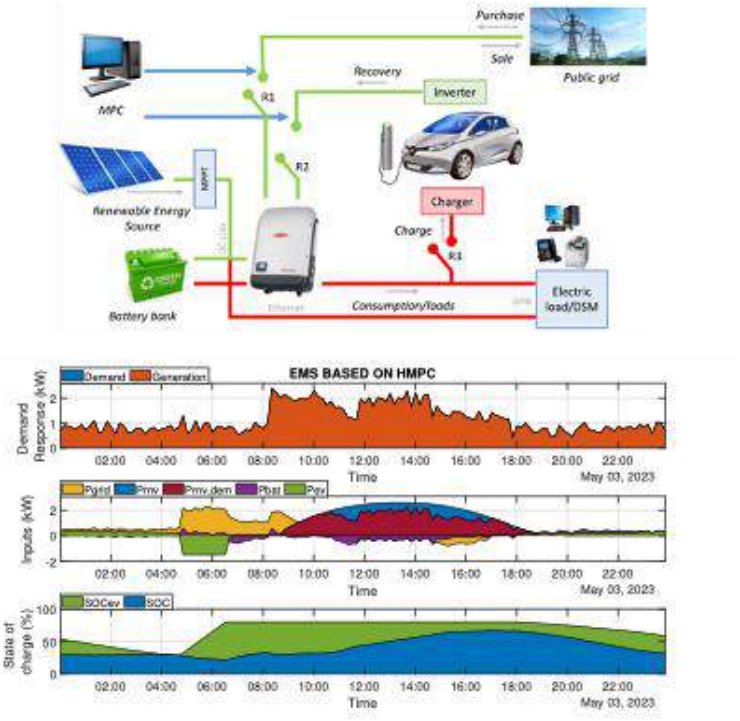
Lidia Roca Sobrino (ORCID 0000-0002-8724-5136, Scopus Author ID 23467603800)
She is a senior scientist in the Energy Department of CIEMA. She has a degree in Electronic Engineering from the Faculty of Sciences of the University of Granada (2004), a Master's degree in Solar Energy from the University of Almeria (2007) and a PhD from the University of Almeria (2009), receiving the extraordinary research award in the area of engineering. She is currently attached to the Solar Thermal Applications Unit at the Almeria Solar Platform, has 45 publications in scientific journals with an impact index, 46 contributions to international congresses and co-author of 3 books. His main lines of research are the modeling, control and optimization of systems powered by solar thermal energy, with more than 15 years of experience in this field and developing his activity through participation in 21 national and international R+D projects.
For more information, please visit: https://arm.ual.es/arm-group/people/lidia-roca-sobrino/

3.4.4 Summary of the functional unit's activities carried out in CIESOL during 2023

- Implementation of a geolocation system for the detection of people.
- Modeling and control of solar desalination plants.
- Standardized evaluation of desalination processes.
- Modeling and control of refrigeration systems for CSP plants.
- Design and evaluation of control strategies in solar fields of flat collectors.
- Design and testing of control strategies in solar ovens.
- Modeling and process control for wastewater treatment.

- Modelling and control of comfort in buildings.
- Modeling and control of energy microgrids.
- Agroconnect tests for the characterization of installations.
- Modelling and control of greenhouse crop growth.
- Optimal management of heterogeneous resources of the water-energy-carbon-food nexus in greenhouse crop production.
- Digitalization of greenhouse crop production processes.
- Robotization of tasks inside greenhouses.





Various examples of the activity of the modelling and control unit. Figure above: Optimal operation of a combined cooling system. Intermediate figure: geolocation system for the detection of people. Figure below: Modeling and control of energy microgrids.

3.4.5 Collaboration with other functional units of CIESOL during 2023

Activity	Organometallics and Photochemistry	Environmental Analysis	Water Regeneration	Modelling and Control	Solar Resources and Solar Cooling	Desalination and Photosynthe
Papers			2			8
Projects		2	1		1	4

In 2023, the Modelling and Control Unit has maintained collaborations with the following CIESOL Functional Units:

- Desalination and Photosynthesis: European projects (India H2O, REALM), national plan projects (HYCO2BIO, SOLHYCOOL), joint publications (desalination, photobioreactors, greenhouses, ...) Joint supervision of TFG, TFM and Doctoral Theses. Collaboration within the scope of the Sfera III project.
- Environmental Analysis: projects of the JA (MODITRAGUA), collaboration at the level of joint management of TFG and TFM. Collaboration within the scope of the Sfera III project. Planning of joint publications.
- Water Regeneration: collaboration at the level of joint management of TFG and TFM. Planning of joint publications. Collaboration within the scope of the Sfera III project.
- Solar Resources and Solar Cooling: National project TED call (NTech4Build). Planning of joint publications.

3.4.6 Human resources of the Research Group

Stays and visits at CIESOL: :

- María Alice Freitas Marquez. Universidad Federal de Bahía, Brasil (15/09/2023-14/04/2024).
- Igor Pararo. Universidad Federal de Bahía, Brasil (01/09/2020-31/08/2024).
- Hèlene Sadelli. Polytech Marseille (15/05/2023-06/08/2023).

Stays of CIESOL researchers in other centres:

- Juan Miguel Serrano Rodríguez. The Cyprus Institute, Chipre (15/05/2023-26/05/2023).
- Pablo Otálora Berenguel. Norwegian University of Science and Technology (NTNU), Noruega (12/08/2023-13/11/2023).
- Juan Diego Gil Vergel. Universitè Mohammed V Rabat, Rabat, Marruecos (29/05/2023-02/06/2023).

Students in curricular practices:

- Juan Sánchez Estrella. Degree in Industrial Electronics and Automation Engineering (01/02/2023-30/03/2023).
- Alberto Martínez Segura. Degree in Computer Engineering (08/11/2022-23/01/2023).
- Álvaro Martínez Fernández. Degree in Industrial Electronics and Automation Engineering (07/11/2022-27/02/2023)
- Antonio Martínez Roa. Degree in Industrial Electronics and Automation Engineering (13/02/2023-05/05/2023).
- Atanasio Jesús Alarcón Redondo. Degree in Industrial Electronics and Automation Engineering (13/02/2023-05/05/2023).
- Carmen Sánchez Salinas. Degree in Industrial Electronics and Automation Engineering (13/02/2023-05/05/2023).
- Daniel Pérez Sánchez. Degree in Industrial Electronics and Automation Engineering (05/02/2023-25/04/2023).
- Javier Cantón Ortiz. Degree in Mathematics (24/04/2023-08/06/2023).
- Laaroussi Mohamed Salec. Master in Solar Energy (01/02/2023-31/07/2023)
- Pedro Antonio Sánchez Sánchez. Degree in Industrial Electronics and Automation Engineering (13/02/2023-05/05/2023).
- Rolando Lazaro Cabrera Dalés. Master in Solar Energy (23/05/2023-22/12/2023)

3.4.7 Summary tables of scientific production

The scientific production of the functional unit during 2023 is summarised in the following tables containing the number of indexed articles, participation and contributions to congresses, organisation of congresses, book chapters, as well as theses defended and in progress. The complete production can be consulted in the corresponding Annex at the end of this report.

Number of papers	Number of papers in each Quartile				Number of papers with international collaborations
	Q_1	Q_2	Q_3	Q_4	
30	15	9	3	3	17

Congress attended	21
Contributions to congress	32
Oral	24
Poster	7
Organization of congress	1
Book chapters	3
PhD theses	3
PhD theses in progress	14

3.4.8 Members of the Research Group

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Professor of Systems Engineering and Automatic Control
UAL

Dr. Francisco Rodríguez Díaz

Professor of Systems Engineering and Automatic Control
UAL

Dr. José Luis Guzmán Sánchez

Professor of Systems Engineering and Automatic Control
UAL

Dr. Javier Bonilla Cruz

Researcher
CIEMAT-PSA

Dr. Manuel Pérez García

Assoc. Professor of Applied Physics
UAL

Dr. Antonio Giménez Fernández

Professor of Mechanical Engineering
UAL

Dr. Julián García Donaire

Assoc. Professor of Computer Architecture and Technology
UAL

Dr. José Carlos Moreno Úbeda

Assoc. Professor of Computer Architecture and Technology
UAL

Dr. José Luis Blanco Claraco

Professor of Mechanical Engineering
UAL

Dr. Jorge Antonio Sánchez Molina

Assoc. Professor of Systems Engineering and Automatic Control
UAL

Dra. María del Mar Castilla Nieto

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Dr. José Luis Torres Moreno

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Dr. Juan Diego Gil Vergel

Lecturer
UAL

Dr. Jerónimo Ramos Teodoro

Posdoctoral Researcher

Dr. Enrique Rodríguez Miranda

Posdoctoral Researcher

Dr. Manuel Muñoz Rodríguez

Hired Researcher
IoF2020

Dra. Ángeles Hoyo Sánchez

Hired Researcher
HYCO2BIO

Dr. Francisco García Mañas

Predoctoral scholarship
CIEMAT-PSA

Pablo Otálora Berenguel

Contratado Ministerio de Ciencia, Innovación y Universidades
FPU

Juan Miguel Serrano Rodríguez

Contratado predoctoral
CIEMAT

Marta Leal Rueda

Predoctoral scholarship
COMMIT4.0EB

3.4.9 Proyects in force during 2023

	Started in 2023	Started before 2023
European projects		3
National projects		6
Regional projects	3	1

3.4.9.1 Projects under implementation started in 2023

3.4.9.1.1 Optimisation of crop growth in Agrikubic containers based on economic and resource efficiency criteria (Optikubic).

Participants:

Research group 'Automatics, Robotics and Mechatronics'. University of Almeria (TEP 197)
CIESOL (Spain), joint UAL-CIEMAT centre.
Agrikubic Systems

Contacts:

Francisco Rodríguez Díaz (frrodrig@ual.es)

Source of funding:

UAI Transfiere

Duration:

April 2023 – March 2024

Status:

Under development

Summary:

In the current context of the need for food and the energy crisis, the control of the growth of intensive crops in controlled environments must take into account economic criteria that optimize their profit, understood as the income obtained from the sale of their production minus the costs of energy resources (electricity, heat and cold) and materials such as water and fertilizers. The Automatic, Robotics and Mechatronics Group (ARM-TEP197) has developed a technology that implements this approach to greenhouse crop control with a success that reaches an 18% increase in producer profits, in addition to reducing energy consumption, making the system more sustainable. On the other hand, the company Agrikubic Systems, S.L. has developed the Agrikubic container for intensive agriculture, fully automated, which is modular, flexible and transportable. The main objective of this proposal is the transfer of the technology developed by the ARM-TEP197 Group for the optimization of the growth of crops under greenhouses, to other models of intensive agriculture such as Agrikubic. This system will be incorporated as an element of the iVeg platform also developed by the research group, with intellectual property registration number 04/2022/956, so that Agrikubik's integration and interconnectivity properties are increased. With the incorporation of this technology, the aim is to improve the performance of this cultivation system, being able to achieve a new version of it. In addition, you will be able to offer a better service to your customers with automatic advice on climate management, estimated production and the required energy and water costs

3.4.9.1.2 Development and optimisation of comfort systems in bioclimatic buildings: CIESOL (CIECONFORT)

Participants:

CIESOL-Universidad de Almería
Grupo de Inv. "Automática, Robótica y Mecatrónica". Universidad de Almería (TEP 197)
Grupo de Inv. "Recursos Energéticos Solares, Climatología, Física De La Atmósfera". Universidad de Almería (TEP 165)
Sistemas de Calor

Contacts:

José Domingo Álvarez Hervás (jhervas@ual.es)
Joaquín Blas Alonso Montesinos (joaquin.alonso@ual.es)

Source of funding:

UAL Transfiere

Duration:

December 2023 – December 2025

Status:

Under development

Summary:

The Centre for Research in Solar Energy (CIESOL), is a research centre shared between the University of Almeria (UAL) and the Centre for Energy, Environmental and Technological Research – Plataforma Solar de Almería (CIEMAT-PSA), it is divided into six functional units and has infrastructures related to the use of solar energy that allow the development of solar energy. at the pilot plant level, the characterization, optimization and design of systems in different areas of solar energy use (oriented to the production environment), as well as the development of experiments in the following areas: operation and control of solar thermal plants, energy efficiency and use of solar energy in energy micro-grids through IoT technologies, Analysis and optimisation of natural and solar conditioning processes, improvement of comfort conditions in buildings, use of solar energy in desalination processes, water regeneration, biomass production through microalgae, energy generation (electricity and heat/cold processes) for use in agriculture and efficient energy management of electric vehicles. These scientific infrastructures, consolidated in recent years through the

centre's participation in national and international projects, require specialised maintenance due to the diversity and complexity of the elements that constitute them. Likewise, the carrying out of experiments in the aforementioned areas requires the assistance of the research staff by technical personnel with knowledge in solar energy, automation, industrial computing and control engineering, design of experiments, modelling, simulation and optimisation, as well as in the design of prototypes, so that, among other tasks, they can optimise the resources and capabilities offered by the centre. Exploit and expand monitoring systems and intercommunicate existing software and hardware systems. This project proposes the application of new digital technologies to reduce the energy consumption of buildings and, therefore, drive their carbon footprint towards zero. This digital transition will be carried out using IoT and machine learning algorithms and will be tested in an existing bioclimatic building, the CIESOL research centre. To this end, it will be necessary to: i) manage energy efficiency and comfort control within the building through the production and management of the hot/cold installation and decarbonization through thermal production systems for climate and DHW based on heat pump and photovoltaic solar energy, ii) the design and optimization of solar cooling and heating plants by contributing to the design and management of hydraulic and solar heating systems. thermal production, iii) the design and optimisation of cooling and heating systems using groundwater and geothermal exchangers.

3.4.9.1.3 AGROTECH DIH. Andalucía AGROTECH DIH

Participants:

Research group 'Automatics, Robotics and Mechatronics'. University of Almeria (TEP 197)
CIESOL (Spain), joint UAL-CIEMAT centre.

Contacts:

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Source of funding:

Horizonte Europa

Duration:

January 2024 – December 2027

Status:

Under development

Summary:

The main objective of the project is the design and delivery of higher education programme(s) - level I master's degree (at ISCED LEVEL 7 or equivalent) - the enrichment of existing bachelor's and master's degrees and the development of related autonomous modules/courses (online or face-to-face) to train specialists in digital transition for food farms and businesses, leading to recognized certifications. These objectives will be achieved by a European consortium of 7 higher education institutions, 5 companies and 1 research and excellence centre.

Digitalization in agriculture can generate multiple benefits: increasing productivity, improving efficiency and quality of work, reducing pressure on natural resources, and promoting market integration. In addition, it can improve farmers' access to knowledge, foster peer-to-peer learning, support innovation networks, improve links between rural and urban areas and between producers and consumers, and reduce bureaucratic burden. However, the opportunities for economic, social and environmental prosperity offered by digitalization also come with risks. Indeed, unregulated digitalisation in agriculture, or incentivising uptake without providing sufficient (regulatory) protection, can have detrimental economic, social and environmental consequences for vulnerable individuals, communities and regions across the EU.

To maximise fair opportunities and mitigate risks, companies in the agricultural sector need to increase their knowledge and skills to use digital technologies effectively and responsibly.
The project will work on the design and delivery of international higher education programs dedicated to training specialists in Digital Agriculture:
- to explore technological solutions for digital agriculture with a focus on responsible innovation
- Learn how to interact with technology providers and developers for the design and selection of innovative applications - Learn how to use digital farming tools
- Learn how to assess the socio-economic impacts of digital technologies.

3.4.9.2 Projects under implementation started before 2023

3.4.9.2.1 Hybrid control and optimization of a sustainable biorefinery for the industrial production of microalgae, HYCO2BIO

Participants:
CIESOL (Spain), a joint UAL-CIEMAT centre.
Research group "Automática, Robótica y Mecatrónica". Universidad de Almería (TEP 197)
Research group "Informática Industrial". Universidad de Murcia.

Contacts:
José Luis Guzmán Sánchez (joseluis.guzman@ual.es)
José Carlos Moreno Úbeda (jcmoreno@ual.es)

Source of funding:
State R+D+I Program Oriented to the Challenges of Society, Ministry of Science and Innovation

Duration:
Septermber 2021 – August 2024

Status:
Under development

Summary:

This project deals with the analysis, study and application of modelling, hybrid control and data-based learning techniques for the optimization of microalgae production with the simulataneous aim of generating biofuels, obtaining bioferlizers, wastewater treatment and making derived food products. In the last decades, microalge have been considered as promisings solution to build microalgae-based biorefineries because of their high contents in proteins, lipids and carbohydrates. Thus, the main objective of this project consists in the development of a self-sustinable process for the biomass production, which allows to mitigate greenhouse gas emisions, tranform residual and produce high-added derived products. Notice that these proceses present a highgly compelx nonlinear dynamics with different time scales, mainly due to the biological character of these systems and the high influecne of weather conditions. Therefore, the following modelling and control tasks are proposed in order to fulfill the objectives of this project:

1. Development of modelling framework to obtain nonlinear models and estimators for the microalgae production into a sustanible biorefinery.
2. Developtment of hybrid control and data-based learning techniques for a efficient and sustanible production of microalgae.
3. Implemenation and valdiation of the proposed modelling and control approaches on industrial photobioreactors as part of a micralgae-based biorefinery.

This proposal constitutes a continuation of two consolidated research lines by the applicant groups. First, it is considered as natural continuation of the research line about biomass production in industrial photobioreactors, where the Almería group has leaded 3 research projects in previous National Research Plans. Second, for the Murcia group, it contitues a continuation of the research line on hybrid control, where

also 3 research projects were lead in the past on this topic. Notice that the groups involved have a strong and close collaboration through projects and joint publications. Thanks this remarkable experience, it is expected to exploit this potential throught a high-level theoretical-practical synergy. Moreover, it is important to highligh the international scope of the propsal with the participation of 4 foregin researchers (Sweden, Italy, Isarel and USA). In the same way, the subject of the project is framed in the strategic lines of the European Union and the Spanish National Plan of Research, within of the challenges of Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and Bioeconomy. In this sense, the achievement of the objectives would have a significant contribution in this fields and would have a real impact on the competitiveness of this kind of processes in the industrial sector. As a result, several companies and research centres have shown their interest in this proposal, such as European Algae Biomass Association, Aqualia, Biorizon, CIESOL, Mtorres, Centro Tecnológico Naval y del Mar y Centro Tecnológico Nacional de la Conserva y la Alimentación.

3.4.9.2.2 Next Generation Training on Intelligent Greenhouses NEGHTRA

Participants:

Research group 'Automatics, Robotics and Mechatronics'. University of Almeria (TEP 197)
CIESOL (Spain), joint UAL-CIEMAT centre.

Contacts:

Francisco Rodríguez Díaz (frrodrig@ual.es)

Source of funding:

Erasmus+ KA2: Cooperation for innovation and the exchange of good practices - Knowledge Alliances. Call: EAC/A02/2019. Project ID. 621723-EPP-1-2020-1-EL-PPKA2-KA

Duration:

November 2020 – October 2023

Status:

Under development

Summary:

The Next Generation Training on Smart Greenhouses (NEGHTRA) is a specialised training project that addresses knowledge transfer in precision agriculture based on specific needs and challenges, identified from a comprehensive needs analysis. It aims to provide innovative training on smart greenhouse technologies, together with a selection of optimal technology/crop combinations with regions that include conditions for economic and environmental sustainability. NEGHTRA aims to develop an adaptable and flexible lifelong learning system, which ensures high quality and efficient teaching. It aims to make farmers aware of how innovation, entrepreneurship and the use of technology can benefit their businesses, their personal skills and the development of their competences. The target groups are: a) higher education institutions and research institutions that will update the portfolio of training programmes, b) agricultural intermediaries that provide advice and training to farming communities and c) the farming community in the participating countries and beyond.

3.4.9.2.3 Agricultural Collaborative Robot Inside IoT (AGRICOBIOT II)

Participants:

Research group 'Automatics, Robotics and Mechatronics'. University of Almeria (TEP 197)
CIESOL (Spain), joint UAL-CIEMAT centre.

Contacts:

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José Carlos Moreno Úbeda (jcmoreno@ual.es)

Source of funding:
Plan Andaluz de Investigación, Desarrollo e Innovación (PAIDI 2020)
Duration:
January 2021 – March 2023
Status:
Under development
Summary:

This project aims to develop a fleet of collaborative mobile robots able to assist the operator in his daily work inside a greenhouse, allowing to maintain the traceability of the tasks performed by the human and the robot, resulting in an improvement in terms of work safety, food safety and sustainability. The robots must be able to transport material inside the greenhouse, from defined stations to the human operator. For this purpose, two tasks will be distinguished: the navigation of the robots inside the greenhouse and their interaction with the human operator, so that the worker can move freely near the platform minimizing the risks for the human, the robot and the crop. In order to achieve a global optimum, in terms of sustainability, the robot must be able to communicate with other agricultural machines.

3.4.9.2.4 Go inverconec. Invernadero conectado. Desde el cultivo hasta el consumidor final

Participants:
Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.
Grupo de Inv. "Automática, Robótica y Mecatrónica". Universidad de Almería (TEP 197)
Asociación de organizaciones de productores de frutas y hortalizas de almería, COEXPHAL
Asociación de productores-exportadores de frutas y hortalizas de la región de murcia, PROEXPORT
ANECOOP SCA
Grupo Hispatec Informática Empresarial, S.A.
Fundación Cajamar
Agroplanning Agricultura Inteligente, S.L
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Jorge Antonio Sánchez Molina (jorgesanchez@ual.es)

Source of funding:
Fondo Europeo Agrícola de Desarrollo Rural (FEADER) de la Unión Europea y el Ministerio de Agricultura, Pesca y Alimentación (MAPA), en el marco del Programa Nacional de Desarrollo Rural 2014-2020
Duration:
June 2021 – May 2023
Status:
Under development
Summary:

This project aims to build a technological platform for the digitalization and production control of greenhouses. This platform will be related to productivity, sustainability, optimal performance and traceability to improve the competitiveness of our production system and, at the same time, encourage entrepreneurship. The platform, once evaluated, and associated with a strategy of control and reduction of inputs and supplies, will be the basis for developing an application for farmers.

3.4.9.2.5 CyberGreen - CYBERphysical control architecture for the optimization of the water-energy-carbon-food nexus in GREENhouses

Participants:
CIESOL (España), centro mixto UAL-CIEMAT
Contacts:
Jorge Antonio Sánchez Molina
Antonio Giménez Fernández

Funds:
Project PID2021-122560OB-I00 fund MCIN/ AEI /10.13039/501100011033/ and FEDER.
Time Period:
September 2022 – August 2025
Current Situation:
In progress
Summary:

The proposal aims to develop an optimisation framework for automatic management and control that, through the generation, storage, reuse and use of water, energy and CO2 in climate control, fertigation. In addition, the study of capacities and protocols aimed at integrating these heterogeneous elements into a tool that supports decision-making by the farmer will play an important role. The tests will be carried out at the IFAPA Centre in La Cañada, specifically in the infrastructure called 'AgroConnect' (Aid EQC2019-006658-P financed by MCIN/AEI/ 10.13039/501100011033 and by 'FEDER A way of doing Europe') under the agreement between IFAPA and the University of Almeria (IFAPA File 116/2020). This test bed, unique in the world, consists of a fully equipped greenhouse, which includes electrical and thermal supply, heating and cooling, and generation and reuse of water and CO2 from renewable sources with technologies such as desalination, distillation, solar photovoltaic, solar thermal, adsorption, aerothermal... The results will come from tests with real equipment, which facilitates their transfer to companies. In addition, the iVeg platform, designed by the ARM group in a previous project, will facilitate the integration and interoperability of the different components, as well as the design and implementation of the new cyber-physical architecture and the different optimisation and control algorithms.

3.4.9.2.6 COMMIT4.0EB - COntrol and ManageMent systems using Information and communications Technologies FOR ZERO Energy Buildings.

Participants:
CIESOL (España), UAL-CIEMAT
Research group "Automática, Robótica y Mecatrónica". Universidad de Almería (TEP 197)
Contacts:
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Manuel Pérez García (mperez@ual.es)
Funds:
Project PID2021-126889OB-I00 fund MCIN/ AEI /10.13039/501100011033/ and FEDER.
Duration:
September 2022 – August 2025
Status:
Under development
Summary:

This project proposes the development of advanced controllers for the three levels listed in the previous paragraph that will be validated in a bioclimatic building, the CIESOL building, which is placed at the campus of the University of Almería. This building uses ICT to monitor various physical variables in most of its enclosures, as well as the production and consumption of each of its components. The developed controllers will be validated with real tests, for which it will be necessary: i) to develop a digital twin of the building that allows modelling and predicting the production and consumption of the different systems that make up the building, ii) the analysis of thermal and electrical consumptions within the building and the production by the systems based on renewable energies that the building has integrated (flat solar collectors and photovoltaic panels). Specific integration and optimization options that result in a preponderant use of such systems will be evaluated; iii) the development of advanced controllers to manage the building energy at various levels

in order to overlap the building demand and production curves, maximizing the energy produced by renewable energy sources whereas energy consumption from the electrical grid is minimized.

3.4.9.2.7 NTech4Build - New technologies for enhancing energy efficiency in buildings.

Participants:

Centro de Investigaciones en Energía Solar CIESOL (España), centro mixto UAL-CIEMAT
Grupo de Inv. "Automática, Robótica y Mecatrónica". Universidad de Almería (TEP 197)

Contacts:

José Domingo Álvarez Hervás (jhervas@ual.es)
María del Mar Castilla Nieto (mcastilla@ual.es)

Source of funding:

Proyecto TED2021-131655B-I00 financiado por MCIN/ AEI /10.13039/501100011033/ y por European Union Next GenerationEU

Duration:

December 2022 – November 2024

Status:

Under development

Summary:

This project proposed the application of new digital technologies to reduce buildings' energy consumption and, thus, drive their carbon footprint towards zero. Such a digital transition will be performed using IoT and machine learning algorithms and tested in an existing bioclimatic building located at the campus of the UAL, the CIESOL research center. To do that, it will be necessary to: i) develop an anomalies detection system supported by AR to facilitate on-site checks and to reduce the time needed for maintenance tasks. This system will use data-driven and knowledge based techniques to check in real-time the operation of the main subsystems of the building, ii) Characterize users' behaviour inside the building by means of an occupancy tracking strategy composed of anchors, tags, and cameras, and using machine learning algorithms to obtain models of users' behaviour, iii) predict the solar irradiation using data from a pyranometer and machine learning techniques together with the production of the photovoltaic panels through a video stream acquired by a camera which will be used to detect the amount of dust onto the photovoltaic panels.

3.4.9.2.8 SFERA III Solar Facilities for the European Research Area

Participants:

CIESOL (España), UAL-CIEMAT

Contacts:

J.A. Sánchez (jsanchez@ual.es)

Source of funding:

European Commission-DG RTD Horizon 2020 Framework Programme H2020-INFRAIA-2018-2020 (H2020-INFRAIA-2018-1)

Duration:

January 2019 – December 2023

Status:

Under development

Summary:

SFERA III is a Horizon 2020 project funded under the Research Infrastructure Programme. The consortium is coordinated by CIEMAT-PSA and is made up of a total of 15 partners from 9 EU member countries. The project runs from January 2019 to December 2022 and will receive a grant of 9,103 million euros from the EC over these 4 years. The overall objective of this project is to continue the work done over the last 8 years in the

SFERA 1 and SFERA 2 projects and to strengthen the sustainability of European advanced concentrating solar energy research infrastructure activities.

These activities will comprise: (i) networking activities to further develop cooperation between research infrastructures, the scientific community, industries and other stakeholders; (ii) transnational access activities aimed at providing all European researchers, both from academia and industry, with access to unique scientific and technological solar research infrastructures; and (iii) joint research activities with the sole objective of improving the integrated services provided by the infrastructure.

3.4.9.2.9 Reusing effluents from Agriculture to Unlock the potential of microalgae (REALM).

Participants:

CIESOL-Universidad de Almería
Grupo de Inv. "Automática, Robótica y Mecatrónica". Universidad de Almería (TEP 197)
Grupo de Inv. "Desalación y Fotosíntesis". Universidad de Almería (BIO 352).

Contacts:

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Francisco Gabriel Acién Fernández (facien@ual.es)

Source of funding:

Horizon Europe Framework Programme (HORIZON)
Circular economy and bioeconomy sectors (HORIZON-CL6-2021-CIRCBIO-01)

Duration:

July 2022 – June 2026

Status:

Under development

Summary:

The main objective of this project is to develop an innovative, sustainable and cost-effective system to cultivate microalgae. Core aspects are the reuse of drain water from soilless greenhouses, the application of the continuous production mode at industrial scale and the use of renewable energy. The novel system will be tested in Southern, Central and Northern Europe, so it is applicable to all European countries.

Novel sensors will monitor the growth and physiological state of microalgae in real-time. Their data will help to create digital twins and predictive models, essential to automate production and harvest. They will ensure a high quality of the cultures. Based on the continuous data collection, we establish growth models for different microalgae species and provide these data to the scientific community and microalgae producers.

3.4.9.2.10 Hybrid cooling solutions for water saving in solar thermal applications (SOLHYCOOL)

Participants:

PSA - CIEMAT
CIESOL
University of Huddersfield (Reino Unido)
Automatics, Robotics and Mechatronics Research Group. University of Almeria (TEP 197)
Desalination and Photosynthesis' Research Group. University of Almeria (BIO 352).

Contacts:

Lidia Roca (lidia.roca@psa.es)
Patricia Palenzuela (patricia.palenzuela@psa.es)

Source of funding:

Call for Knowledge Generation Projects 2021. State Research Agency. Ministry of Science and Innovation and by FEDER A way of doing Europe.

Duration:

September 2022 – August 2025

Status:

Under development

Summary:

The object of this project is to advance in the hybrid cooling technology for its use in solar thermal applications at comercial scale, like are the Concentrating Solar Power plants and the multi-effect distillation plants driven by solar energy and located in land, to thus achieve a reduction in water consumption in such applications. Through the use of methods in automatic control, it should be achieved an optimum management of the operation of the hybrid cooling systems in terms of water consumption avoiding the penalty in the efficiency of the solar thermal applications in which the cooling systems are integrated, thus making the technology feasible from the technical and economical point of views.

3.4.10 Network participation during 2023

Participation in national networks	1
Participation in international networks	

National Automatics Network

Participants:

Universities of Huelva (coordinadora), A Coruña, Almería, Carlos III de Madrid, Castilla-La Mancha, Complutense de Madrid, La Laguna, León, Politécnica de Madrid, Salamanca, Sevilla, UNED, Valladolid

Contacts:

Manuel Berenguel (beren@ual.es)

Funds:

Ministry of Science and Innovation. Research Networks 2022. RED2022-134223-T.

Time Period:

2023-2024

Current Situation:

In progress

3.4.11 Transfer and Complementary Activities

Contract with companies

Project title: Dimensionamiento y viabilidad económica de una instalación de ciclo combinado para la agroindustrial utilizando como combustible el deshecho de nuez pecana, Reference: 001388, Inicio: 01/09/2023, End: 31/08/2015, Budget: 33.500,00 €, Centro de gastos: 401799 Entidad: Sercom Automation S.L. Coordinator: Jorge Antonio Sánchez Molina.

Agreement with Universities

Double Degree Agreement in Industrial Electronic Engineering from the University of Almeria and Laurea in Ingegneria dell'Automazione Industriale from the University of Brescia (Italy).

Collaboration with programmes (ERASMUS, STUDY ABROAD,…)

Several of the members of the team are Erasmus coordinators with European universities. The University of Brescia (IT) stands out.

Collaboration with the Politecnico di Milano in the Bachelor's Degree in Agricultural Engineering.

Collaboration with another institutions

The group maintains relationships with international research groups from the following universities: Ghent (BE), Politechnika Wroclawska (PL), Brescia (IT), Lund University (SW), Universidad Federal de Santa Catarina (BR), Universidad Federal de Bahia (BR), Arizona State University (USA), Chapingo (MX), NTNU (NO), Lisbon (PT), Nantes Université (FR).

3.4.12 Training and Dissemination Activities

Organization of Courses

- Digital twins. Juan Manuel Escaño (US), Almería, 2023
- Introduction to 3D Vision and its application to visual localisation problems and map creation. Javier González (UMA), Almería 2023.

Other training and outreach activities

- Divulgación de las actividades del grupo durante 2023: https://arm.ual.es/arm-group/2023/10/17/grupo-arm-a-la-vanguardia-en-automatica-y-robotica/

  https://miguelblanco.blog/2023/12/14/grupo-arm-a-la-vanguardia-en-automatica-y-robotica/
- La Noche Europea de los Investigadores, Almería, España, 2023.
- Semana de la Ciencia, Almería, España, 2023.
- III Feria de la Ciencia, El Ejido, España, 2023
- Experiencias Profesionales "Charlas en el Aula", Almería, España, 2023
- La Noche en las Aulas, Almería, España, 2023
- Semana Europea de la Robótica, Almería, España, 2023.
- Desafío de robótica 2023, Almería, España, 2023

3.4.13 Projects requested during 2023

- SOL-préndete: Didactics and dissemination of concentrating solar power with new augmented and virtual reality technologies. FECYT call for the promotion of scientific, technological and innovation culture 2023. Lidia Roca.
- LIFE ACCLIMATE. Cultivating Resilience: Climate Change Adaptation Strategies for Greenhouses to Enhance Yield and Resource Efficiency. LIFE projects, LIFE-2023-SAP-CLIMA, Proposal number: 101157315. Jorge A. Sánchez
- NEGHTRA 2. Upgrading Conventional Greenhouses for Improved Productivity and Sustainability. ERASMUS-EDU-2023-PI-ALL-INNO, Proposal number: 101140136. Jorge Antonio Sánchez Molina.
- CFE. Climate Smart Experiments. HORIZON-CL6-2023-CLIMATE-01, Proposal number: 101136395. Jorge Antonio Sánchez Molina
- CIECONFORT. Development and optimisation of comfort systems in bioclimatic buildings: CIESOL. José Domingo Álvarez Hervás.

3.4.14 Others

Final degree projects:

- Alberto Martínez Segura (Degree in Computer Engineering). Temperature prediction system for a flat plate solar collector field using Machine Learning techniques.
- Alejandro Dimas Rodríguez (Degree in Industrial Electronic Engineering). Design and development of a SCADA tool on HMI screens for industrial photobioreactors.

- Alfonso Jesús Ferre Montoya (Degree in Industrial and Automatic Electronic Engineering). Modelling of an H20/LiBr absorption water chiller using Machine Learning techniques..
- Ángel López Gázquez (Degree in Industrial Electronic Engineering). Simulation of the Husky robot for collaborative applications in greenhouses.
- Antonio Martínez Roa (Degree in Industrial Electronics and Automatic Engineering). Control architecture of an advanced solar collector for use in desalination.Francesco Iaconis (Degree in Industrial Electronics and Automatic Engineering). Multivariable control strategy applied to a wastewater nanofiltration pilot plant.
- Brian Alexander Flores López (Degree in Computer Engineering). Development of a thermal comfort voting system with a gender perspective.
- Carlos Prieto Nemesio (Degree in Industrial Electronic Engineering). Design and development of Hammerstein-Wiener models for pH in microalgae production processes.
- Clara Iborra Martínez (Degree in Industrial Electronic Engineering). Non-linear control techniques for natural ventilation in greenhouses.
- Daniel Bervel Morales (Degree in Industrial Electronic Engineering). Artificial vision-based system for postural monitoring of the back during physical activity.
- Daniel Pérez Sánchez (Degree in Industrial Electronic Engineering). Multivariable control techniques for greenhouse cooling in Mediterranean climates.
- Enrico Ferlinghetti (Degree in Industrial Electronic Engineering). Detection of hand position and posture during wheelchair tennis propulsion using vision systems.
- Jorge Pérez Cano (Degree in Industrial Electronic Engineering). Model with 4 motors for teaching basic concepts of automation.
- José Gabriel Martínez Hernández (Degree in Industrial Electronic Engineering). Vector control of a three-phase synchronous motor.
- José García Gallardo (Degree in Industrial Electronic Engineering). Virtual laboratory of a raceway reactor using Easy Javascript Simulations.
- José Ruiz Capel (Degree in Industrial Electronic Engineering). Design and implementation of a workspace for the UR3 collaborative robot.
- Juan Modesto Espinosa Bogas (Degree in Industrial Electronic Engineering). Development of an HRI based on OpenBCI for basic robot control.
- Manuel Roda Casas (Degree in Industrial Electronic Engineering). Optimal design of a solar-powered membrane distillation plant based on techno-economic criteria.
- Manuel Jesús Segura Valverde (Degree in Industrial Electronic Engineering). Simulated implementation of a robotic assistant with autonomous navigation.
- Marta Leal Rueda (Degree in Electrical Engineering). Optical study of a multifunctional collector for thermal and photovoltaic uses.
- Matteo Crotti (Degree in Industrial Electronic Engineering). Microrobotic systems for the electromechanical characterisation of biological samples.
- Pablo Marín Molina (Degree in Industrial Electronic Engineering). Development of a simulator for the DuckieTwon of the UAL.
- Pedro Antonio Sánchez Sánchez (Degree in Industrial Electronics and Automation Engineering). Commissioning and characterisation of a commercial-scale membrane distillation system for water desalination.
- Rachid Eddaha (Degree in Industrial Electronic Engineering). Estimation of the load transported by a bridge crane from the model.
- Sergio Rodríguez Perales (Degree in Industrial Electronic Engineering). Development of a virtual laboratory for the simulation of water decontamination systems using the photo-Fenton process.
- Verónica Abad Alcaraz (Degree in Industrial Electronic Engineering). Simulator of the UAL-ECARM electric urganic vehicle at ROS.

- Víctor Manuel Rodríguez Zurita(Degree in Industrial Electronic Engineering). CODESYS integration of measurement and actuation systems using OPC on Arduino and Raspberry PI.

Master's Thesis:

- Adrián Giménez Miralles (Master's Degree in Industrial Engineering). Design of a robotic station for painting and welding bicycle frames.
- Álvaro Rodríguez Escudero (Master's Degree in Industrial Engineering). Design of a modular multifunctional mobile robot.
- Ana Cleia González Alves (Master's Degree in Industrial Engineering). Improvement of the dynamometers and the translation movement for the REPAS test bench at the Plataforma Solar de Almería.
- Ana Gómez Espinosa (Master's Degree in Industrial Engineering). Design and control of an assistive device for lower limb disabled people.
- Antonio José Martín Puertas (Master's Degree in Industrial Engineering). Techno-economic analysis of different desalination technologies for their application in intensive farming in the province of Almeria.
- Carlos Javier Lopes Gomes (Master's Degree in Solar Energy). Didactic use of a photovoltaic micro-grid emulator in the energy and environment laboratory of the UAL.
- Daniel Membrives Céspedes (Master's Degree in Industrial Engineering). Design of a robotic cell in the manufacturing industry.
- Douglas Enrique Rosales Baptista (Master's Degree in Solar Energy). Comparative techno-economic analysis of the use of modules with M10 and G12 technology for the design of a photovoltaic plant..
- Emilio Berasategui Arocha (Master's Degree in Solar Energy). Design and basic engineering of a self-consumption photovoltaic system for a beverage company.
- Fernando Cañadas Aránega (Máster en Ingeniería Industrial). Robot móvil tipo Ackermann para asistencia en invernadero: diseño, modelado y control.
- Hernán Moreno Abadía (Master in Digital Transformation of Companies) Modelling the automatic inventory management of a warehouse in an agri-food industry.
- Jerónimo Ramos Teodoro (Interuniversity Master's Degree in Representation and Design in Engineering and Architecture) Analysis of the economic viability of a heat network for greenhouse crops in the municipality of El Ejido.
- José González Hernández (Master's Degree in Industrial Engineering). Design of a biomass concentration estimator using the luminosity obtained by an RGB sensor.
- Pablo Arias Moreno (Master's Degree in Industrial Engineering). Design and study of a tornado simulator for the study of wind erosion.
- Raúl Aguilera López (Master's Degree in Industrial Engineering). Analysis and compensation of oscillations in a hydraulic actuator.
- Rodrigo Romero Coronel (Master's Degree in Industrial Engineering). Design of a two-axis tracking system for photovoltaic solar panels.

PhD theses in progress

- Artero Carrillo, Francisco (supervisor Pérez García, Manuel).
- Cañadas Aránega, Fernando (supervisors José Carlos Moreno, José Luis Blanco)
- Caparroz, Malena (supervisor José Luis Guzmán, Manuel Berenugel)
- Carreño Zagarra, José (supervisore José Carlos Moreno, José Luis Guzmán).
- García Ruiz, Rubén Antonio (supervisors José Luis Blanco Claraco, Javier López Martínez).
- González Hernández, José (supervisors José Luis Guzmán, José Carlos Moreno).

- González Morales, Rubén (supervisors Francisco Rodríguez, Francisco García).
- Chunhao, Zhang (supervisor Francisco Rodríguez)
- Leal Rueda, Marta (supervisors María del Mar Castilla Nieto, José Domingo Álvarez Hervás).
- Otálora Berenguel, Pablo (supervisors José Luis Guzmán, Francisco Gabriel Acién).
- Pataro, Igor (supervisors José Luis Guzmán, Juan Diego Gil).
- Romero Ramos, Jose Alfonso (supervisor Pérez García, Manuel).
- Serrano Rodríguez, Juan Miguel (supervisors Lidia Roca, Patricia Palenzuela, Manuel Berenguel)
- Topa Gavilema, Alex Omar (supervisors José Domingo Álvarez, José Luis Torres).

Awards during 2023

- Juan Diego Gil, Lidia Roca, Guillermo Zaragoza, Julio Normey, Manuel Berenguel. The 2023 IFAC Foundation Kwon Award, for outstanding contributions in the area of sustainability through optimal control for start-up procedures in solar thermal plants. 2023.
- José Luis Blanco. Third place in the BARN Challenge on autonomous navigation at the IEEE International Conference on Robotics and Automation (ICRA).
- Alejandro Bueso Sánchez (tutored by Juan Diego Gil and Manuel Berenguel). Award for the best final master's degree project of the Aqualia Chair of the Integral Water Cycle 2023.
- Carmen Sánchez y Lidia Martínez (tutored by Manuel Berenguel). CIRCE Prize in the Control Engineering Competition 2023.
- José Luis Guzmán, award for tutoring Daniel Rodríguez, United Nations Special Prize in the XX Certamen Universitario Arquímedes de Introducción a la Investigación Científica.

3.5 ACTIVITIES OF SOLAR RESOURCES AND SOLAR COOLING RESEARCH

3.5.1 Functional unit description

The Solar Resources and Solar Cooling Unit is made up of the members of the groups "Solar Energy Resources and Climatology (TEP165)" and the "Interdisciplinary Group on Complex Fluids (FQM230)". The experience of the TEP 165 group in the study of solar resources and cloud cover over the last few decades has enabled the development of systems for predicting solar radiation and cloud cover in the short term, aimed at optimizing solar energy plants, mainly concentrating solar power plants (parabolic trough and central tower) and photovoltaic plants. Likewise, a reference METEO station has been set up at the Solar Energy Research Centre (CIESOL) to monitor the atmosphere and develop predictive systems that affect the production of solar plants in general. Regarding the integration of the FQM230 group, work has been ongoing on the development of new scenarios for harnessing energy in materials with phase change, thanks to the knowledge and dedication of the experts in the complex fluid dynamics group. These techniques are being applied mainly to cooling and heating in self-sufficient buildings, as well as in other fields such as industry and greenhouses.

3.5.2 Main research lines

The main strategic lines of the group within the CIESOL Joint Centre are as follows:

- Evaluation and forecast of solar resource.
- Remote sensing systems.
- Design and optimization of solar thermal cooling and heating systems.
- Design and optimization of air-conditioning system coupled with shallow geothermal systems and ground-coupled heat exchanger.
- Design and optimization of trigeneration systems.
- Integration of the solar thermal and photovoltaic energy in the construction, warehouses, or greenhouses.
- Thermal energy storage through phase change materials (PCM).
- Geographic Information Systems (GIS).
- Cooling applied to agri-food industry.

3.5.3 Main researchers

Joaquín Alonso Montesinos (ORCID 0000-0002-0902-5680, Scopus Author ID 57219382156)

PhD from the University of Almeria in Applied Environmental Sciences (2014) in Solar Energy. Associate Professor at the University of Almeria. Principal investigator of a project funded by the Ministry of Science and Innovation. Member of five research projects (one international, two national and two contracts with private companies). Head of the research group of the Andalusian Plan for Research, Development, and Innovation PAIDI "TEP 165, Solar Energy Resources, Climatology and Physics of the Atmosphere" of the University of Almeria since 2013. Among my concerns for the improvement of society, I have been able to develop and contribute work focused on the optimisation of solar resources for commercial solar thermal plants, such as Gemasolar (Seville), which has been the world reference plant in central tower technology and daytime and night-time electricity production; or the Valle 1 and 2 parabolic trough plants (Cadiz). There have been numerous scientific publications throughout my career as a researcher, with more than 50 articles indexed in scientific journals of impact, being the first author of half of the publications, and about 60 communications to conferences, organised by the highest entities in the field of renewable energies (ISES, SolarPACES, Enersol,

ECAC). Active member of the international task 16 "Solar Resource for High Penetration and Large-Scale Applications" of the International Energy Agency and invited by several international forums, such as ENERSOL 2017 or SOLAR WORLD CONGRESS 2019. Director of two doctoral theses and director of approximately 20 final projects (master's and bachelor's degrees). Participant in the European Researchers' Night and reviewer in several high-impact scientific journals related to renewables, and guest editor of the journals: Remote Sensing and Journal of Energy and Power Technology.

Jesús María Ballestrín Bolea (ORCID 0000-0002-1800-7273, Scopus Author ID 56202533400)

Jesús Ballestrín, PhD in Physics in 1997, has developed his activity in CIEMAT from 1990. He has been collaborating from 1997 in many national and international projects concerning Solar Radiation knowledge, covering different topics of Concentrating Solar Systems. He is a senior researcher of CIEMAT-PSA, with more than twenty-five years of R+D experience on Solar Concentrating Technologies as central receivers, heliostats, and solar furnaces. He is the head of PSA Radiometry Laboratory and since 2010 he is head of the Andalusian research group Solar Concentration Technology TEP247 made up of 19 researchers. Current research topics include the development of measuring devices and procedures for magnitudes related with concentrated solar radiation as high irradiance, high superficial temperature, and atmospheric attenuation of solar radiation. Author of one patent, the worldwide commercialization of a solar extinction measurement system, many scientific publications, book chapters and supervisor of PhDs related to these subjects. He is also a regular reviewer for multiple journals related to his field: Solar Energy, Applied Energy, Measurement Science and Technology, etc. He is also a regular reviewer of proposals for ANEP national projects, CDTI, Torres Quevedo, etc.

3.5.4 Summary of the functional unit's activities carried out in CIESOL during 2023

During this year 2023, numerous important milestones have been reached in the Unit. The line of previous years has been followed, with the substantial improvement of the work carried out at the experimental and real level of the current projects. This year, it has been possible to create a characterization map of the Spanish territory thanks to geographic information systems (GIS) for its application to photovoltaic electricity production systems. In addition, new variables of interest have been defined, such as fouling, economic profitability or levels of CO2 savings in these spaces if photovoltaic plants were implemented. It has been possible to unify the weather station data, creating a repository visible to any user through the web (https://tep165.ual.es). Also, new components have been integrated into the unit, thus strengthening the projects and lines of research in development.

Also, we have continued the experiments with the pilot plant for refrigeration, particularly the storage tank based on PCMs. All the PCM nodule geometries purchased previously have been studied, as well as different configurations of the nodules inside the tank. It was concluded after all tests, that the best nodules were disk-shape ones, vertically oriented and parallel to the heat-transfer-fluid flow. Two reports were prepared afterwards; the first one with these experiments, corresponding to Deliverable D3 of the project, "Report on the pilot-tank experiments", and the second one is the Deliverable A4: "Report on EPCM selection". The results were discussed with all other members of the consortium in the coordination meeting held in Poland, in July 2023. In autumn, the vertically oriented pilot tank was placed in the pilot plant, and the research experiments were started in November. Following this experimental work, the two storage tanks, 2000 litres of capacity each one, were designed in collaboration with the group from Wroclaw, and in June the designed

was passed to the Hedera Helix (partner of the project) for construction. The delivery of these tanks is expected for the early 2024, and the necessary modification of the refrigeration facility in CIESOL will start immediately after.

3.5.5 Collaboration with other Functional Units of CIESOL during 2023

Activity	Organometallics and Photochemistry	Environmental Analysis	Water Regeneration	Modelling and Control	Solar Resources and Solar Cooling	Desalination and Photosynthe
Papers						
Projects				1		

We continue to be linked and collaborating under the project of the Ministry of Science and Innovation (Ecological and Digital Transition 2021), New technologies to increase energy efficiency in buildings (NTech4Build), with reference TED2021-131655B-I00, and where we are involved in carrying out a characterization of the CIESOL building at the energy level and production and prediction of the photovoltaic solar plant.

3.5.6 Human Resources of the research group

Stays and visits at CIESOL:

- Lutz Meyer. University of Applied Sciences and Arts Hanover, Germany (23/02/2023-24/02/2023).
- Dr. Miguel Larrañeta Gómez-Caminero. University of Sevilla, Spain (12/06/2023 – 14/07/2023).

Stays of CIESOL researchers in other centers:

- Joaquín Alonso Montesinos. University of Antofagasta, Chile (04/11/2023-17/12/2023).
- Joaquín Alonso Montesinos. National Autonomous University of Mexico, México (22/11/2023-05/12/2023).
- María Jesús Ariza Camacho. PROZON Fundacja Ochrony Klimatu, Varsovia, Polonia (12/07/23-14/07/23).
- Juan Luis Bosch Saldaña. PROZON Fundacja Ochrony Klimatu, Varsovia, Polonia (12/07/23-14/07/23).
- Álvaro Castro Vizcaíno. PROZON Fundacja Ochrony Klimatu, Varsovia, Polonia (12/07/23-14/07/23).
- Antonio Manuel Puertas López. PROZON Fundacja Ochrony Klimatu, Varsovia, Polonia (12/07/23-14/07/23).
- Manuel Servando Romero Cano. PROZON Fundacja Ochrony Klimatu, Varsovia, Polonia (12/07/23-14/07/23).

Students in curricular internships:

- Francisco Javier Moreno Yeste. Computer Science Degree (01/02/2023-30/04/2023).
- Alejandro Morales Gómez. Computer Science Degree (01/02/2023-30/04/2023).

3.5.7 Summary tables of scientific production

The scientific production of the functional unit during 2023 is summarised in the following tables containing the number of indexed articles, participation and contributions to congresses, organisation of congresses,

book chapters, as well as theses defended and in progress. The complete production can be consulted in the corresponding Annex at the end of this report.

Number of papers	Number of papers in each Quartile				Number of papers with international collaborations
	Q1	Q2	Q3	Q4	
5	4		1		4

Assistance to congresses	7
Contributions to congresses	11
Oral	7
Poster	4
Congress organization	-
Chapters of book	-
Defended doctoral theses	-
Doctoral theses in progress	2

3.5.8 Members of the Research Group

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Full Professor
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Mercedes Martínez Durbán

Associate Professor
UAL

Manuel Servando Romero Cano

Associate Professor
UAL

Juan Luis Bosch Saldaña

Associate Professor
UAL

María Jesús Ariza Camacho

Associate Professor
UAL

Fernando Sánchez Rodrigo

Associate Professor
UAL

Sabina Rosiek-Pawlowska

Postdoctoral researcher
Wroclaw University of Science and Technology

Gabriel López Rodríguez

Associate Professor
UHU

Álvaro Castro Vizcaino

Predoctoral researcher
UAL

Noelia Simal Pérez

Predoctoral researcher
PSA-UAL

Aitor Marzo Rosa

Ramón y Cajal reseracher
UGR

María Elena Carra

Posdoctoral researcher
CIEMAT-PSA

3.5.9 Proyects in force during 2023

	Started in 2023	Started before 2023
European projects		3
National projects		3
Regional projects		0

3.5.9.1 Projects under implementation started in 2023

3.5.9.1.1 Development of an economic profitability map for solar photovoltaic systems in Spain, based on meteorological parameters, remote sensing and artificial intelligence (MAPVSpain).

Participants:
University of Almería.
Contacts:
Joaquín Alonso Montesinos (joaquin.alonso@ual.es)
Funds:
Ministry of Science and Innovation
Time Period:
November 2021 - October 2024
Current Situation:
In progress
Summary:

The presented project aims to develop a methodology for evaluating the potential capacity to produce electricity from photovoltaic systems at any national geolocation while considering dust losses. Basically, the project is structured into distinct, yet closely linked, stages: solar resource estimation using satellite images; determining dust losses according to meteorological variables; economic analysis of the losses produced in the photovoltaic systems; study of the plant's economic profitability, based on the stock market at the time the plant is installed at the place being studied; techniques for optimizing the photovoltaic system's cleaning and maintenance once it is operating; and predicting the electricity production in real time.

3.5.9.1.2 An innovative solar-powered cooling device, based on climate-friendly refrigerant and thermal energy storage (COOLSPACES 4 LIFE)

Participants:
Wroclaw University of Science and Technology, WUST (Poland)
PROZON Fundacja Ochrony Klimatu (Poland)
Universidad de Almería
Hedera Helix Ingenieria y Biotecnologia S.L.
Contacts:
Sabina Rosiek (sabina.rosiek@pwr.edu.pl) – Overall PI of the project
Antonio Manuel Puertas López (apuertas@ual.es) – PI of the group from the UAL in the project
Source of funding:
LIFE20 action - LIFE CLIMATE CHANGE MITIGATION
Duration:
September 2021 – August 2026
Status:
Ongoing
Summary:
In this project we aim to develop a prototype of refrigeration device with low Global Warming Potential (low-GWP), running with photovoltaic solar energy and a system of thermal energy storage at low temperatures. The group in the UAL-CIESOL is responsible for the design and test of the storage system in the laboratory scale, including the selection of a phase change material for this purpose. In a later stage, this storage system will be up-scaled to the prototype of refrigeration device to be designed and built by the group from the WUST and PROZON, and the new system will be implemented in CIESOL, including two tanks of PCM for thermal storage of ca. 4000 liters. In the final stage of the project, starting in summer 2024, the system is expected to be ready for testing its performance and optimization. The results will be compared with a similar system implemented in Poland, in a very different climatic environment.

3.5.9.1.3 Solar Facilities for the European Research Area - third phase (SFERA III)

Participants:
CIEMAT, CNRS (Francia), DLR (Alemania), ENEA (Italia), ETHZ (Suiza), CEA (Francia), UEVORA (Portugal), IMDEA (España), CYI (Chipre), FRAUNHOFER (Alemania), LNEG (Portugal), METU (Turquía), UAL (España), EURO (Francia), ESTELA (Bélgica)

Contacts:
Ricardo Sánchez (ricardo.sanchez@psa.es)
Jesús Ballestrín (jballestrin@psa.es)

Source of funding:
European Commission-DG RTD. Proyecto 823802 H2020-INFRAIA-2018-1.

Duration:
January 2019 – December 2023

Status:
Ongoing

Summary:
The overall objective of this project is to continue the work done over the last 8 years for the sustainability of the activities of the European advanced solar laboratories participating in SFERA and SFERA Phase 2, and to extend these activities to the new solar laboratories that will bring added value to this European Research Infrastructure for Concentrating Solar Power. The specific objective is to contribute to ensuring the long-term sustainability of these advanced European solar laboratories, supporting Europe as a world leader in solar research infrastructures. These activities will include (i) networking activities to further develop cooperation between research infrastructures, the scientific community, industries and other stakeholders; (ii) trans-national access activities aimed at facilitating access for all European researchers, both from academia and industry, to scientifically and technologically unique solar research infrastructures; and (iii) joint research activities with the sole objective of improving the integrated services provided by the infrastructure. This would contribute to the scientific excellence of these research infrastructures (RIs), to strengthen the interaction between the CSP industry and these RIs, to further enhance innovation, to develop new activities, and to boost the productivity and competitiveness of the European economy by contributing to the creation of new jobs in the CST sector. In addition, these activities will contribute to the development of new common standards that will support the CST industry in the development of new components and systems and in the construction of new commercial facilities. At the same time, these standards will also support the European Commission in the development of European policy for the CST sector.

3.5.9.1.4 Campos de Heliostatos más Eficientes para Plantas Solares de Torre (HELIOSUN).

Participants:
CIEMAT, Universidad Palma de Mallorca

Contacts:
Jesús Ballestrín (jballestrin@psa.es))

Source of funding:
Ministry of Science and Innovation. KNOWLEDGE GENERATION PROJECTS 2021..

Duration:
September 2022 – Auguts 2025

Status:
Ongoing

Summary:

Concentrating solar thermal plants should play an important role in the energy transition towards renewable energy sources, since they offer a simple and economical way of storing energy, allowing the generation of electricity to be extended to those moments when there is no solar radiation. direct (at night or on cloudy

days). Among the different concentrating solar technologies, the central receiver tower technology is the one that presents the greatest potential for improvement: higher conversion efficiencies when operating at higher temperatures, as well as a greater reduction in costs in its implementation. And among the components of this technology (solar field, receiver, energy storage system and power block), the reduction of costs in the solar field, made up of thousands of heliostats, is the one that would have the greatest impact on reducing costs. of a central receiver plant, since it represents up to 60% of the investment cost for plants with more than 100MWe of nominal power, in addition to also assuming a majority cost in the costs of operation and maintenance of this type of plants.

This project addresses cost reduction from 3 different but complementary points of view. First, an artificial vision system for object recognition is proposed, based on neural networks, which allows closed-loop control of the pointing of the heliostats in the field. The system, which consists of a low-cost camera and processor installed in each of the heliostats, will make it possible to eliminate positioning sensors as well as improve the pointing accuracy of the heliostats in the solar receiver. This strategy contributes to improving the industrialization of heliostats (industry 4.0), in addition to being aligned with the SmartCSP lines promoted by the European Commission. Secondly, a correct measurement of the atmospheric attenuation suffered by the solar radiation concentrated by the heliostats on its way to the solar receiver, with distances greater than 1500m for those solar plants with nominal power greater than 100MWe, will allow, in the first place, , an adequate selection of those locations with the best characteristics for the implantation of tower plants with a central receiver; and, in addition, to optimize the routine operation of the solar plant with real-time measurements of atmospheric attenuation. For this, the proposal intends to work on the generation of a typical year of extinction for the Plataforma Solar de Almería; in addition to generating and validating atmospheric extinction prediction models based on climatic variables. Finally, using the generated models and satellite images, it is intended to build an atmospheric extinction map for Spain, very useful for those companies interested in the development of technology at a national level.

Finally, it is proposed to develop a ray tracing model that allows a more accurate prediction of the behavior of a central receiver tower solar plant considering spectral analysis, as well as including all the experimental results exposed above.

These three approaches will make it possible to improve the operation of the central tower solar plants, optimizing in particular the operation of the solar receiver and the solar field, increasing the annual electricity generation and therefore the technical and economic efficiency of these systems.

https://www.ciemat.es/cargarAplicacionNoticias.do?identificador=2597&idArea=-1

3.5.9.1.5 Solar field measurements to improve performance (LEIA).

Participants:

CIEMAT, ACCIONA INDUSTRIAL S.A., CSP Services GmbH, DLR, TEWER ENGINEERING, FUNDACION CENER, Siemens Energy Global GmbH & Co. KG

Contacts:

Antonio Luis Avila (Antonio.avila@ciemat.es)
Jesús Ballestrín (jballestrin@psa.es)

Source of funding:

AEI, CDTI. CSP ERANET Additional Call 2021

Duration:

December 2022 – November 2025

Status:
Ongoing
Summary:

The objective of the project is to contribute to the market deployment of the next generation of innovative, reliable, and intelligent Concentrated Solar Power (CSP) plants, focusing on new control and Operation and Maintenance (O&M) solutions for central receiver technology through molten salts, as the most promising profitable solution with the greatest market potential. To achieve this, the LEIA project will develop and test at PSA, CENER and the Cerro Dominador ESTC plant:

- Intelligent heliostat field control solutions to automate and improve calibration and characterization.
- Intelligent receiver control solutions to measure receiver temperature, emittance, and distribution of high solar irradiance.
- Control strategies for the operation and maintenance of the solar field, such as automated dirt inspection and an intelligent energy management system.

CIEMAT-PSA will participate, through the development up to TRL 7/8, in the automated characterization of heliostats and the measurement of high solar irradiance in situ for plants and commercial receptors.

3.5.9.1.6 New technologies to increase energy efficiency in buildings (NTech4Build).

Participants:
UAL, CIEMAT
Contacts:
José Domingo Álvarez Hervás (jhervas@ual.es)
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Manuel Pérez García (mperez@ual.es)
Joaquín Alonso Montesinos (joaquin.alonso@ual.es)
Source of funding:
Ministry of Science and Innovation. TED 2021.
Duration:
December 2022 – November 2024
Status:
Ongoing
Summary:

This project proposed the application of new digital technologies to reduce buildings' energy consumption and, thus, drive their carbon footprint towards zero. Such a digital transition will be performed using IoT and machine learning algorithms and tested in an existing bioclimatic building located at the campus of the UAL, the CIESOL research center. To do that, it will be necessary to: i) develop an anomalies detection system supported by AR to facilitate on-site checks and to reduce the time needed for maintenance tasks. This system will use data-driven and knowledge based techniques to check in real-time the operation of the main subsystems of the building, ii) Characterize users' behaviour inside the building by means of an occupancy tracking strategy composed of anchors, tags, and cameras, and using machine learning algorithms to obtain models of users' behaviour, iii) predict the solar irradiation using data from a pyranometer and machine learning techniques together with the production of the photovoltaic panels through a video stream acquired by a camera which will be used to detect the amount of dust onto the photovoltaic panels.

3.5.10 Transfer and Complementary Activities

Agreements with Universities

Collaboration with the University of Antofagasta (Chile).

Collaboration with the National Autonomous University of Mexico (México).

Collaboration with programs (ERASMUS, STUDY ABROAD…)

Erasmus + (Staff Mobility For Training).

Collaboration with other centers

Collaboration with the Antofagasta Energy Development Center.

Institute of Geophysics (UNAM).

Institute of Atmospheric Sciences and Climate Change (UNAM).

3.5.11 Training and Dissemination Activities

Organization of Courses

- Renewable energies for a more sustainable society, Almeria, Spain, 2023.
- Renewable energies, Huelva, Spain, 2023.

Other training and dissemination activities

- New sources of sustainable energy from solar radiation in Mexico: A perspective from climate change mitigation, México City, México, 2023. Joaquín Alonso Montesinos.
- Importance of forecasting methods in the global solar industry**,** Antofagasta, Chile, 2023. Joaquín Alonso Montesinos.
- Commercial Concentrated Solar Thermoelectric Plants, Almería, Spain, 2023. Jesús Ballestrín Bolea.
- International Day of Women and Girls in Science, Almería, Spain, 2023. María Jesús Ariza Camacho, María José García Salinas. IES Celia Viñas, IES Campos de Níjar.
- European night of researchers. Almería, Spain, 2023. María Jesús Ariza Camacho, Joaquín Alonso Montesinos, Juan Luis Bosch Saldaña, Álvaro Castro Vizcaíno, Antonio Manuel Puertas López, Manuel S. Romero Cano.

3.5.12 Others

Final degree projects:

- Oliver Gómez Cerezuela (Degree in Mechanical Industrial Engineering). "Análisis de datos experimentales de un sistema de climatización solar".

Final master projects:

- Fatima Sánchez López (Master in Secondary Education Teaching). Conceptos fundamentales de las energías renovables y su aplicación en el aula.
- María José Cánovas Aragón (Master in Secondary Education Teaching). Aprendizaje basado en proyectos: aplicación de las energías renovables para la mitigación de la crisis ambiental.
- María Márquez Puertas (Master in Secondary Education Teaching). La química como enseñanza centralizada en proyectos desarrollados en el centro de investigación en energía solar (CIESOL).

Doctoral theses in progress

- Noelia Simal Pérez (supervisors: Jesús Ballestrín Bolea / María Elena Carra Artero).
- Álvaro Castro Vizcaino (supervisor: Antonio M. Puertas López).

Awards obtained during 2023

- SAN ALBERTO RESEARCH AWARD 2023 the best research articles within Q1 published in 2021. €250.00. Faculty of Experimental Sciences of the University of Almería. The University of Almería awarded the 2023 San Alberto Research Award to the article published with the title " Economic and environmental solutions for the PV solar energy potential in Spain".

3.6 ACTIVITIES IN DESALINATION AND PHOTOSYNTHESIS

3.6.1 Functional unit description

The "Desalination and Photosynthesis" unit is made up of researchers from the Department of Chemical Engineering of the University of Almeria and the Plataforma Solar de Almeria who have set up a new independent research group "Desalination and Photosynthesis" (BIO-352) with synergies from both fields. The researchers of this unit are also attached to the research groups of the Andalusian Research Plan "Solar Desalination, TEP026". This unit was launched in 2014 and focused its activity on improving the sustainability of the water-energy-food nexus, starting with the start-up and operation of new facilities and installations dedicated to solar-powered water desalination and with the added value of brine valorisation, as well as the application of solar energy in biological purification processes based on microalgae. Both lines present ample opportunities for synergies and joint work with other CIESOL R&D units, which will lead to frequent collaborations.

3.6.2 Main research lines

The group is working on two parallel lines that address the application of solar energy in desalination and brine concentration and the cultivation of microalgae, especially oriented towards recycling through solar-driven synthesis of commodities such as biofertilisers or biodiesel and valuable products such as carotenoids and essential fatty acids. Seawater is the main raw material addressed by the research, although other types of feedstock such as freshwater, brine, brackish water or wastewater are also considered. The main strategic lines of the group within the CIESOL Joint Centre are as follows:

- Development of solar desalination and water treatment systems using membranes.
- Application of solar energy to the treatment of hypersaline media.
- Recovery of valuable compounds from brines and hypersaline effluents.
- Design of photobioreactors for the cultivation of microalgae.
- Microalgae applications for wastewater and industrial effluent treatment
- Valorisation of microalgal biomass obtained from wastewater.

3.6.3 Main researchers

José M. Fernández Sevilla (ORCID 0000-0002-0290-5810, Scopus Autor 6602856181)

He is Professor of Chemical Engineering at the University of Almeria, currently attached to the Engineering Department of the University of Almeria. He obtained his degree in Industrial Chemistry from the University of Granada in 1991 and his Ph. D. in Chemistry in 1995 at the University of Almeria. He has worked in twelve R&D projects at international and Spanish national level, as principal investigator in five of them. He has also participated in 15 research contracts financed by companies, and has also advised on six Ph. Theses and is co-author of seven patents and more than one hundred scientific publications in international peer-reviewed journals.

Guillermo Zaragoza del Águila (ORCID 0000-0002-4452-9980, Scopus Author 6701505211)

D. in Applied Physics from the University of Granada, Spain (1996). He has held academic positions at the Spanish National Research Council (CSIC), the University of Oxford, "Las Palmerillas" Experimental Station (Cajamar Foundation) and is a Senior Researcher in the Energy Department of CIEMAT (Centre for Energy,

Environmental Research and Technology), at the Plataforma Solar de Almería, where he is currently head of the scientific unit of Solar Thermal Applications. He has published more than 85 papers in international peer-reviewed journals, presented more than 125 papers at international conferences, authored 8 book chapters and co-authored 4 books. Lecturer in international courses on Solar Desalination organised by the European Desalination Society (EDS) and in the Master in Solar Energy organised by CIESOL. He leads the Renewable Energy Desalination Working Group in the Water Europe platform, of which he is also an ambassador.

3.6.4 Summary of the functional unit's activities carried out in CIESOL during 2023

- Use of nanofiltration as a pretreatment to improve the efficiency of thermal desalination plants by operating at higher temperatures and recovery factors.
- Development of standardisation methodologies to reliably assess the performance indexes of thermal desalination plants.
- Experimental characterisation of a multi-effect distillation pilot plant at high operating temperatures using water pre-treated by Nanofiltration.
- Commissioning of a commercial-scale desalination unit using membrane distillation for brine concentration, powered by solar energy and biomass boiler.
- Commissioning, experimental characterisation and modelling of a solar-powered multi-effect vacuum membrane distillation pilot plant for brine concentration.
- Evaluation of membrane distillation at pilot scale operating in recirculation for brine concentration, comparing modules with different characteristics and operating conditions.
- Experimental characterisation of a membrane distillation pilot plant coupled to a photovoltaic concentrated solar power system.
- Wastewater treatment with membrane distillation for the removal of pollutants such as the anti-inflammatory drug Ketoprofen.
- Evaluation of the possible fouling of membranes in membrane distillation during brine concentration.
- Revalorisation of industrial wastewater for hydrogen production with solar energy evaluated under different operating conditions, including the photocatalyst used.
- Development of continuous processes for wastewater treatment using microalgae and water recycling for greenhouses.
- New advanced systems for monitoring and control of large-scale microalgae systems
- Production and evaluation of algae-based food and feed end products.
- Demonstration of technologies for large-scale production of macroalgae.
- Development of new membrane-based technologies for harvesting algae cultures.

3.6.5 Collaboration with other Functional Units of CIESOL during 2023

Activity	Organometallic and photochemistry	Analysis Environmental	Regeneration of wáter	Modelling and control	Solar resources and solar cold	Desalination and photosynthesis
Papers	0	0	3	5	0	-
Projects	0	0	3	5	0	-

- During 2021 we have worked closely with the Functional Unit "Modelling and Control" in the framework of the SOLWARIS project. We have worked together on tasks related to modelling, optimisation and control, fulfilling all milestone items so far.
- In 2022 we had a close collaboration with the Functional Unit "Modelling and Control" in the framework of different projects (National and EU Projects) such as CALRESI, DIGITALGAE, PRODIGIO and REALM. The activities are related to the development and implementation of advanced process control technologies related to microalgae.
- In 2023 we collaborated in the Improvement of the large-scale production capacity of Spirulina platensis in open systems through a contract with the company Algaria SRL (2000-2024), the optimisation of the design and operation of the Carboneras (ALGAVILLAGE) AlgaVillage plant (2022-2024) aimed at improving the design and operation of microalgae production plants, in the town of Carboneras (Almeria), for the company ALGAVILLAGE. Evaluation of the CO2 capture potential of processes based on aquatic plants and algae through collaboration with the company CHLYDRO (2022-2024). And finally, the development of a Chlorella production process for food use through collaboration with ALGEMY INGREDIENTS, S.L. (2022-2024).
- Collaboration with the CIESOL research group: Water regeneration, in the activity Wastewater treatment by membrane distillation for the elimination of the drug Ketoprofen. Dr. Paula Soriano Molina, a member of this group, coordinated and supervised the measures of

3.6.6 Human Resources of the research group

Stays and visits at CIESOL::

- Kacper Szymanski y Aleksandra Piatkowska. University of Breslavia (Wroclaw), Polonia (31/07/2023-02/08/2023).
- Ana Filipa Cruz Esteves. University of Oporto (Oporto), Portugal (01/10/2023-31/03/2024).
- Miguel José Vega Quiel. University autonomic of Chiriquí, Panama (15/09/2023-8/11/2023).
- Andrea Viktoria Polo Beitia. University autonomic of Chiriquí, Panama (15/09/2023-15/12/2023).
- Byron Elhyel Álvarez Zapata. University autonomic of Chiriquí, Panama (15/09/2023-15/12/2023).
- Alice Maria Garcia Ferreira. National Laboratory of Energy and Geology (Lisboa), Portugal (01/09/2023-01/12/2023)
- Monyca Félix Castro. BINOR (La Paz), Mexico (01/08/2023-02/11/2023).

Stays by CIESOL researchers in other centres:

- Isabel Requena. University of Arizona, Estados Unidos (08/09/2023-14/12/2023).
- Alba Ruiz-Aguirre. theVap, Alemania (02/10/2023-16/10/2023).
- Alba Ruiz-Aguirre. Solar Spring e Instituto Fraunhofer, Alemania (04/12/2023-15/12/2023).
- Silvia Villaró-Cos. National Laboratory of Energy and Geology, Portugal (07/03/2023-07/06/2023)
- Ana Sánchez-Zurano. National Laboratory of Energy and Geology, Portugal (07/03/2023-07/06/2023)
- Rebecca Nordio, National Institute for Research in Digital Science and Technology, Francia (01/03/2023-1/07/2023)

Students on curricular internships:

- Simón Domínguez. Chemistry(10/01/2023-10/02/2023).
- Estefanía de los Ángeles Gazquez Romero (04/05/2023-04/06/2023).
- David Mata Zafra (10/01/2023-01/03/2023)
- Paola Vico Aguilera (10/01/2023-01/03/2023)
- Sandra Valero Cardozo (18/01/2023-12/03/2023)
- Carmen Sánchez Salinas (18/01/2023-12/03/2023)
- Antonio Martínez Rosa (18/01/2023-12/03/2023)
- Alicia del Carmen Valero Vizcaino (18/01/2023-12/03/2023)
- Javier Jesús Tripiana Martínez (18/01/2023-12/03/2023)
- Raúl Gazquez González (18/01/2023-12/03/2023)
- María Salinas García (18/01/2023-12/03/2023)
- Irene Rodríguez de Cos (18/01/2023-12/03/2023)
- Ema Rosa Morillas Veselinovic (18/01/2023-12/03/2023)
- Javier Garrido Romero (11/12/2023-27/02/2024)
- Anastasia Alicia del Águila Pérez (01/10/2023-09/11/2023)

3.6.7 Summary tables of scientific production

The scientific production of the functional unit during 2023 is summarised in the following tables containing the number of indexed articles, participation and contributions to congresses, organisation of congresses, book chapters, as well as theses defended and in progress. The complete production can be consulted in the corresponding Annex at the end of this report.

Number of articles	Number of articles in each quartile				Number of articles with international collaborations.
	Q1	Q2	Q3	Q4	
24	14	8	2	-	11

Conferences attended	41
Contributions to conferences	63
Oral	42
Posters	21
Organisation of congresses	8
Book chapters	7
Doctoral theses defended	2
Doctoral theses in progress	10

3.6.8 Members of the Research Group

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Francisco Gabriel Acién Fernández

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University of Almeria (UAL)

Diego César Alarcón Padilla

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Celeste Elena Brindley Alías

Senior Lecturer
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Higher Graduate
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3.6.9 Projects in force during 2023

	Started in 2023	Started before 2023
European Projects		5
National Projects	1	7
Regional Projects	2	3

3.6.9.1 Projects under implementation started in 2023

3.6.9.1.1 Sustainable Indoor Production Of Macroalgae For Food Applications Alimentarias (SUMAPRO)

Participants:
University of Almeria (ES)
Contacts:
Dra. Cintia Gómez Serrano (cgs1818@ual.es)
Dr Francisco Gabriel Acién Fernández
Funds:
Marine Science and Recovery, Transformation and Resilience Plan Supplementary Plan.
Timer Period:
December 2023 - December 2024
Current Situation:
In progress
Summary:

Macroalgae are generally recognised as a safe and environmentally sustainable source of bioactive compounds. However, even so, the algae production portfolio is rather limited for several reasons, such as (i) difficulties in licensing the production or harvesting of macroalgae from natural environments, (ii) the low range of species allowed for production, (iii) the limited capacity/knowledge on continental algae production, and (iv) the limited number of applications already developed from this type of feedstock. Macroalgae are mainly produced as a source of carrageenans and in small quantities for food-related applications. However, the incorporation of macroalgae in livestock and aquaculture feeds allows reducing the use of other less sustainable ingredients, and allows incorporating compounds of high nutritional value to the target animal, and therefore improving the quality and sustainability of feed production. Objectives:

- The objective of the SUMAPRO project is to develop and validate large-scale processes for the sustainable continental production of macroalgae for food-related applications. To achieve this goal, major challenges will be faced:

- Macroalgae are at the core of the process and, although there is currently a portfolio of algae species produced, the portfolio of genera suitable for production is much larger. The challenge is to select the best strains of algae to produce and characterise them, determining the optimal conditions for their production.

- Currently, macroalgae are mainly harvested from the sea (wild or aquaculture). The challenge is to use current technologies for microalgae production and adapt them to macroalgae production. In addition, gentle processes will be required for biomass harvesting and processing.

- High energy consumption and the use of fertilisers in the production process compromise the sustainability of the process. The challenge is to increase the sustainability of production by recycling agro-industrial effluents as a source of nutrients, reducing energy consumption and integrating the use of renewable energies.

- The aquaculture and livestock sectors require healthy and sustainable ingredients to be incorporated into feed. The challenge is to produce high value feeds to move livestock and aquaculture production through a more sustainable system, balancing the ability to use inedible feed for humans and improving the quality of the final product.

3.6.9.1.2 Sustainable Production Of Food Ingredients And Agricultural Products Following A Microalgal Biorefinery Approach (SOLAR-FOODS)

Participants:
University of Almeria
Contacts:
Dr. Tomás Valentín Lafarga Poyo (tomas.lafarga@ual.es)
Dr José María Fernández Sevilla (jfernand@ual.es)
Funds:
Knowledge Generation Projects 2022
Time Period:
December 2023 – December 2026
Current Situation:
In progress
Summary:

SOLAR-FOODS aims to solve the main problems that currently limit the implementation of microalgae-based products and processes. The microalgae sector in the EU is growing exponentially and Spain has the capacity to become a world leader. The main problems include (i) high production costs, (ii) low production capacities, (iii) lack of knowledge about the environmental impact of microalgae production and (iv) a large knowledge gap about consumers' needs and their knowledge and perception of microalgae. These challenges are common to all EU countries and have recently been highlighted in a Communication entitled Towards a strong and sustainable algae sector in the EU. Objectives:

The main objective of SOLAR-FOODS is to boost the production and use of microalgae biomass by contributing to these four challenges simultaneously. The project will be based on three pillars: sustainable production, innovative technologies and uses, and consumers.

3.6.9.2.3 Towards the Next Generation of Sustainable Products Based on Under-studied Microalgae and a Biorefinery Approach (BLUE.FUTURE)

Participants:
University of Almeria
Contacts:
Dr. Tomás Valentín Lafarga Poyo (tomas.lafarga@ual.es)
Funds:
Marine Science Supplementary Plan and the Recovery, Transformation and Resilience Plan 2023
Time Period:
December 2023 – December 2024
Current Situation:
In progress
Summary:
Andalusia has the potential to become a world leader in innovation and production of microalgae biomass and the next generation of safe, high quality and sustainable algae products. BLUE-FUTURE's hypothesis is that microalgae can be used to divert industrial production from its current unsustainable path towards greener processes that minimise emissions of CO2 and other pollutants toxic to humans and the environment. Objectives:

The project has three main objectives: (i) to identify new and overlooked microalgae strains, (ii) to demonstrate the technical feasibility of producing sustainable and high quality microalgae biomass in Andalusia under extreme climatic conditions and using renewable resources; and (iii) to design sensors, monitoring and control technologies to improve the efficiency, productivity and optimisation of microalgae-based biorefineries.

3.6.9.2 Projects under implementation started before 2023

3.6.9.2.1 Sustainable production of bioproducts from cyanobacteria by treating waste effluents (CYAN2BIO).

Participants:
University of Almeria
Polytechnic University of Catalonia
Contacts:
Dra. Cynthia González López (cgl665@ual.es)
Funds:
Ministry of Economy, Industry and Competitiveness
Time Period:
December 2023 – December 2025
Current Situation:
In progress
Summary:
The Cyan2Bio project aims to develop and demonstrate a sustainable process for the production of bioproducts from cyanobacteria, including biopolymers (PHB), pigments (phycobiliproteins) and biostimulants/biopesticides, and ultimately biogas. This approach requires a multidisciplinary research group, which is best suited by combining the expertise of two complementary groups in a coordinated proposal: the Research Group in Environmental Engineering and Microbiology of the Universitat Politècnica de Catalunya (GEMMA-UPC, Subproject 1) and the Department of Chemical Engineering of the University of Almeria (DIQUAL, Subproject 2). The Cyan2Bio project aims to produce bioproducts and bioplastics from cyanobacteria in a sustainable process by:

- Exploration: The productivity of bioplastics is strain-specific, so a wide range of strains should be tested to find highly productive microorganisms. The strains selected will contain pigments and bioactive molecules that should be considered as potential by-products.
- Trials: Selected strains will be produced under different cultivation conditions (both laboratory and large-scale) to identify those that provide the richest biomass of target compounds. For biopolymer production, the organic substrate added after starvation under mixotrophic conditions must be an organic residue (e.g. a mixture of organic sugars from the food industry) to increase the circularity of the process, but this reasoning can be extended to the use of waste streams as a source of nutrients also in the autotrophic production mode.
- Process development: Appropriate production and further processing of the biomass needs to be developed and validated, including monitoring of the biological system and the use of suitable multi-strain cultures that could be better able to cope with environmental changes due to treated waste effluents, and also with eventual competition/predation relationships with micro-organisms present in these waste streams. In addition, the development of biorefineries to maximise product yield and produce other by-products such as biostimulants, biofertilisers or pigments together with PHB will increase the cost-effectiveness of the process.

3.6.9.2.2 New family of ecological and sustainable biopesticides based on microalgae using a circular economy approach (ALGAENAUTS).

Participants:
University of Almeria
BIORIZON BIOTECH SL, Spain
Contacts:
Dr. Francisco Gabriel Acién Fernández (facien@ual.es)
Funds:
TEMFF-BEW-2020 - Call for blue economy SMEs window
Time Period:
December 2023 – March 2024
Current Situation:
In progress
Summary:
Five selected strains with proven antifungal, antibacterial and biostimulant activity will be cultivated using wastewater. The cultivation conditions and operational aspects of microalgae production will be optimised, as well as the yield and efficiency of large-scale production systems. Optimisation of harvesting and downstream processing is mandatory to ensure the most efficient operational cost. Seawater and waste (sewage and pig manure) will be used to achieve sustainable processes. Optimised microalgae systems will be able to operate in continuous mode for six months without collapse, with productivities above 70 t/ha/year, with energy consumptions below 5/m3 and recovering more than 90% of the nutrients contained in the waste. Up to 10 t/ha/year and 2 tP/ha/year will be recovered at a biomass production cost of less than 1.0 €/kg. Objectives:

- Optimisation of large-scale production and processing of microalgae strains with biopesticidal activity for the production of final products: Laboratory optimization of culture conditions to produce selected microalgae strains for enhanced biopesticidal activity. Optimal production of selected strains on a large scale using waste. Optimal harvesting and further processing of biomass for the production of biopesticides and biofertilizers.

- Engineering and scaling for industrial manufacturing processes: Complete engineering development of pilot lines for. Pre-commercial processing. Construction and assembly. Commissioning and optimization.
- Agronomic validation: In vitro and plant tests. Field trials on a pre-commercial scale. Trials with farmers and distributors in real conditions.
- Optimisation of large-scale production and processing of microalgae strains with biopesticidal activity for the production of final products: Laboratory optimisation of cultivation conditions to produce selected microalgae strains for enhanced biopesticidal activity. Optimal production of selected strains on a large scale using waste. Optimal harvesting and further processing of biomass for biopesticide and biofertiliser production.
- Engineering and scale-up for industrial manufacturing processes: Complete development of pilot line engineering for. Pre-commercial processing. Construction and assembly. Commissioning and optimisation.
- Agronomic validation: In vitro and in plant trials. Pre-commercial scale field trials. Trials with farmers and distributors under real conditions.

3.6.9.2.3 Development of early warning systems to improve microalgae PRODUCTION and anaerobic DIGESTION (PRODIGIO)

Participants:
University of Almeria
CSIC
Contacts:
Dr. Francisco Gabriel Acién Fernández (facien@ual.es)
Funds:
Research and Innovation Actions (EU H2020)
Time Period:
October 2021 - June 2024
Current Situation:
In progress
Summary:
The MAIN objective of PRODIGIO is to establish a knowledge base for the development of a system failure prediction technology that will increase the performance of microalgae biomass production and anaerobic digestion systems and move towards a more favourable techno-economic, environmental and social performance for more sustainable microalgae. Biogas. Objectives:
The objective of PRODIGIO is to identify early warnings as a means to avoid process failure by predicting more accurately WHEN it will occur.

3.6.9.2.4 A knowledge-based training network for the digitisation of photosynthetic bioprocesses (DIGITALGAE)

Participants:
University of Almeria
University of Padova
Contacts:
Dr. Francisco Gabriel Acién Fernández (facien@ual.es)
Funds:
Call for Innovative Training Networks (ITN): H2020-MSCA-ITN-2020
Time Period:
October 2021 - June 2024

Current Situation:
In progress
Summary:

DigitAlgaesation aims to propose a digitisation approach to optimise the control and operation of microalgae cultivation processes in order to maximise their light conversion efficiency and drive the sustainable portfolio of microalgae-based processes towards commodity and energy markets. Artificial intelligence and model-based automatic control approaches can be of great help to understand, optimise and, in turn, remedy the gap between lab-scale observations and industrial-scale reality. Objectives:

Propose a digitalisation approach to optimise the control and operation of microalgae cultivation processes in order to maximise their light conversion efficiency and boost the sustainable portfolio of microalgae-based processes towards commodity and energy markets.

3.6.9.2.5 Reuse of Agricultural Effluents to Release Microalgae Potential (REALM)

Participants:
University of Almeria
Nekton
Contacts:
Dr. Francisco Gabriel Acién Fernández (facien@ual.es)
Dr. José Luis Guzmán Sánchez (joseluis.guzman@ual.es)
Funds:
HORIZON-CL6-2021-CIRCBIO-01-09-Unlocking the potential of algae for a thriving European Blue Bioeconomy
Time Period:
July 2022 - June 2026
Current Situation:
In progress
Summary:
The overall objective of REALM is to develop an innovative, sustainable and highly efficient strategy for the production and processing of microalgae biomass, applicable to all European countries. This will be achieved by using a waste product, drainage water from soilless agriculture, rich in nutrients needed for microalgae growth, combined with a continuous microalgae production mode, applied for the first time on an industrial scale: the turbidostat mode. This cultivation mode allows microalgae to grow with maximum productivity, with continuous biomass harvesting and addition of culture medium.

Objectives: Microalgae cultivation facilities will be installed next to the greenhouses to supply drainage water, while centralised processing facilities will convert the microalgae biomass into products.

3.6.9.2.6 Sustainable production of agricultural biostimulants and biopesticides from agricultural residues (GREENFARM)

Participants:
University of Almeria
Contacts:
Dr. José María Fernández Sevilla (jfernand@ual.es)
Funds:
Agencia Estatal de InvestigaciónConvocatoria de proyectos de i+d+i para la realización de "pruebas de concepto", en el marco del programa estatal de i+d+i orientada a los retos de la

sociedad, del plan estatal de investigación científica y técnica y de innovación 2017-2020. convocatoria 2021.

Time Period:

November 2021 – November 2023

Current Situation:

Finished

Summary:

The GREENFARM project aims to develop a sustainable microalgae-based biorefinery to recover more than 90% of the nutrients from agro-industrial waste, while producing value-added biostimulants and biopesticides. The result is a zero-emission process. GREENFARM is based on the partners' extensive proven experience in microalgae production, the use of pig slurry as a source of nutrients, the capacity of microalgae to produce biostimulants and biopesticides, and the market demand for such services and products. . The GREENFARM project is supported by farmers' associations and biotechnology companies, and will be carried out in collaboration with the IFAPA research centre with extensive experience in agriculture.

Microalgae will be used to recover nutrients (carbon, nitrogen and phosphorus) from agro-industrial waste, avoiding the need to use chemical fertilisers that exert a high sustainability pressure on the environment, while at the same time obtaining a benefit from the treatment of this water. copyright. using less energy than that associated with conventional treatment processes. Objectives:

Scaling up of the results of the PURASOL project (completed in 2021) to pilot-scale photobioreactors, evaluation of the process, technical-economic study and sustainability of the process.

3.6.9.2.7 New silica-free advanced agglomerated materials (Silestone® Silica Free Advanced) (FREE ADVANCED-COSENTINO)

Participants:

University of Almeria

Contacts:

Dr. José María Fernández Sevilla (jfernand@ual.es)

Funds:

Agencia Estatal de InvestigaciónConvocatoria de proyectos de i+d+i para la realización de "pruebas de concepto", en el marco del programa estatal de i+d+i orientada a los retos de la sociedad, del plan estatal de investigación científica y técnica y de innovación 2017-2020. convocatoria 2021.

Time Period:

November 2021 – November 2023

Current Situation:

Finished

Summary:

The main objective of the project is to develop the knowledge and technology necessary to redefine the current quartz agglomerates known as Silestone® into agglomerated materials with a quartz and cristobalite content of less than 10% in composition. Objectives:

- Fluid-dynamic study of the process of mixing inerts with resins for the company COSENTINO.
- Decrease the mineral composition below 10%.

3.6.9.2.8 Concentrated Solar Power water regeneration (RAYO)

Participants:
University of Almeria
Contacts:
Dr. J. L. Casas López (jlcasas@ual.es)
Funds:
REGIONAL MINISTRY OF KNOWLEDGE, RESEARCH AND UNIVERSITIES. General Secretariat for Universities, Research and Technology. REGIONAL GOVERNMENT OF ANDALUSIA. Call for grants for "R+D+i projects" universities and public research entities. RETOS modality.
Time Period:
October 2021 – June 2023
Current Situation:
Finished
Summary:
On 25 May 2020, Regulation (EU) 2020/741 of the European Parliament on minimum requirements for water reuse was published, applicable from June 2023. This regulation promotes the reclamation of wastewater in Europe for agricultural irrigation, of particular importance in Almeria. Almeria, with a high water deficit and an economy linked to intensive agriculture. It should also promote the development of sustainable technologies that meet these requirements in an environmentally safe way. This proposal represents a paradigm shift in water disinfection using solar energy, such as the use of concentrated solar radiation. To date, research in this field has been carried out with static collection systems without active solar position tracking. On the one hand, in PET bottles for the disinfection of water for human consumption in areas without direct access to drinking water; on the other hand, in tubular photoreactors with compound parabolic solar collectors (CPC), or open channel reactors (raceway pond reactor, RPR) using the photo-Fenton process that uses iron peroxide and hydrogen together with solar radiation. In this proposal, wastewater will be disinfected, for the first time, with concentrated solar energy, in tubular reactors located in the focal zone of low-cost parabolic trough collectors with concentration factors between 3 and 5. With this, they will operate at temperatures between 60 -70C and UV irradiances of up to 150 W/m2, accelerating the inactivation of microorganisms and the degradation of emerging pollutants. In addition, special attention will be paid to the economics of the process, the impact of regeneration and the economic boost to agriculture focused on the use of renewable resources. This two-year project will lay the scientific and economic foundations for a new technology for the regeneration of clean water for agricultural irrigation. Objectives:

- This project proposes, for the first time, the disinfection of secondary WWTP effluents by concentrated solar radiation in photoreactors operated in continuous mode. The general objectives of the project, taking into account the available funding and the two-year duration, can be summarised as follows:
- Design and build a prototype solar photoreactor with concentration factors between 3 and 5, which can operate in continuous flow.
- To study concentrated solar disinfection from a phenomenological and kinetic point of view. Determine the safe UV dose for all pathogens included in the new European regulations: E. coli, coliphages and spores of sulphate-reducing bacteria.
- Optimise the continuous operating variables of the photoreactor for wastewater reclamation at pilot scale.
- Study the economic feasibility of the proposed new process and investigate the potential of new regeneration technologies in the water market, their impact on the economic development of the region, with particular reference to agriculture and tourism.

3.6.9.2.9 Next Generation Intelligent Water Management Systems: Large-scale demonstrations for a circular economy and society (WATER-MINING)

Participants:

UNIVERSIDAD TÉCNICA DE DELFT (NL)
SEALEAU BV (NL)
KWR AGUA BV (NL)
FUNDACIÓN EURECAT (ES)
UNIVERSIDAD TÉCNICA NACIONAL DE ATENAS (HE)
S.EL.IS LAMPEDUSA SPA (IT)
CIEMAT-PSA (ES)
DECHEMA GESELLSCHAFT FUER CHEMISCHE TECHNIK UND BIOTECHNOLOGIE EV (DE)
UNIVERSIDAD BRUNEL DE LONDRES (REINO UNIDO)
UNIVERSIDAD DE ABERDEEN (Reino Unido)
AGUA EUROPA (BE)
RESOLUCIÓN INVESTIGACIÓN NEDERLAND BV (NL)
UNIVERSITA DEGLI STUDI DI PALERMO (IT)
WETSUS (NL)
UNIVERSIDAD AUTÓNOMA DE BARCELONA (ES)
RED DE IMPLEMENTACIÓN CONJUNTA DE STICHTING (NL)
ACSA OBRAS E INFRAESTRUCTURAS SAU (ES)
INSTITUTO DE COMUNICACIONES Y SISTEMAS INFORMÁTICOS (HE)
HASKONINGDHV NEDERLAND BV (NL)
KANZLER VERFAHRENSTECHNIK GMBH (AT)
JUNTA DE ALCANTARILLADO Y DRENAJE DE LARNACA (CY)
STICHTING NATIONAAL CENTRUM VOOR WETENSCHAPS-EN TECHNOLOGIECOMMUNICATIE (NL)
ACCIONA AGUA SA (ES)
UNIVERSIDAD DE SANTIAGO DE COMPOSTELA (ES)
INSTITUTO DE ESTUDIOS ISRAELÍES DE JERUSALÉN (IL)
AGUAS DEL ALGARVE SA (PT)
REVOLVER (ES)
RED EUROPEA DE LIVING LABS IVZW (BE)
AGUA Y ENERGÍA INTELLIGENCE BV (NL)
LENNTECH BV (NL)
TITAN SALT BV (NL)
ASSOCIATION EUROPEENNE DES EXPOSITIONS SCIENTIFIQUES TECHNIQUES ET INDUSTRIELLES (BE)
SOFINTER SPA (IT)
EL INSTITUTO DEL AZÚCAR VASANTDADA (EN)
ATMOLEVITOS TERMOSOL ANONIMI ETAIREIA (HE)
NOURYON INDUSTRIAL CHEMICALS BV (NL)
FLOATING FARM HOLDING BV (NL)
MADISI LTD (CY)

Contacts:

Dr. Guillermo Zaragoza (guillermo.zaragoza@psa.es)

Funds:

European Commission, Horizon 2020 programme

Time Period:

September 2020 – August 2024

Situación:

In progress

Resumen

Water security is one of the most crucial challenges for water management today. As a consequence, innovative water management solutions and alternative water resources are required. The EU-funded WATER-MINING project will showcase and validate innovative next generation water solutions on a pre-commercial demonstration scale in line with relevant legislation, such as the Water Framework Directive, the Circular Economy and the EU Green Deal packages. It will combine water management services with the enhancement of renewable resources such as mining water. It is envisaged that value-added end products will provide regional resource supplies to increase economic growth. The project will examine different proposed designs for urban wastewater treatment and seawater desalination and innovative service-based business models with the aim of enhancing public and private stakeholder participation. Objectives:

The Water Mining project aims to address the challenge of ensuring access to safe drinking water and sanitation by developing innovative solutions for the sustainable use of alternative water sources, including urban and industrial wastewater and seawater desalination. The project considers water as a resource, a consumable good and a durable good. To capture the full potential of the circular water economy, the WATER-MINING project proposes different strategies for each of these three forms of water, involving six sector-specific case studies (CS).

PSA-CIEMAT, together with UAL-CIESOL, is responsible for CS2, corresponding to one of the two marine mining case studies. In particular, CS2 aims to demonstrate that thermal desalination can improve the sustainability of current technologies (reverse osmosis) for seawater desalination by reaching higher concentrations to facilitate the implementation of Zero Liquid Discharge schemes with lower primary energy consumption (i.e. use of low temperature solar heat). To improve the efficiency of the thermal desalination process, the seawater to be fed to the MED will be pre-treated using a nanofiltration (NF) system to retain divalent ions (Mg2+, Ca2+, SO42-), resulting in a rich and purified sodium chloride (NaCl) permeate stream. By using it as a feed, the recovery of the MED plant can be increased, and also the operating temperature (normally limited to 70ºC to avoid fouling), significantly improving thermal efficiency. The objective is to demonstrate the potential to achieve record low thermal desalination energy consumption (below 25 kWhth/m3) without exceeding 100ºC at Maximum Brine Temperature. In addition, the use of polymeric materials in the MED plant will be evaluated by replacing the metal evaporator tubes to decrease the cost of the desalination plant. To achieve zero liquid discharge desalination, the concentrated brine released from the MED plant will be treated with solar-powered crystallisation. As the MED brine will be free of divalent ions, the salts produced in the crystalliser can be pure NaCl with higher added value. In addition, the brine from the NF system, with a higher concentration of divalent salts, will be used to remineralise the distilled water produced in the MED and crystalliser, for use in irrigation. Divalent ions are tolerated by crops and some act as fertilisers.

3.6.9.2.10 Sustainable membrane distillation for industrial water reuse and decentralised desalination approaching zero waste (MELODIZER)

Participants:

POLITECNICO DE TURIN (IT)
INSTITUTE OF MEMBRANE TECHNOLOGY - CNR-(IT)
AMAPEX ENVIRONMENT (ES)
SOLARSPRING GMBH (DE)
INOTEX SPOL. S.R.O. (CZ)
DELTAMEM AG (CH)
ATHINAIIKI ZYTHOPIIA ANONYMOS ETAIRIA (EL)
WINGS ITC (EL)
AQUABIOTECH (MT)
INNOVATION IN RESEARCH & ENGINEERING SOLUTIONS (BE)
BLUETECH RESEARCH LTD (IE)
CIEMAT (ES)
AALBORG UNIVERSITY (DK)
WARRANG HUB S.P.A. (IT)
POLYMEM (FR)
ENGITS GMBH (DE)
FRAUNHOFER ISE, (DE)
MUNICIPALITY OF EILAT (IL).

Contacts:

Dr. Guillermo Zaragoza (guillermo.zaragoza@psa.es)

Funds:
European Commission, Horizon 2020 programme
Duración prevista:
Dicember 2022 - Dicember 2026
Current Situation:
In progress
Summary:

The overall objective of MEloDIZER is to provide the necessary step to transform membrane distillation (MD) and especially its core components, namely membranes and membrane modules, into products for the benefit of industry and society. MEloDIZER implements high-performance membranes and modules in strategic membrane distillation (MD) applications, thus providing the decisive step for successful MD.

The specific objectives are: (i) the creation of next generation membranes and modules obtained with environmentally friendly and easily scalable approaches; (ii) to rationally integrate innovative core components of membranes and modules with control and energy systems that maximise their performance and enable smart utilisation of renewable energy; (iii) demonstrate the performance of next generation membrane components in the overall system for industrial waste stream reduction, water reuse, resource extraction and drinking water production through decentralised and distributed human-scale MD units; (iv) demonstrate the economic and environmental benefits associated with the implementation of innovative membrane components and the resulting improved MD technology, also providing sustainable end-of-life management of membrane components and systems.

3.6.9.2.11 Circular economy for the production of biostimulant extracts from microalgae by recovery of residual nitrogen and phosphorus (ALCERES)

Participants:
University of Almeria (ES)
BIORIZON BIOTECH
FUNDACION CAJAMAR
Contacts:
Dr. Francisco Gabriel Acién Fernández (facien@ual.es)
Funds:
Aid for public-private collaboration projects, of the state programme to promote scientific-technical research and its transfer, of the state plan for scientific, technical and innovation research 2021-2023, within the framework of the recovery, transformation and resilience plan..
Time Period:
October 2021 – October 2025
Current Situation:
In progress
Summary:
The ALCERES project aims to develop a new and novel line of biostimulants based on microalgae extracts with plant growth promoting activity, in order to provide agriculture with nutritional tools that contribute to reducing the use of chemical nitrogen and phosphorus. In addition, the development of a production process of a Trichoderma fungus, Biorizon Biotech's own, non-commercial to date and with a potent antifungal activity that would be the basis of a new biopesticide that would contribute to the reduction of the use of chemical synthesis phytosanitary products is also proposed as an objective. Objectives:

- Development of microalgae biomass production process in waste streams for N and P recovery.

- Modelling of the cultivation process in waste streams.
- Production of strains with biostimulant activity.
- Maximisation of biostimulant profile based on medium and growing conditions.
- Large-scale cultivation of selected microalgae on an industrial scale.
- Optimisation of cultivation in a pilot raceway system (80 m2, parameters and management).
- Modelling of the crop in an industrial system.
- Development of harvesting methodologies and stabilisation of biomass.
- Cultivation without use of fresh water.
- Open production without contamination.

3.6.9.2.12 Algae for more sustainable and healthier functional foods (ALGA-HUB)

Participants:

UNIVERSIDAD DE ALMERIA
UNIVERSIDAD DE JAEN
UNIVERSIDAD DE MALAGA
UNIVERSIDAD DE CADIZ
PORTOMUIÑOS
BIORIZON

Contacts:

Dr. Francisco Gabriel Acién Fernández (facien@ual.es)

Funds:

Call 2021 'Green Transition and Digital Transition Projects', through the Recovery, Transformation and Resilience Plan.

Time Period:

October 2021 – October 2024

Current Situation:

In progress

Summary

The ALGA-HUB project hypothesises that the latest technologies and knowledge on algae management and production can be integrated to develop and demonstrate processes capable of producing functional foods based on these organisms. Objectives:

- The ALGA-HUB project aims to contribute to the development of healthy foods related to algae for a more sustainable and healthy society, facing three major challenges such as:
- Improve knowledge about algae, their benefits as a source of functional foods and the most relevant factors that determine their production and quality,
- Develop pilot-scale processes for the production of algae-related functional foods and validate them under real conditions.
- Enhance the portfolio of algae-related functional foods, expanding the portfolio of end products and demonstrating their benefits for society.

3.6.9.2.13 Urban wastewater reclamation by integrating solar technologies based on microalgae (secondary treatment) and photo Fenton (tertiary treatment) (INTEGRASOL)

Participants:

University of Almeria

Contacts:

Dr. Jose Jesús Casas Jimenez (jjcasas@ual.es)

Funds:

Ministry of Science and Innovation. Green Transition and Digital Transition Projects 2021

Time Period:
Dicember 2022 – November 2024
Current Situation:
In progress
Summary:
The new European Water Reuse Regulation (WWR-EU) establishes four quality classes of reclaimed water for agricultural irrigation and will enter into force in June 2023. Existing reclamation facilities, which have been in operation for years, will have to upgrade their treatment systems or incorporate new treatments to meet the new quality requirements. In addition to the regulated parameters, water reuse must consider anthropogenic organic micropollutants, antibiotic resistant bacteria and antibiotic resistance genes, collectively designated as Pollutants of Emerging Concern. Objectives:

- The general objective of the proposal is the evaluation of the combination of microalgae-based wastewater treatment with effluent regeneration by solar photo-Fenton in raceway pond reactors operated in continuous flow. For this purpose, the following specific objectives will be addressed:
- Optimise the operating conditions of the secondary treatment with microalgae to minimise the concentration of ammonium, phosphate and carbonate in the effluent. To this end, the effect of hydraulic residence time, cell retention time, biomass concentration and liquid depth on the removal of nutrients C, N and P and pollutants (bacteria, coliphages, organic micropollutants) will be studied.
- To evaluate the influence of the concentration of carbonates, ammonium and phosphates in the solar photo-Fenton reaction in order to establish their limiting concentrations for the combination of both processes, microalgae-based wastewater treatment and secondary effluent regeneration by solar photo-Fenton.
- To optimise the operating conditions of the tertiary treatment based on solar photo-Fenton in order to maximise the treatment capacity while minimising the consumption of reagents.
- Optimise the integration of microalgae-based secondary treatment with solar photo-fenton-based tertiary treatment to maximise treatment capacity and microalgae productivity.
- To assess the presence of micropollutants in the different stages of the integrated process in both water and microalgal biomass, in order to determine the predominant removal mechanism.
- Evaluate from a techno-economic and sustainable point of view the integrated process and its possible full-scale implementation.

3.6.9.2.14 Hybrid cooling solutions for water saving in solar thermal applications (SOLHYCOOL)

Participants:

PSA - CIEMAT
CIESOL
University of Huddersfield (Reino Unido)
Automatics, Robotics and Mechatronics Research Group. University of Almeria (TEP 197)
Desalination and Photosynthesis' Research Group. University of Almeria (BIO 352).

Contacts:
Lidia Roca (lidia.roca@psa.es)
Patricia Palenzuela (patricia.palenzuela@psa.es)
Source of funding:
Call for Knowledge Generation Projects 2021. State Research Agency. Ministry of Science and Innovation and by FEDER A way of doing Europe.

Duration:
September 2022 – August 2025
Status:
Under development
Summary:

The object of this project is to advance in the hybrid cooling technology for its use in solar thermal applications at comercial scale, like are the Concentrating Solar Power plants and the multi-effect distillation plants driven by solar energy and located in land, to thus achieve a reduction in water consumption in such applications. Through the use of methods in automatic control, it should be achieved an optimum management of the operation of the hybrid cooling systems in terms of water consumption avoiding the penalty in the efficiency of the solar thermal applications in which the cooling systems are integrated, thus making the technology feasible from the technical and economical point of views.

3.6.9.2.15 Air Purification And Climate Change Mitigation Through A Decentralised Microalgae Production Approach (CLEAN ·AIR)

Participants:
University of Almeria
Contacts:
Dr. Tomás Valentín Lafarga Poyo (tomas.lafarga@ual.es)
Funds:
Strategic Proj. Orient. Ecological Transition and the Digital Transition 2021Digital 2021
Time Period:
Dicember 2022 – Dicember 2024
Current Situation:
In progress
Summary:

Air pollution is the biggest environmental risk factor for premature death and causes 1 in 9 deaths worldwide. CLEAN-AIR aims to transform cities, major emitters of CO2 and other pollutants, into important components in the implementation of climate change adaptation and CO2 mitigation policies. To this end, the project will develop and validate a novel air filtration process based on microalgae that will ensure safe and comfortable air quality inside buildings regardless of ambient air quality. Objectives:

The project will also develop a novel decentralised microalgae production strategy using buildings and houses as biological factories that will serve a centralised processing facility to produce sustainable food and agricultural products.

3.6.10 Participation in Networks during 2023

Participation in national networks	
Participation in international networks	5

Ibero-American Network for the Treatment of Effluents with Microalgae (RENUWAL)

https://www.cyted.org/renuwal
Funds:
CYTED Ibero-American Science and Technology for Development Programme
Time Period:
2020-2024

Current Situation:
In progress
Objective:
To develop dissemination and training activities, as well as collaborations with companies in the field of microalgae biotechnology applied to wastewater treatment.

International Network for Research and Transfer in Sustainable Processes Based on Microalgae (RITAL)

Participants:
ORGANISATION OF IBERO-AMERICAN STATES FOR EDUCATION, SCIENCE AND CULTURE (OEI)
Contacts:
ORGANISATION OF IBERO-AMERICAN STATES FOR EDUCATION, SCIENCE AND CULTURE (OEI)
Funds:
ORGANISATION OF IBERO-AMERICAN STATES FOR EDUCATION, SCIENCE AND CULTURE (OEI)
Current Situatioin:
In progress
Objetivo:
The RITAL network aims to improve existing knowledge on microalgae-based processes for wastewater treatment and the production of products of agricultural and aquaculture interest, as well as the training of scientists, technologists and professionals in this field, and the transfer of knowledge to the productive sector..

European Algae Biomass Association (EABA)

Participants:
https://www.eaba-association.org/en
Contacts:
carlos.unamunzaga@eaba-association.org
https://www.eaba-association.org/en
Funds:
https://www.eaba-association.org/en
Time Period:
Indefinite
Current Situation:
In progress

EU4Algae Maritime Forum

Participants:
https://maritime-forum.ec.europa.eu/theme/blue-economy-and-fisheries/blue-economy/eu4algae_en
Contacts:
eu4algae@gmail.com
Funds:
European Commission
Time Period:
Indefinite
Current Situation:
In progress

ParAqua COST Action. Applications of zoosporic parasites in aquatic systems (ParAqua) CA20125

Participants:

https://www.cost.eu/actions/CA20125/#tabs+Name:Working%20Groups%20and%20Membership

Contacts:

Dr. Francisco Gabriel Acién Fernández (facien@ual.es)

Funds:

EU ParAqua COST Action

Time Period:

Junuary 2022 – Junuary 2025

Current Situation:

In progress

3.6.11 Transfer and Complementary Activities

Contracts with companies

- Research contract with the company CHLYDRO for the sustainable production of microalgae using CO2 from the air.
- Research contract with the company Biorizon Biotech for the development of improved processes for obtaining biostimulants and biopesticides from microalgae within the ALGENAUTS contract.
- Industrial development contract with the company D&BTech for the installation of new microalgae production reactors (COVAP, CEPSA).

3.6.12 Training and Dissemination Activities

Course Organisation

- Short training for technical staff and scientists, Hydrogen production by solar photocatalysis in presence of organic contaminants, Almería, Spain, 2023.

Other training and outreach activities

- European Researchers' Night 2023 - University of Almeria, Almeria, Spain, 2023
- XII Simposio Ciencias Experimentales San Alberto - University of Almeria, Almeria, Spain, 2023
- Workshop on alternative industrial effluent treatments based on microalgae cultures - Iberoamerican Network for the treatment of effluents with microalgae. Buenos Aires, Argentina 2023
- Workshop on alternative treatments of industrial effluents based on microalgae cultures - Iberoamerican Network for the treatment of effluents with microalgae (RENUWAL). Buenos Aires, Argentina 28 June 2023
- Conference "Uses of microalgae in agriculture and livestock" - SFTT Servicio de Formación y Transferencia Tecnológica de la CARM. Murcia, Spain, 2023
- Algae (Microalgae): New sustainable ingredients for the functional food industry. Lecture to Biotechnology students, UNAP Project Research Team Meeting, Visit to Solarium Biotechnology and Atacama Bio Companies, Definition of future collaborative work. Iquique, Chile 2023.
- Participation in the Almeria Science Fair (4 May)
- Participation in the European Researchers' Night (29 September)
- Educational activities on solar thermal energy and desalination in: IES Pablo Ruiz Picasso de El Ejido (Patricia Palenzuela, 17 February); IES Cerro Milano de Alhama de Almería (Isabel Requena, 21 February); IES Río Aguas de Sorbas (Isabel Requena, 10 April); and IES Sol de Portocarrero (Isabel Requena, 3 May and Alba Ruiz-Aguirre, 16 June).
- Participation in "Noche en las aulas" (IES Bahía de Almería, Patricia Palenzuela, 29 September)

- Participation in "Cafés in the garden" at the Science Park of Granada (Guillermo Zaragoza, 15 June, "Living Lab on Sustainable Desalination: decarbonisation of desalination and recovery of its waste").
- Participation in the workshop "Solar-powered high-recovery groundwater desalination with salt-tolerant crop cultivation for integrated brine management" in Limassol, Cyprus (Guillermo Zaragoza, 26 May).
- Participation in a course on "Use of solar energy in desalination" organised by the Environmental Research Laboratory of Arid Zones Arica, Chile (31 May).
- P. Palenzuela, J.M. Serrano, "Cómo llegamos al mundo de la ciencia y qué se investiga en la PSA", Talk for students of the Instituto de Educación Secundaria (IES) Pablo Ruíz Picasso, 17 February 2023, Almería.
- I. Requena, J.A. Andrés-Mañas, "Uso de la energía solar para obtener agua potable", Talk for students of the Instituto de Educación Secundaria (IES) Cerro Milano, 21 February 2023, Alhama de Almería.
- G. Zaragoza, Innovation for sustainable desalination, INVITED ORAL PRESENTATION. Conference "La desalación y los cultivos marinos en la estrategia andaluza de economía azul sostenible", organised by the Secretaría General de Sostenibilidad, Medio Ambiente, Agua y Economía Azul de la Junta de Andalucía, 19 April 2023, Almería (Spain).
- P. Palenzuela, L. Roca, Concentrating Solar energy and desalination. ORAL PRESENTATION. Conference for the students from Internationa French School in Dubai, 24 april 2023, Almería (Spain).
- I. Requena, J.A. Andrés-Mañas, "Uso de la energía solar para obtener agua potable", Talk for students of the Instituto de Educación Secundaria (IES) Sol de Portocarrero, 3 May 2023, Almería.
- III Science Fair with IES Río Aguas and IES Gaviota (Almería). 4th May 2023. Almería.
- G. Zaragoza, Desalination Technologies. Technology transfer seminar organised by the Environmental Laboratory of Arid Zones (LIMZA) of the University of Tarapacá (Chile), 31 May 2023, Arica (Chile).
- P. Palenzuela, Innovation in desalination with renewable energies. INVITED ORAL PRESENTATION. Thematic panel "Renewable Energies and Climate Change" in the framework of the Andalusian Strategy for a Sustainable Blue Economy, 14 June 2023.
- G. Zaragoza, Solutions for a successful implementation of small-scale desalination. Webinar "Small Scale Desalination" organised by the European Desalination Society, 14 September 2023. (online)
- G. Zaragoza, Water Mining: Sustainable Desalination Living Lab, INVITED ORAL PRESENTATION. Workshop: Regulatory learning with Living Labs. Open Living Lab days, 22 September 2023, Barcelona (Spain).
- P. Palenzuela, L. Roca, "La importancia del agua en plantas termosolares de producción de electricidad", Talk for students of the IES Bahía de Almería on the occasion of the Night in the Classroom, 29 September 2023, Almería.
- European Researchers' Night, 29 September 2023. Almeria.
- G. Zaragoza, Experience with Sustainable Desalination Living Lab, INVITED ORAL PRESENTATION. Workshop "Stakeholder engagement in EU projects - Experiences from the CIRSEAU cluster projects", 7 November 2023. (online).

  G. Zaragoza, Sea Mining case studies in Water Mining project, INVITED ORAL PRESENTATION. Workshop "Critical Raw Materials from unconventional water sources: Ensuring supply through Circular Economy", 17 November 2023, Barcelona (Spain)

3.6.13 Projects requested during 2023

- EU MicroALgae-based Carbon fixation Integrated with Biomass combustion And DEveloped to transform regions' Sustainability – ALCIBIADES

- EU Biogenic CO2 capture into Sustainable Energy Carriers - A novel photosynthetic and hydrogenotrophic CO2 fixation combined with waste nutrient upcycling for production of carbon negative energy carriers (COSEC)
- EU Advancing European seaweed and microalgae production systems for feed and food uses
- Proyecto Life SALTEAU ("Sustainable drinking and irrigation water production from saline alternative water resources") coordinado por Aqualia, PSA (participante), UAL (third party)

3.6.14 Others

Final Degree Projects:

- María Salinas García (Degree in Biotechnology); directors: Ana Sánchez Zurano y Cintia Gómez Serrano
- María Martínez Manresa (Degree in Biotechnology); directors: Tomas Lafarga y Silvia Villaró Cos
- Sandra Valero Cardoso (Degree in Biotechnology); directors: Tomas Lafarga y Silvia Villaró Cos
- Javier Tripiana Martínez (Degree in Biotechnology); directors: Tomas Lafarga y Cristina Cerdá Moreno
- Javier Morales Carrillo (Degree in Biotechnology); directors: Tomas Lafarga y Silvia Villaró Cos
- José Ramón Ruiz Fernández (Degree in Biotechnology); directors: Tomas Lafarga y Cynthia González López

Master's thesis:

- Rubén López Pastor (Master in Solar Energy). Solar Thermal Energy Applied to Microalgae Drying.

Doctoral theses in progress

- Bueso Sánchez, Alejandro (G. Zaragoza, JD Gil)
- Requena Requena, Isabel (G. Zaragoza, JA Andrés-Mañas)
- Serrano Rodríguez, Juan Miguel (Lidia Roca, Patricia Palenzuela).
- Villachica Llamosas, Joyce Gloria (Sixto Malato, Alba Ruiz-Aguirre).
- Rebecca Nordio (Francisco Gabriel Acien Fernández)
- Cristian Inostroza González (José María Fernández Sevilla)
- Pablo Fernández del Olmo (José María Fernández Sevilla)
- José Vicente Reinoso Moreno (Francisco Gabriel Acien Fernández)
- Loreto Cavieres Sena (Francisco Gabriel Acien Fernández)
- Martina Ciardi (José María Fernández Sevilla y Cintia Gómez Serrano)
- Silvia Villaró Cos (Tomas Lafarga)
- Elia Rivera (Tomas Lafarga)

Awards won during 2023

- Cluster Martítimo Marino de Andalucía. 2023.
- Alejandro Bueso Sánchez. Premio mejor trabajo fin de máster Catedra Aqualia. 2023.
- Isabel Requena, Juan Antonio Andrés Mañas y Guillermo Zaragoza. Premio Mejor Póster en el congreso internacional AEDyR `Mirando al futuro del agua´. 2023.

4. COMMITTEES AND ACTIVITY MANAGERS.

4.1 MANAGEMENT OF THE CENTER

Director	**José Luis Casas López** Full Professor, University of Almería joseluis.casas@ual.es
Subdirector	**Sixto Malato Rodríguez** Senior Researcher OPI, CIEMAT-PSA sixto.malato@psa.es

4.2 TECHNICAL EQUIPMENT

Chimical area	**Octavio Malato Rodríguez** omalato@ual.es
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Dissemination and transfer area	**Irene Fernández Gómez** Irene.Fdz@ual.es

4.3 ACTIVITY MANAGERS

Activity	University of Almeria (UAL)	Plataforma Solar de Almería (PSA)
Organometallics and Photochemistry	**Antonio Romerosa** Full Professor of UAL romerosa@ual.es	**Christoph Richter** DLR Resedarcher PSA CIEMAT christoph.richter@dlr.de
Environmental Analysis	**Ana Agüera López** Full Professor of UAL aaguera@ual.es	**Isabel Oller Alberola** Senior Researcher OPI - CIEMAT-PSA isabel.oller@psa.es
Water Regeneration	**José A. Sánchez** Full Professor of UAL jsanchez@ual.es	**Inmaculada Polo López** Senior Researcher OPI - CIEMAT-PSA mpolo@psa.es
Modeling and Automatic Control	**José Domingo Álvarez Hervás** Professor of UAL jhervas@ual.es	**Lidia Roca Sobrino** Senior Researcher OPI - CIEMAT-PSA lroca@psa.es
Desalination and Phostosynthesis	**José M. Fernández** Full Professor of UAL jfernand@ual.es	**Guillermo Zaragoza** Senior Researcher OPI - CIEMAT-PSA guillermo.zaragoza@psa.es
Solar resources and solar cooling research	**Joaquín Alonso Montesinos** Professor of UAL joaquin.alonso@ual.es	**Jesús María Ballestrín Bolea** Senior Researcher OPI - CIEMAT-PSA jballestrin@psa.es

4.3 COORDINATION AND MONITORING COMMITTEE

José Antonio Sánchez Pérez vidiual@ual.es
Vice-Rector for Science Policy, University of Almeria

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Full Profesor University of Almeria

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CIEMAT Research

4.4 EXTERNAL EVALUATION COMMITTEE

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Full Professor of Polytechnic University of Valencia

David Serrano Granados david.serrano@imdea.org
Full Professor of Chemical Engineering and IMDEA-Energy Director

5. ANNEX - DETAILED SCIENTIFIC PRODUCTION OF RESEARCH GROUPS

5.1 ORGANOMETALLIC CHEMISTRY AND PHOTOCHEMISTRY

Articles without collaboration with other CIESOL research groups

- Study of the biological activity of photoactive bipyridyl-Ru(II) complexes containing 1,3,5-triaza-7-phosphaadamantane (PTA). José Manuel Veiga del Pino, Franco Scalambra, Cristina Bermejo-Casadesús, Anna Massaguer, Federico García-Maroto, Antonio Romerosa*. *Journal of Inorganic Biochemistry 246 (2023) 112291. DOI: doi.org/10.1016/j.jinorgbio.2023.112291*
- Tetranuclear Ru_2Cu_2 and Ru_2Ni_2 complexes with nanomolar anticancer activity. Andrés Alguacil, Franco Scalambra, Pablo Lorenzo-Luis, Adrián Puerta, Aday González-Bakker, Zenaida Mendoza, José M. Padrón, Antonio Romerosa*. *Dalton Trans., 2023, 52, 9541–9545. DOI: 10.1039/D3DT01284K*
- Evaluation of the Antiproliferative Properties of CpRu Complexes Containing N-Methylated Triazaphosphaadamantane Derivatives. Andres Alguacil, Franco Scalambra, Antonio Romerosa, Andreia Bento-Oliveira, Fernanda Marques, Ines Maximiano, Rodrigo F. M. de Almeida, Ana Isabel Tomaz, and Andreia Valente. *Bioinorganic Chemistry and Applications, 2023, Article ID 6669394. DOI: doi.org/10.1155/2023/6669394*
- Ru complexes containing N-methyl-1,3,5-triaza-7-phosphaadamantane (mPTA) as catalysts for the isomerization of 2-cyclohexen-1-ol. Belén López-Sánchez, Ana Belén Bohome-Espinosa, Franco Scalambra, Antonio Romerosa. *Applied Organometallic Chemistry, 2023, e6971. DOI: 10.1002/aoc.6971*

Participation in congresses

- Symposium of Rare Earths, Sapporo, 30-31 mayo de 2023
- The 34th Annual Meeting of Photochemistry of Coordination Compounds, 2023, Yamanashi (Japan)

Contributions to conferences

- Water-soluble lanthanide complexes containing mPTAO ligands (N-mthyl-1,3,5-triaza-7-phosphaadamantane-7-oxide). J Veiga, I.F. Diaz-Ortega, F. Scalambra, A. Romerosa, M. Hasegawa. *Symposium of Rare Earths, Sapporo, 30-31 mayo de 2023. Comunicación oral 1A-15.*
- Luminescence properties of lanthanide complexes containing mPTAO ligands (N-methyl-1,3,5-triaza-7-phosphadamantane-7-oxide). J Veiga, F. Scalambra, I.F. Diaz-Ortega, Akinari Abe, Hitomi Ohmagari, M. Hasegawa, A. Romerosa. *The 34th Annual Meeting of Photochemistry of Coordination Compounds, 2023, Yamanashi (Japan). Poster and flash presentation. P57.*

Doctoral theses defended

- Isomerización de Alcoholes Alílicos Catalizada por Complejos de Rutenio Hidrosolubles. María Belén López Sánchez. Universidad de Almeria. FACULTAD/ESCUELA: Departamento de Química y Física. 30/06/2023. Excellent CUM LAUDE Unanimously.
- Nuevos complejos poliheterometálicos con actividad anticancerígena que contienen el ligando dmoPTA (3,7-dimetil-1,3,7-triaza-5 fosfabiciclo[3.3.1]nonano). Andrés Alguacil Alarcón. Universidad de Almeria, 22/09/2023, Excellent CUM LAUDE Unanimously.

5.2 ENVIRONMENTAL ANALYSIS

Articles without collaboration with other CIESOL research groups

- Solar photo-Fenton optimization at neutral pH for microcontaminant removal at pilot plant scale. Hinojosa, M., Oller, I., Quiroga, J.M., Malato, S., Egea-Corbacho, A., Acevedo-Merino. *Environmental Science and Pollution Research, 30 (42), pp. 96208-96218, 2023. DOI: 10.1007/s11356-023-28988-7*.

Articles in collaboration with other CIESOL research groups

- Assessment of new immobilized photocatalysts based on TiO2 for wastewater decontamination. Hernández-Zanoletty, A., Cabezuelo, O., París-Reche, A., Oller, I., Polo-López, M.I., Agüera, A., Plaza, P., Marín, M.L., Boscá, F., Malato, S. *Journal of Environmental Chemical Engineering, 11 (6), art. no. 111291, 2023. DOI: 10.1016/j.jece.2023.111291*
- Pilot-scale sulfate radical-based advanced oxidation for wastewater reuse: simultaneous disinfection, removal of contaminants of emerging concern, and antibiotic resistance genes. Guerra-Rodríguez, S., Abeledo-Lameiro, M.J., Polo-López, M.I., Plaza-Bolaños, P., Agüera, A., Rodríguez, E., Rodríguez-Chueca, J. *Chemical Engineering Journal, 477, art. no. 146916, 2023. DOI: 10.1016/j.cej.2023.146916.*
- Continuous flow operation of solar photo-Fenton fused with NaOCl as a novel tertiary treatment. Attar, S.B.-E., Soriano-Molina, P., Pichel, N., París-Reche, A., Plaza-Bolaños, P., Agüera, A., Pérez, J.A.S. *Journal of Hazardous Materials, 460, art. no. 132354, 2023. DOI: 10.1016/j.jhazmat.2023.132354*.
- Continuous solar photo-Fenton for wastewater reclamation in operational environment at demonstration scale. Gualda-Alonso, E., Pichel, N., Soriano-Molina, P., Olivares-Ligero, E., Cadena-Aponte, F.X., Agüera, A., Sánchez Pérez, J.A., Casas López, J.L. *Journal of Hazardous Materials, 459, art. no. 132101, 2023. DOI: 10.1016/j.jhazmat.2023.132101*.
- Novel Pilot-Scale Photocatalytic Nanofiltration Reactor for Agricultural Wastewater Treatment. Theodorakopoulos, G.V., Arfanis, M.K., Sánchez Pérez, J.A., Agüera, A., Cadena Aponte, F.X., Markellou, E., Romanos, G.E., Falaras, P. *Membranes, 13 (2), art. no. 202, 2023. DOI: 10.3390/membranes13020202*.
- Assessment of solar water disinfection enhancement with H2O2 and dissolved oxygen on inactivating different waterborne pathogens. Martínez-García, A., Nahim-Granados, S., Berruti, I., Oller, I., Polo-López, M.I. *Journal of Environmental Chemical Engineering, 11 (6), art. no. 111145, 2023. DOI: 10.1016/j.jece.2023.111145*.
- Ozonation Vs sequential solar driven processes as simultaneous tertiary and quaternary treatments of urban wastewater: A life cycle assessment comparison. Maniakova, G., Polo López, M.I., Oller, I., Malato, S., Rizzo, L. *Journal of Cleaner Production, 413, art. no. 137507, 2023. DOI:* 10.1016/j.jclepro.2023.137507.
- Peroxymonosulfate/Solar process for urban wastewater purification at a pilot plant scale: A techno-economic assessment. Berruti, I., Nahim-Granados, S., Abeledo-Lameiro, M.J., Oller, I., Polo-López, M.I. *Science of the Total Environment, 881, art. no. 163407, 2023. DOI: 10.1016/j.scitotenv.2023.163407*.
- The reactivity of peroxymonosulfate towards sulfamethoxazole. Berruti, I., López, M.I.P., Oller, I., Laurenti, E., Minella, M., Calza, P. *Catalysis Today, 413-415, art. no. 113975, 2023. DOI: 10.1016/j.cattod.2022.12.006*.
- Microcontaminant removal in solar pilot scale photoreactors with commercial iron nanoparticles obtained from olive mill wastewater. Roccamante, M., Ruiz-Delgado, A., Cabrera-Reina, A., Malato, S., Oller, I., Hernández-Zanoletty, A., Miralles-Cuevas, S. *Catalysis Today, 413-415, art. no. 113968, 2023. DOI: 10.1016/j.cattod.2022.11.029*.

Participation in congresses

- 18 International Conference on Environmental Science & Technology, Atenas, Grecia, 2023.
- V congreso de procesos avanzados de oxidación y II Simposio de Química básica y aplicada, Santiago de Cali, Colombia, 2023.
- IOA World Congress & Exhibition, Milan, Italy, 2023.

- International Conference on Environmental & Food Monitoring (ISEAC 41), Amsterdam, Paises Bajos, 2023.
- XII Asamblea General de la Mesa Española de Tratamiento de Agua, Oviedo, España, 2023.
- XI Simposio de Investigación en Ciencias Experimentales, Almería, España, 2023
- XXII Meeting of the Spanish Society of Chromatography and Related Techniques, S'Arenal, Mallorca, 2023.
- 11th World Congress of Chemical Engineering (WCCE11), Buenos Aires, Argentina, 2023.

Contributions to conferences

- Disinfection by products and toxicity for the treatment of Urban Wastewater Effluent by ozonation at pilot plant. K.J. Castañeda Retavizca, S. Malato, M.I. Polo-López, I. Oller, S. Nahim-Granados, S. Pillai, K. O'Dowd, A. Agüera, P. Plaza-Bolaños. *IOA World Congress & Exhibition, Milan, Italy, 2023 (Poster)*.
- Evaluación analítica de procesos avanzados de oxidación. Ana Agüera. *V congreso de procesos avanzados de oxidación y II Simposio de Química básica y aplicada, Santiago de Cali, Colombia, 2023. (Oral Invitada)*
- Tratamiento, regeneración y valorización de aguas residuales. Monitorización mediante técnicas analíticas y microbiológicas avanzadas. Isabel Oller. *V Congreso Colombiano de Procesos Avanzados de Oxidación (VCCPAOX) y II Simposio Colombiano de química "Nuevas tendencias y desafíos en química verde y ambiental", Universidad del Valle, Cali (Colombia), 3 de noviembre de 2023. (Plenaria invitada)*.
- Photocatalytic nanofiltration reactor for agricultural wastewater purification and reuse. Theodorakopoulos G.V., Arfanis M.K., Agüera A., Cadena-Aponte F.X., Sánchez-Pérez J.A., Markellou E., Romanos G.Em., Falaras P. *18 International Conference on Environmental Science & Technology, Atenas, Grecia, 2023 (Oral)*.
- Evaluation of antibiotic levels in a real water reuse system for agricultural irrigation. P. Plaza-Bolaños, F.X. Cadena-Aponte, S. Nahim-Granados, I. Polo-López, I. Oller, A. Agüera. *International Conference on Environmental & Food Monitoring (ISEAC 41), Amsterdam, Paises Bajos, 2023. (Oral)*.
- Determination of haloacetic acids in reclaimed water and drinking water by direct injection and hydrophilic interaction chromatography coupled with mass spectrometry. E. Jambrina-Hernández, P. Plaza-Bolaños, S. Nahim-Granados, A. París-Reche, I. Oller, A. Agüera. *International Conference on Environmental & Food Monitoring (ISEAC 41), Amsterdam, Paises Bajos, 2023. (Oral)*.
- Organic microcontaminant levels in treated and reclaimed water from wastewater treatment plants in southeastern Spain: are they ready for future EU requirements. P. Plaza-Bolaños, E. Jambrina-Hernández, A. París-Reche, F.X. Cadena-Aponte, I.Rodríguez-Ruano, J.L. Casas-López, F.J. Martínez-Rodríguez, A. Agüera. *International Conference on Environmental & Food Monitoring (ISEAC 41), Amsterdam, Paises Bajos, 2023. (Poster)*.
- Evaluation of the generation of trihalomethanes in reclaimed water produced by advanced chlorination tertiary treatments using headspace and gas chromatography coupled to mass spectrometry. E. Jambrina-Hernández, A. París-Reche, S. Belachqer-El Attar, P. Soriano-Molina, P. Plaza-Bolaños, J.A. Sánchez-Pérez, A. Agüera. *International Conference on Environmental & Food Monitoring (ISEAC 41), Amsterdam, Paises Bajos, 2023. (Poster)*.
- Herramientas analíticas para el diseño de tratamientos de contaminantes de preocupación emergente en aguas, P. Plaza-Bolaños. *XII Asamblea General de la Mesa Española de Tratamiento de Agua, Oviedo, España, 2023. (Oral)*
- Target and suspect analysis of contaminants of emerging concern in water reuse practices: challenges and future perspectives. Ana Agüera, Patricia Plaza-Bolaños, Flor X. Cadena Aponte, Agustín París-Reche, Eva Jambrina. *XXII Meeting of the Spanish Society of Chromatography and Related Techniques, S'Arenal, Mallorca, 2023. (Plenaria Invitada)*.
- Direct injection analysis of haloacetic acids in treated wastewater and drinking water by hydrophilic interaction chromatography coupled to mass spectrometry. Patricia Plaza-Bolaños, Eva Jambrina-Hernández, Samira Nahim-Granados, Agustín Paris-Reche, Ana Agüera. *XXII Meeting of the Spanish Society of Chromatography and Related Techniques, S'Arenal, Mallorca, 2023. (Poster)*.

- Evaluation of pilot-scale advanced oxidation treatments on a real secondary effluent for the removal of contaminants of emerging concern and antibiotic resistance genes. Guerra-Rodríguez, S, Abeledo-Lameiro, M.J., Polo-López, M.I., Plaza-Bolaños, P, Agüera, A., Rodríguez, E, Rodríguez-Chueca, J. *11th World Congress of Chemical Engineering (WCCE11), Buenos Aires, Argentina, 2023.*
- Evaluación química del proceso Foto-Fenton solar para tratamiento de aguas residuales: determinación de contaminantes de preocupación emergente mediante UHPLC-QqLIT-MS/MS. F. X. Cadena-Aponte, P. Plaza-Bolaños, A. Agüera. *XI Simposio de Investigación en Ciencias Experimentales, Almería, España, 2023 (Oral Flash)*.
- Monitoring of antibiotics in a real water reuse agricultural environment: water, soil and tomato. F. X. Cadena-Aponte, S. Nahim-Granados, A. Gonzáles-García, A. Agüera, I. Polo, P. Plaza-Bolaños. *XI Simposio de Investigación en Ciencias Experimentales, Almería, España, 2023 (Cartel)*.
- Development of a direct injection method for the analysis of 224 organic micropollutants in wastewater and drinking water samples using ultra-high performance liquid chromatography coupled to mass spectrometry. E. Jambrina-Hernández, P. Plaza-Bolaños, A. Agüera. *XI Simposio de Investigación en Ciencias Experimentales, Almería, España, 2023 (Cartel)*.
- Sensitive monitoring of estrogens in wastewater and drinking water by ultra-high performance liquid chromatography coupled to mass spectrometry. E. Jambrina-Hernández, P. Plaza-Bolaños, I. Oller, A. Agüera. *XI Simposio de Investigación en Ciencias Experimentales, Almería, España, 2023 (Cartel)*.
- Evaluation of the formation of trihalomethanes in reclaimed water generated by chlorination and solar photo-Fenton processes. A. París-Reche, S. Belachqer, P. Soriano-Molina, P. Plaza-Bolaños, J. A. Sánchez-Pérez, A. Agüera. *XI Simposio de Investigación en Ciencias Experimentales, Almería, España, 2023 (Cartel)*.

Organisation of congresses

- V congreso de procesos avanzados de oxidación y II Simposio de Química básica y aplicada, Santiago de Cali, Colombia, 1-3 noviembre, 2023.

Doctoral theses defended

- Nuevas tecnologías solares aplicadas a la eliminación de contaminantes de preocupación emergente presentes en aguas naturales. Melina A. Roccamante. Departamento de Ingeniería Química. 23 de enero de 2023. Sixto Malato Rodriguez y Sara Miralles Cuevas.

5.3 ADVANCED TECHNOLOGIES FOR WATER REGENERATION

Articles without collaboration with other CIESOL research groups

- Demonstrating the feasibility of a novel solar photo-Fenton strategy for full-scale operationalization according to EU 2020/741 disinfection targets for water reuse. N. Pichel, S. Belachqer-El Attar, P. Soriano-Molina, J.A. Sánchez Pérez. *Chemical Engineering Journal 472 (2023) 144935. DOI: 10.1016/j.cej.2023.144935*

Articles in collaboration with other CIESOL research groups

- The reactivity of peroxymonosulfate towards sulfamethoxazole. I. Berruti, M. I. Polo López, I. Oller, E. Laurenti, M. Minella, P. Calza. *Catalysis Today, 413-415, 113975, 2023. DOI: 10.1016/j.cattod.2022.12.006*
- Ozonation Vs sequential solar driven processes as simultaneous tertiary and quaternary treatments of urban wastewater: A life cycle assessment comparison. G. Maniakova, M.I. Polo López, I. Oller, S. Malato, L. Rizzo. *Journal of Cleaner Production, 413, 137507, 2023. DOI: 10.1016/j.jclepro.2023.137507*
- Assessment of solar water disinfection enhancement with H2O2 and dissolved oxygen on inactivating different waterborne pathogens. A. Martínez-García, S. Nahim-Granados, I. Berruti, I. Oller, M.I. Polo-López. *Journal of Environmental Chemical Engineering, 11, 111145, 2023. DOI: 10.1016/j.jece.2023.111145*
- Peroxymonosulfate/Solar process for urban wastewater purification at a pilot plant scale: A techno-economic assessment. Science of the Total Environment. I. Berruti, S. Nahim Granados, M.J. Abeledo Lameiro, I. Oller, M.I. Polo López. *Science of the Total Environment, 881, 163407, 2023. DOI: 10.1016/j.scitotenv.2023.163407*
- Regeneración de efluentes de EDAR mediante tecnologías solares a escala planta piloto. M.J. Abeledo-Lameiro, K.J. Castañeda Retavizca, A. Hernández-Zanoletty, I. Berruti, S. Nahim-Granados, S. Malato Rodríguez, I. Oller Alberola, M.I. Polo López. *Industria química, 115, 30-3, 2023.*Continuous flow operation of solar photo-Fenton fused with NaOCl as a novel tertiary treatment. S. Belachqer-El Attar, P. Soriano-Molina, N. Pichel, A. París-Reche, P. Plaza-Bolaños, A. Agüera, J.A. Sánchez Pérez. *Journal of Hazardous Materials 460 (2023) 132354. DOI: 10.1016/j.jhazmat.2023.132354*
- Continuous solar photo-Fenton for wastewater reclamation in operational environment at demonstration scale. E. Gualda-Alonso; N. Pichel; P. Soriano-Molina; E. Olivares-Ligero; F.X. Cadena-Aponte; A. Agüera; J.A. Sánchez Pérez; J.L. Casas López. *Journal of Hazardous Materials 459 (2023) DOI: 10.1016/j.jhazmat.2023.132101*
- FentonSims®: A novel interactive simulation tool for computational kinetics of microcontaminant removal by the solar photo-Fenton process. E. Gualda-Alonso, D. Rodríguez-García, P. Soriano-Molina, J.L. Guzmán, J.L. García Sánchez, J.L. Casas López, J.A. Sánchez Pérez. *Chemical Engineering Journal 468 (2023) 143791. DOI: 10.1016/j.cej.2023.143791*
- A novel control system approach to enhance the efficiency of solar photo-Fenton microcontaminant removal in continuous flow raceway pond reactors. D. Rodríguez-García, P. Soriano-Molina, J.L. Guzmán Sánchez, J.L. García Sánchez, J.L. Casas López, J.A. Sánchez Pérez. *Chemical Engineering Journal 455 (2023). 140760. DOI: 10.1016/j.cej.2022.140760*
- Experimental study of wastewater micropollutant removal by solar photo-Fenton using a virtual lab. M.G. Pinna-Hernández, J.L. Casas López, A.B. Esteban García, A.S. Zurano, J.M. Fernández Sevilla. *Computer Applications in Engineering Education 31 (2023) 457–468. DOI: 10.1002/cae.22699*
- Influence of culture media composition on the rheology of microalgae concentrates on a large scale. S. Belachqer-El Attar, A. Morillas-España, A. Sánchez-Zurano, J.L. Casas López, G. Acién. *New Biotechnology 77 (2023) 90-99. DOI: 10.1016/j.nbt.2023.07.005*
- Thermochemical valorization of greenhouse cucumber, tomato and pepper as biofuel. M. Guadalupe Pinna-Hernández, M. J. Díaz Villanueva, M. Cortés-Izurdiaga, S. Jiménez Becker , J.L. Casas López, F.G. Acien Fernández. *Heliyon 9 (2023) e22513. DOI: 10.1016/j.heliyon.2023.e22513*

- Virtual labs for the study of enzymatic stirred tank bioreactors. A. Sánchez Zurano, J.M. Fernández Sevilla, A.B. Esteban García, M.G. Pinna-Hernández, J.L. Casas López. *Computer Applications in Engineering Education 31 (2023) 457–468. DOI: 10.1002/cae.22510*
- Pilot-scale sulfate radical-based advanced oxidation for wastewater reuse: simultaneous disinfection, removal of contaminants of emerging concern, and antibiotic resistance genes. S. Guerra-Rodríguez, M.J. Abeledo-Lameiro, M.I. Polo-López, P. Plaza-Bolaños, A. Agüera, E. Rodríguez, J. Rodríguez-Chueca. *Chemical Engineering Journal, 477, 146916, 2023. DOI: 10.1016/j.cej.2023.146916*
- Assessment of new immobilized photocatalysts based on TiO2 for wastewater decontamination. A. Hernández-Zanoletty, O. Cabezuelo, A. París-Reche, I. Oller, M. I. Polo-López, A. Agüera, P. Plaza, M. L. Marín, F. Boscá, S. Malato. *Computer Applications in Engineering Education, 11, 111291, 2023. DOI: 10.1016/j.jece.2023.111291*

Participation in congresses

- WCCE11 - 11th World Congress of Chemical Engineering, Buenos Aires, Argentina, 2023.
- Water innovation and circularity conference (WIIC), Atenas, Grecia, 2023.
- 6th IWA International Conference on eco-Technologies for Wastewater Treatment, Girona, España, 2023.
- 26th World Congress & Exhibition Ozone and Advanced Oxidation Leading-edge science and technologies, 2023.
- Mesa Española de Tratamiento de Aguas (META). Seminario Técnico sobre Contaminantes Emergentes en Aguas y Lodos. Oviedo, España, 2023.
- 4th Doctoral Colloquium. SFERA-III Solar Facilities for the European Research Area, Cologne, Alemania, 2023.
- 2nd Edition of the International School on Water Reuse, Torino, Italia, 2023.
- 8th International Conference on Semiconductor Photochemistry (SP 8), Strasbourg, Francia, 2023.
- XXII Meeting of the Spanish Society of Chromatography and Related Techniques (SECyTA). S'Arenal, Mallorca, 2023.
- V congreso de procesos avanzados de oxidación. Santiago de Cali, Colombia, 2023.
- VII Reunión Nacional de Grupos de Fotocatálisis, Valencia, España, 2023.
- XII Simposio de investigación en ciencias experimentales 2023, Almeria, España, 2023.
- XII SIMPOSIO DE INVESTIGACIÓN EN CIENCIAS EXPERIMENTALES 2023. Universidad de Almería, España, 2023.
- International Conference on Environmental & Food Monitoring (ISEAC-41), Amsterdam, Paises Bajos, 2023.

Contributions to conferences

- Peroxymonosulfate/Solar process for the simultaneous disinfection and decontamination of urban wastewater at pilot plant scale. I. Berruti, S. Nahim-Granados, M.J. Abeledo-Lameiro, I. Oller, M.I. Polo-López. *6th IWA International Conference on eco-Technologies for Wastewater Treatment, Girona, España, 2023. (Oral)*
- Natural based solutions combined with solar processes at pilot scale for urban wastewater reclamation. A. Hernández-Zanoletty, P. Simón, S. Nahim-Granados, I. Oller, M.I. Polo-López. *6th IWA International Conference on eco-Technologies for Wastewater Treatment, Girona, España, 2023. (Oral)*
- Evaluation of pilot-scale advanced oxidation treatments on a real secondary effluent for the removal of contaminants of emerging concern and antibiotic resistance genes. S. Guerra-Rodríguez, M.J. Abeledo-Lameiro, M.I. Polo-López, P. Plaza-Bolaños, A. Agüera, E. Rodríguez, J. Rodríguez-Chueca. *WCCE11 - 11th World Congress of Chemical Engineering, Buenos Aires, Argentina, 2023. (Oral)*

- Development of SODIS technologies for the effective disinfection of drinking water: Microbicidal efficacy, toxicity and long-term use. K. O'Dowd, I. Oller, M.I. Polo-López, J. Marugán, H. Gómez-Couso, R. Marasini, K.G McGuigan, S.C. Pillai. *WCCE11 - 11th World Congress of Chemical Engineering, Buenos Aires, Argentina, 2023. (Oral)*
- AQUACYCLE project: anaerobic bioreactors combined with natural based solutions and solar open photoreactors for wastewater recovery. A. Hernández-Zanoletty, P. Simón, S. Nahim-Granados, I. Oller, M.I. Polo-López, K. Plakas. *Water innovation and circularity conference (WIIC), Atenas, Grecia, 2023. (Oral)*
- Urban wastewater treatment by ozonation: pathogens and microcontaminants removal, disinfection byproducts and toxicity evaluation. K.J. Castañeda Retavizca, K. O'Dowd, S. Nahim-Granados, P. Plaza-Bolaños, S. Malato, M.I. Polo-López, S. Pillai, A. Agüera, I. Oller. *26th World Congress & Exhibition Ozone and Advanced Oxidation Leading-edge science and technologies, Milan, Italia, 2023. (Flash & Poster)*
- Nuevo tratamiento sostenible de regeneración de aguas residuales para reúso en riego agrícola: cloro-foto-Fenton. S. Belachqer-El Attar, P. Soriano-Molina, A. Paris, E. Gualda-Alonso, E. Olivares-Ligero, A. Agüera, J.A. Sánchez Pérez. *Mesa Española de Tratamiento de Aguas (META). Seminario Técnico sobre Contaminantes Emergentes en Aguas y Lodos. Oviedo (España), 2023. (Oral)*
- Acoplamiento de procesos UVC-LED y foto-Fenton/UVA-LED en reactores de flujo continuo para la regeneración de aguas residuales con eliminación simultánea de microcontaminantes. M.G. Pinna-Hernández, A.G. Trovó, P. Soriano-Molina, D. Rodríguez-García, J.L. Casas López, J.A. Sánchez Pérez. *Mesa Española de Tratamiento de Aguas (META). Seminario Técnico sobre Contaminantes Emergentes en Aguas y Lodos. Oviedo (España), 2023. (Oral)*
- Assessment of two solar photoreactor´s design for water decontamination using photo Fenton reactions. K.J. Castañeda Retavizca, M.I. Polo-López, S. Malato. *4th Doctoral Colloquium. SFERA-III Solar Facilities for the European Research Area, Cologne, Alemania, 2023. (Oral)*
- Decontamination of secondary wastewater treatment plant effluents by TiO2 immobilized on silica support. A. Hernández-Zanoletty, I. Oller, M. I. Polo-López, O. Cabezuelo, M. L. Marín, F. Boscá, S. Malato. *8th International Conference on Semiconductor Photochemistry (SP 8), Strasbourg, Francia, 2023. (Flash & Poster)*
- Design and assessment of low cost solar photocatalytic reactors for water treatment. I. Espinoza Pavón, I. Berruti, S. Nahim Granados, I. Oller, S. Malato, M.I. Polo López. *2nd Edition of the International School on Water Reuse, Torino, Italia, 2023. (Poster)*
- Direct injection analysis of haloacetic acids in treated wastewater and drinking water by hydrophilic interaction chromatography coupled to mass spectrometry. P. Plaza-Bolaños, E. Jambrina-Hernández, S. Nahim-Granados, A. Paris-Reche, A. Agüera. *XXII Meeting of the Spanish Society of Chromatography and Related Techniques (SECyTA). S'Arenal, Mallorca, España, 2023 (Poster)*
- Evaluación de un fertilizante comercial y biodegradable (Fe3+-IDHA) como fuente de hierro para el tratamiento de agua mediante foto-Fenton solar a pH neutro. S. Nahim-Granados, I. Berruti, I. Oller, M.I. Polo López, S. Malato. *V congreso de procesos avanzados de oxidación. Santiago de Cali, Colombia, 2023 (Oral)*
- Evaluación de nuevos fotocatalizadores soportados para la regeneración de aguas residuales urbanas en la Plataforma Solar de Almería. A. Hernández-Zanoletty, A. Ruiz-Delgado, I. Espinoza Pavón, I. Berruti, S. Nahim-Granados, M.J. Abeledo-Lameiro, M. I. Polo-López, I. Oller, S. Malato. *VII Reunión Nacional de Grupos de Fotocatálisis, Valencia, España, 2023. (Oral)*
- Optimization of solar photo-Fenton as a pretreatment for microalgae-based piggery wastewater to reduce water inputs. A. Ferreira, S. Belachqer-El Attar, S. Villaró, M. Ciardi, P. Soriano-Molina, T. Lafarga, C. Marques-dos-Santos, F.G. Acién, L. Gouveia. *XII Simposio de investigación en ciencias experimentales 2023. Almería (España), 15 de noviembre de 2023. (Oral)*
- Pioneering in the scale-up of chlor-photo-Fenton as an eco-sustainable solution for water reuse in agriculture. S. Belachqer-El Attar, P. Soriano-Molina, A. París-Reche, E. Jambrina-Hernández, A. Agüera, J.A. Sánchez Pérez. *XII Simposio de Investigación en Ciencias Experimentales 2023. Almería (España), 2023 (Poster)*
- Feasibility of the application of TiO2 immobilization on stainless steel substrate for development of photocatalytic reactors. I. Espinoza-Pavón, I. Berruti, S. Nahim-Granados, I. Oller, S. Malato, M. I. Polo-

López, C. Monteserín, H. Zarrabe, A. Martinez, M. Blanco. *XII Simposio de Investigación en Ciencias Experimentales 2023, Almeria, España, 2023. (Poster)*

- Urban wastewater treatment by ozonation: pathogens and microcontaminants removal, disinfection byproducts and toxicity evaluation. K. Castañeda Retavizca, K. O'Dowd, S. Nahim-Granados, P. Plaza-Bolaños, S. Malato, M.I. Polo-López, S. Pillai, A. Agüera, I. Oller. *XII Simposio de investigación. Universidad de Almería, España, 2023. (Poster)*
- Evaluation of antibiotic levels in a real water reuse system for agricultural irrigation. P. Plaza-Bolaños, F.X. Cadena-Aponte, S. Nahim-Granados, M.I. Polo-López, I. Oller, A. Agüera. *International Conference on Environmental & Food Monitoring (ISEAC-41), Amsterdam, Paises Bajos, 2023. (Oral)*.
- Determination of haloacetic acids in reclaimed water and drinking water by direct injection and hydrophilic interaction chromatography coupled with mass spectrometry. E. Jambrina Hernández, P. Plaza Bolaños, S. Nahim Granados, A. Paris Reche, I. Oller Alberola, A. Agüera Lopez. *ISEAC-41 International Conference on Environmental & Food Monitoring. Amsterdam, The Netherlands, 2023. (Oral)*

Doctoral theses defended

- Aprovechamiento de residuos vegetales de invernadero para calefacción y enriquecimiento carbónico. José Vicente Reinoso Moreno. Almería, 28/04/2023, Sobresaliente Cum Laude. Programa de Doctorado en Biotecnología y Bioprocesos Industriales Aplicados a la Agroalimentación y el Medio Ambiente. (Directores: Gabriel Acien Fernández y Mª Guadalupe Pinna Hernández)

5.4 MODELLING AND CONTROL

Articles without collaboration with other CIESOL research groups

- A GIS-AHP approach for determining the potential of solar energy to meet the thermal demand in southeastern Spain productive enclaves. J.A. Romero-Ramos, J.D. Gil, J.M. Cardemil, R.A. Escobar, I. Arias, M. Pérez. *Renewable & Sustainable Energy Reviews, 176, 113205, 2023. DOI: 10.1016/j.rser.2023.113205.*
- A hierarchical optimization strategy in the intelligent ecological control of the greenhouse downy mildew. L. Ran, J.L. Guzmán, J.D. Gil, Y. Xinting, L. Ming. *Computers and Electronics in Agriculture, 214, 108337, 2023. DOI: 10.1016/j.compag.2023.108337.*
- A hybrid-MPC based energy management system with time series constraints for a bioclimatic building. A. Topa, J.D. Gil, J.D. Álvarez, J.L. Torres. *Energy, 287, 129652, 2023. DOI: 10.1016/j.energy.2023.129652*
- A learning-based model predictive strategy for pH control in raceway photobioreactors with freshwater and wastewater cultivation media. I. Pataro, J.D. Gil, J.L. Guzmán, M. Berenguel, J. Lemos. *Control Engineering Practice, 138, 105619, 2023. DOI: 10.1016/j.conengprac.2023.105619.*
- A practical solution to the saturation problem in feedforward control for measurable disturbances. Á. Hoyo, T. Hägglund, J.L. Guzmán, J.C. Moreno. *Control Engineering practice, 139, 105636, 2023. DOI: 10.1016/j.conengprac.2023.105636.*
- A Soft Sensor to Estimate the Opening of Greenhouse Vents Based on an LSTM-RNN Neural Network. M- Guesbaya; F. García-Mañas, F. Rodríguez, H. Megherbi; Sensors*, 2023. DOI: 10.3390/s23031250.*
- A Stochastic Nonlinear Predictive Controller for Solar Collector Fields Under Solar Irradiance Forecast Uncertainties. I. M. L. Pataro, J. D. Gil, M. V. A. da Costa, L. Roca, J. L. Guzman, and M. Berenguel. *IEEE Trans. Control Syst. Technol., pp. 1–13, 2023, DOI: 10.1109/TCST.2023.3298230.*
- Balancing CO2 Emissions And Economic Cost In A Microgrid Through An Energy Management System Using Mpc And Multi-Objective Optimization. L. Polanco, J.L. Redondo, J.D. Alvarez, V. Ramirez, J.L. Torres-Moreno. *Applied Energy, 347, 120998, 2023. DOI: 10.1016/j.apenergy.2023.120998.*
- Cloud Detection and Tracking Based on Object Detection with Convolutional Neural Networks. J. A. Carballo, J. Bonilla, J. Fernández-Reche, B. Nouri, A. Avila-Marin, Y Fabel, & D. Alarcón-Padilla. *Algorithms, 16(10), 487.2023. DOI: 10.3390/a16100487.*
- Estrategia de control selectivo de temperatura y humedad para un invernadero solar chino con un enfoque basado en eventos. R. Liu, J. L. Guzmán, F.G. Mañas, and M. Li. *Revista Iberoamericana de Automática e Informática industrial, 20(2), pp. 150–161, 2023. DOI: 10.4995/riai.2022.18119.*
- Hierarchical control based on a hybrid nonlinear predictive strategy for a solar-powered absorption machine facility. I. Pataro, J.D. Gil, J.L. Guzmán, M. Berenguel, J. Lemos. *Energy*, 271, 126964, 2023. DOI: 10.1016/j.energy.2023.126964.
- Improving Temperature Tracking Control for Solar Collector Fields Based on Reference Feedforward. I. M. L. Pataro, J. D. Gil, M. V. A. da Costa, L. Roca, J. L. Guzman, and M. Berenguel. *IEEE Trans. Control Syst. Technol., pp. 1–12, 2023, DOI: 10.1109/TCST.2023.3273398*.
- Hybrid System of Photovoltaic and Solar Thermal Technologies for Industrial Process Heat. Rosales-Pérez JF, Villarruel-Jaramillo A, Romero-Ramos JA, Pérez-García M, Cardemil JM, Escobar R. *Energies 16(5):2220, . 2023; DOI: 10.3390/en16052220.*
- Modeling and Performance Evaluation of Hybrid Solar Cooling Systems Driven by Photovoltaic and Solar Thermal Collectors—Case Study: Greenhouses of Andalusia. Villarruel-Jaramillo A, Rosales-Pérez JF, Pérez-García M, Cardemil JM, Escobar R. *Energies. 16(13):4888. 2023; DOI: 10.3390/en16134888.*
- Modeling and Energy Management of a Microgrid Based on Predictive Control Strategies. A. Topa, J.D. Gil, J.D. Alvarez, J.L. Torres-Moreno, P.G. Manuel. *Solar, vol. 3, no. 1, pp. 62-73, 2023. DOI: 10.3390/solar3010005.*
- Multi-scenario model predictive control for greenhouse crop production considering market price uncertainty. F. García-Mañas, F. Rodríguez, M. Berenguel, and J. M. Maestre. *IEEE Trans. Autom. Sci. Eng., 2023. DOI: 10.1109/TASE.2023.3271896.*

- MultiVehicle Simulator (MVSim): lightweight dynamics simulator for multiagents and mobile robotics research. J.L. Blanco, B. Tymchenko, F. Mañas-Alvarez, F. Cañadas-Aránega, A. López-Gázquez, J.C. Moreno. *SoftwareX, 23, 101443, 2023. DOI: 10.1016/j.softx.2023.101443.*
- On the optimal demand-side management in microgrids through polygonal composition. A. Topa, N.C. Cruz, J.D. Alvarez, J.L. Torres-Moreno. *Sustainable Energy, Grids and Networks, 34, 101066, 2023. DOI: 10.1016/j.segan.2023.101066.*
- Optimal model-free adaptive control based on reinforcement Q-Learning for solar thermal collector fields. I. Pataro, Rita Cunha, J.D. Gil, J.L. Guzmán, M. Berenguel, J. Lemos. *Engineering Applications of Artificial Intelligence*, *126, 106785, 2023. DOI: 10.1016/j.engappai.2023.106785.*
- Performance study of disturbance rejection in linear quadratic controllers: A practical adaptive tuning method. I. Pataro, J.D. Gil, J.L. Guzmán, J. Lemos. *Revista Iberoamericana de Automática e Informática Industrial*, 17, 329-343, 2023. DOI: 10.4995/riai.2023.19703.
- Predictive control strategies for solar furnace systems on the basis of practical constrained solutions. Pataro, J.D. Gil, J.L. Guzmán, M. Berenguel, I. Cañadas. Journal of Process Control, 132, 103114, 2023. DOI: 10.1016/j.jprocont.2023.103114.

Articles in collaboration with other CIESOL research groups

- A novel control system approach to enhance the efficiency of solar photo-Fenton microcontami- nant removal in continuous flow raceway pond reactors. D. Rodríguez-García, P. Soriano-Molina, J. L. Guzmán, J.L, García, J.L. Casas, and J.A. Sánchez- Pérez. *Chemical Engineering Journal, 455, 140760, 2023. DOI: 10.1016/j.cej.2022.140760.*
- An artificial intelligence approach for identification of microalgae cultures. P. Otálora, J.L. Guzmán, F.G. Acién, M. Berenguel, A. Reul. *New Biotechnology, 77, pp. 58-67, 2023. DOI: 10.1016/j.nbt.2023.07.003.*
- Application of Machine Learning to Characterize the Permeate Quality in Pilot-Scale Vacuum-Assisted Air Gap Membrane Distillation Operation. I. Requena, J.A. Andrés-Mañas, J.D. Gil, G. Zaragoza. *Membranes, 13, 857, 2023. DOI: 10.3390/membranes13110857*.
- Data-driven online feedback optimization of solar membrane distillation systems operating in batch mode. J. D. Gil, A. Bueso, L. Roca, G. Zaragoza, and M. Berenguel. *J. Process Control, vol. 129, p. 103056, 2023, DOI: 10.1016/j.jprocont.2023.103056.*
- Data-Driven pH Model in Raceway Reactors for Freshwater and Wastewater Cultures. P. Otálora, J.L. Guzmán, M. Berenguel, F.G. Acién. *Mathematics, 11(7), 1614, 2023. DOI: 10.3390/math11071614.*
- FentonSimsR : A novel interactive simulation tool for computational kinetics of microcontaminant removal by the solar photo-Fenton process. E. Gualda-Alonso, D. Rodríguez-García, P. Soriano-Molina, J. L. Guzmán, J.L. García Sánchez, J.L. Casas López, J.A. Sánchez Pérez. *Chemical Engineering Journal, 468, 143791, 2023. DOI: 10.1016/j.cej.2023.143791.*
- Influence of pH and dissolved oxygen control strategies on the performance of pilot-scale microalgae raceways using fertilizer or wastewater as the nutrient source. R. Nordio, E. Viviano, A. Sánchez-Zurano, J. González-Hernández, E. Rodríguez-Miranda, J. L. Guzmán, and F.G. Acién. *Journal of Environmental Management, 345(1), 118899, 2023. DOI: 10.1016/j.jenvman.2023.118899.*
- Long-term assessment of the nutrient recovery capacity and biomass productivity of Scenedesmus almeriensis in raceway reactors using unprocessed urban waste- water. R. Nordio, F.J. Delgado, A. Sánchez-Zurano, J. González-Hernández, E. Rodríguez-Miranda, J. L. Guzmán, T. Lafarga, and F.G. Acién. *Bioresource Technology, 369, 128374, 2023. DOI: 10.1016/j.biortech.2022.128374.*
- Modelado y control del pH en la producción de microalgas en reactores raceway usando técnicas de adaptación de parámetros. M. Caparroz, P. Otálora, J. L. Guzmán, M. Berenguel, and F. G. Acién. *Revista Iberoamericana de Automática e Informática industrial, 20(4), pp. 379–388, 2023. DOI: 10.4995/riai.2023.19103*.

Participation in congresses

- 14th European Congress of Chemical Engineering & 7th European Congress of Applied Biotechnology, Berlin, Germany, 2023.
- 19th International Conference on Artificial Intelligence Applications and Innovations, León, Spain, 2023.
- 2º Simposio Conjunto de los Grupos Temáticos de CEA: Modelado, Simulación, Optimización e Ingeniería de Control, Madrid, España, 2023.
- 24th Nordic Process Workshop (NPCW), Trondheim, Noruega, 2023.
- 29th SolarPACES Conference, Sydney, Australia, 2023.
- 2023 European Control Conference (ECC). Bucharest, Romania, 2023.
- 9th International Conference on Control, Decision and Information Technologies (CoDIT), Roma, Italia, 2023.
- AlgaEurope, Prague, Czech Republic, 2023.
- Desalination for the Environment: Clean Water and Energy, Limassol, Chipre, 2023.
- European Congress of Marine Biotechnologies, Málaga, Spain, 2023.
- *IEEE International Workshop On Metrology For Agriculture And Forestry, Pisa, Italia, 2023.*
- IFAC World Congress, Yokohama, Japón, 2023.
- International Symposium on Models for Plant Growth, Environments, Farm Management in Orchards and Protected Cultivation, HorchiModel2023, Almería, España, 2023.
- International Symposium on New Technologies for Sustainable Greenhouse Systems, GreenSys2023, Cancún, México, 2023.
- IX Congreso de Comunicación Social de la Ciencia (CCSC2023), Granada, España, 2023.
- Open Living Lab Days, Barcelona, España, 2023.
- XIII Congreso Internacional de AEDyR, Granada, España, 2023.
- XLIV Jornadas de Automática, Zaragoza, España, 2023.
- XXIV Congreso Nacional de Ingeniería Mecánica, Las Palmas de Gran Canaria, 2023.
- VI Jornadas de Doctorado en Informática (JDI'2023), Almería, España, 2023.
- Workshop Andanzas y Desafíos en Control Predictivo, Sevilla, España, 2023.

Contributions to conferences

- A new method to deal with the saturation problem in feedforward control for measurable disturbances. Á. Hoyo, T. Hägglund, J.L. Guzmán, J.C. Moreno. *24th Nordic Process Control Workshop, Trondheim, Noruega, 2023 (abstract, oral)*.
- Advances in Control and Optimization Techniques in Sustainable Water Desalination Using Solar Energy and Application Examples in the Water-energy-food Nexus. Berenguel, M., J.D. Gil. Semi-Plenary talk. *Preprints of the 22nd IFAC World Congress, 8267, Yokohama, Japan, 2023. (Oral)*
- An IoT service of temperature setpoints for tomato crop control in greenhouse. M. Muñoz, J. Ramos-Teodoro, F. García-Mañas, and F. Rodríguez. *International Symposium on Models for Plant Growth, Environments, Farm Management in Orchards and Protected Cultivation, HorchiModel2023, Almería, España, 2023. (Artículo, póster)*.
- Characterization of an Absorption Machine Using Artificial Neural Networks. A. Ferre, M. Castilla, J.A. Carballo, J.D. Álvarez. *19th International Conference on Artificial Intelligence Applications and Innovations, León, Spain, 2023, (oral, artículo)*.
- Comparison between an artificial neural network and Poppe's model for wet cooling tower performance prediction in CSP plants. P. Navarro, JM. Serrano, L. Roca, P. Palenzuela, M. Lucas, J. Ruiz. *Proceedings of ECOS 2023 - the 36th international conference on efficiency, cost, optimization,*

simulation and environmental impact of energy systems, Las Palmas de Gran Canaria, Spain, 2023, (artículo)

- Contribuciones de control robusto para sistemas sometidos a perturbaciones. Á. Hoyo. *VI Jornadas de Doctorado en Informática, Almería, España, 2023 (oral)*.
- Control del circuito de refrigeración en instalaciones de destilación por membranas. A. Bueso, J.D. Gil, I. Requena, L. Roca, J. Liría-García, M. Berenguel. *XLIV Jornadas de Automática, Zaragoza, España, 2023, (póster, artículo)*
- Control issues in solar furnaces. M. Berenguel, J.D. Gil, J.L. Guzmán, L. Roca, I. Cañadas. *24th Nordic Process Control Workshop, Trondheim, Norway, 2023. (Oral)*
- Control óptimo basado en un controlador cuadrático lineal con acción de control por adelanto para hornos solares. I. Pataro, J.D. Gil, José L. Guzmán, J. Lemos, M. Berenguel. *XLIV Jornadas de Automática, Zaragoza, España, 2023, (oral, póster, artículo)*
- Control y optimización de la producción de cultivos bajo invernadero. F. García-Mañas. *2º Simposio Conjunto de los Grupos Temáticos de CEA: Modelado, Simulación, Optimización e Ingeniería de Control, Madrid, España, 2023. (Artículo, oral)*.
- CSP Data: a Data Discovery Web Application of Commercial CSP Plants. J. Bonilla, R. Thonig, J.A. Carballo, J. Lilliestam, D.C. Alarcón-Padilla, E. Zarza. *29th SolarPACES Conference. 2023. Sydney, Australia. 2023 (póster, artículo)*.
- Data-driven model predictive control for pH regulation in raceway reactors. Otálora, P., J.L. Guzmán, J.D. Gil, M. Berenguel, F.G. Acién. IFAC PapersOnLine, 56(2), 6223-6228, 2023. https://doi.org/10.1016/j.ifacol.2023.10.746. *Preprints of the 22nd IFAC World Congress, 10325-10330, Yokohama, Japan, 2023. (Oral)*
- Data-driven modelling and predictive control solutions for pH control in microalgae-based processes. P. Otálora, J.L. Guzmán, J.D. Gil, M. Berenguel. *24th Nordic Process Control Workshop, Trondheim, Noruega, 2023 (abstract, oral)*.
- Desarrollo de modelos de predicción de radiación solar mediante técnicas de machine learning. V. Abad-Alcaraz, M. Castilla, J.D. Álvarez, J.A. Carballo, J. Bonilla. *XLIV Jornadas de Automática, Zaragoza, España, 2023, (póster, artículo)*.
- *Development of a Data Integration Architecture for Modern Sustainable Farming Systems: A Greenhouse Test Case. IEEE International Workshop On Metrology For Agriculture And Forestry, Pisa, Italia, 2023 (Articulo, oral)*.
- Economic analysis of a photovoltaic field on a greenhouse roof. J. A. Sánchez, F. García-Mañas, J. Ramos-Teodoro, and F. Rodríguez. *International Symposium on New Technologies for Sustainable Greenhouse Systems, GreenSys2023, Cancún, México, 2023. (Artículo, oral)*.
- Enhancing microalgae-based wastewater treatment efficiency through pH, dissolved oxygen and culture height optimization in raceway reactors. R. Nordio, J.L. Guzmán, F.G. Acién. *European Congress of Marine Biotechnologies 2023, Málaga, Spain. (Oral)*
- Evaluación del pretratamiento de agua de mar con nanofitración en procesos de destilación multiefecto alimentados con energía solar. L. Roca, P. Palenzuela, J. M. Serrano, D.-C. Alarcón Padilla, M. I. Maldonado, and G. Zaragoza. *XIII Congreso Internacional de Aedyr, Granada, España, 2023, (Oral)*
- Evaluación térmica de un captador cilindroparabólico de pequeña apertura. M. Leal, J.D. Álvarez, M. Castilla, J.L. Torres, M. Pérez. *XLIV Jornadas de Automática, Zaragoza, España, 2023, (póster, artículo)*.
- Increasing biomass productivity in microalgae pilot scale race- way reactors through optimal pH and dissolved oxygen control strategies. R. Nordio, J.L. Guzmán, F.G. Acién. *AlgaEurope, Prague, Czech Republic, 2023 (poster)*.
- Modelado y control del proceso de producción de microalgas mediante estrategias de aprendizaje automático. P. Otálora. *VI Jornadas de Doctorado en Informática, Almería, España, 2023 (oral)*.
- Multivariable control of nighttime temperature and humidity in greenhouses combining heating and dehumidification. García-Mañas, F., T. Hägglund, J.L. Guzmán, F. Rodríguez, M. Berenguel. IFAC

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- Operación óptima de un sistema de refrigeración combinada. J.M. Serrano, J.D. Gil, J. Bonilla, P. Palenzuela, L. Roca. *XLIV Jornadas de Automática, Zaragoza, España, 2023 (Oral, póster, Visual-Abstract, artículo)*
- Optimal control of solar collector fields based on linear quadratic controller with accessible disturbance. I. Pataro, J.D. Gil, J. L. Guzmán, M. Berenguel, and J. Lemos. *2023 European Control Conference (ECC), Bucharest, Romania, 2023 (artículo, oral)*.
- pH and dissolved oxygen control strategies as a key to improve microalgal biomass production in pilot scale raceway reactors. R. Nordio, J.L. Guzmán, F.G. Acién. *14th European Congress of Chemical Engineering & 7th European Congress of Applied Biotechnology, Berlin, Germany, 2023 (oral)*
- Robot tipo Ackermann para tareas de monitorización en edificio bioclimático. J.L. Torres Moreno, J.L. Blanco Claraco, J.D. Álvarez Hervás, M. Castilla. XXIV *Congreso Nacional de Ingeniería Mecánica, Las Palmas de Gran Canaria, España, 2023 (artículo, oral)*.
- Selecting Control Schemes and Tuning Rules in Feedforward Control. J.L. Guzmán, T. Hägglund. *22nd IFAC World Congress. Yokohama, Japan, 2023 (oral)*
- Simultaneous Minimization of Energy Cost and CO 2 Emissions in a Microgrid. J. L. Redondo, J. D. Álvarez, L. O. Polanco, J. L. Torres, V.M. Ramírez. *9th International Conference on Control, Decision and Information Technologies (CoDIT). Rome, Italy, 2023 (oral)*
- Strategies for enhancing the use of solar energy in utility-scale desalination plants. G. Zaragoza, D.C. Alarcón-Padilla, J. Bonilla, P. Palenzuela. *International Association Desalination (IDA) Seville Summit on Water and Climate Change, October Zaragoza, Spain, 2023 (oral, artículo)*.
- Using interactive tools to connect theory and practice. Guzmán, J.L., M. Berenguel, S. Dormido, R. Costa. IFAC PapersOnLine, 56(2), 9606-9611, 2023. https://doi.org/10.1016/j.ifacol.2023.10.265 *Preprints of the 22nd IFAC World Congress, 10325-10330, Yokohama, Japan, 2023 (Oral)*.
- Uso de algoritmo genético para gestionar la demanda energética en microrredes mediante descomposición poligonal. A.O. Topa, N.C. Cruz, J.D. Álvarez, J.L. Torres. *XLIV Jornadas de Automática, Zaragoza, España, 2023 (póster, artículo)*.

Organisation of congresses

- Forum Andaluz.IA, Sevilla, España, 19/12/2023-20/12/2023.

Book chapters

- Automatic Control with Interactive Tools (libro completo). J.L. Guzmán, R. Costa-Castelló, M. Berenguel, S. Dormido. Springer, 2023. ISBN: 978-3-031-09919-9.
- Hierarchical Control and Optimization Strategies Applied to Solar Membrane Distillation Facilities. J.D. Gil. Springer. ISBN 978-3-031-30017-2. 2023.
- Wastewater treatment by microalgae-based processes. F.G. Acién, C. Gómez, A. Morillas, A. Zouhayr, A. Sánchez, R. Nordio, E. Rodríguez, J.L. Guzmán, and J. M. Fernández-Sevilla. In Algal Systems for Resource Recovery from Waste and Wastewater, pp. 77-102. IWA Publishing, 2023. ISBN: 9781789063547.

Doctoral theses defended

- Automatic Control Strategies for Optimal Economic and Energy Management of Greenhouse Crop Production. F. García-Mañas. Universidad de Almería, 25/07/2023, Sobresaliente *cum laude*.
- Contributions to Classic Control Strategies and Application to Industrial Facilities. Ángeles Hoyo Sánchez. Universidad de Almería, 21/09/2023. Sobresaliente cum laude.
- Plataforma IoT para la provisión de servicios en procesos industriales. Manuel Muñoz Rodríguez. Universidad de Almería, 31/03/2023, Sobresaliente *cum laude*.

5.5 SOLAR RESOURCES AND SOLAR COOLING

Articles without collaboration with other CIESOL research groups

- Probabilistic Solar Forecasts as a Binary Event Using a Sky Camera. David, M., Alonso-Montesinos, J., Le Gal La Salle, J., Lauret, P. *Energies, 16 (20), art. no. 7125, 2023. DOI: 10.3390/en16207125.*
- DNI nowcasting applying a differential approach method into sky camera images. Mondragon-Rodriguez, R.D., Riveros-Rosas, D., Gay-Garcia, C., Alonso-Montesinos, J. *IEEE Transactions on Geoscience and Remote Sensing, pp. 1, 2023. DOI: 10.1109/TGRS.2023.3344119*
- Economic and environmental solutions for the PV solar energy potential in Spain. Pérez, N.S., Alonso-Montesinos, J. *Journal of Cleaner Production, 413, art. no. 137489, 2023. Doi: 10.3390/en13236376*
- Photovoltaic power electricity generation nowcasting combining sky camera images and learning supervised algorithms in the Southern Spain. Trigo-González, M., Cortés-Carmona, M., Marzo, A., Alonso-Montesinos, J., Martínez-Durbán, M., López, G., Portillo, C., Batlles, F.J. *Renewable Energy, 206, pp. 251-262, 2023. DOI: 10.1016/j.renene.2023.01.111*
- Increasing the Resolution and Spectral Range of Measured Direct Irradiance Spectra for PV Applications. López, G., Gueymard, C.A., Polo, J., Alonso-Montesinos, J., Marzo, A., Martín-Chivelet, N., Ferrada, P., Escalona-Llaguno, M.I., Batlles, F.J. *Remote Sensing, 15 (6), art. no. 1675, 2023. DOI: 10.3390/rs15061675*

Participation in congresses

- WORKSHOP INTERNACIONAL "DESAFÍOS TÉCNICOS Y DE TALENTO HUMANO DE LA INDUSTRIA SOLAR EN EL NORTE DE CHILE", Antofagasta, Chile, 2023.
- PhDay´s CONGRESO ENERGÍA SOLAR, Antofagasta, Chile, 2023.
- International Conference on Time Series and Forecasting, Gran Canaria, España, 2023.
- RAUGM 2023, Ciudad de México, México, 2023.
- SolarPaces 2023, Sydney, Australia, 2023.
- XVIII Interbienal del Grupo Especializado de Termodinámica (GET-23) de las Reales Sociedades Españolas de Física y Química, Sevilla, España, 2023.
- CINECO II Congreso Internacional de Innovación Docente, Educación y Transferencia del Conocimiento, Online, 2023.

Contributions to conferences

- "THERMAL ENERGY STORAGE FOR BUILDING COOLING AND HEATING: COOLSPACES 4 LIFE" A. Castro-Vizcaíno, M. S. Romero-Cano, J. L. Bosch-Saldaña, J. Alonso-Montesinos, M. J. Ariza, F.J. Batlles, A.M. Puertas, B. Gil, S. Rosiek. *XVIII Interbienal del Grupo Especializado de Termodinámica (GET-23) de las Reales Sociedades Españolas de Física y Química. Sevilla 2023 (Contribución oral)*
- "COLD THERMAL STORAGE SYSTEM: LOADING AND UNLOADING STUDY ASSISTED BY A COOLING PROTOTYPE". A. Castro-Vizcaíno, M. S. Romero-Cano, J. L. Bosch-Saldaña, J. Alonso-Montesinos M. J. Ariza, F.J. Batlles, A.M. Puertas, K. Babul, B. Gil, S. Rosiek. *XVIII Interbienal del Grupo Especializado de Termodinámica (GET-23) de las Reales Sociedades Españolas de Física y Química. Sevilla 2023 (Póster)*
- Smart Heliostat Tracking System based on Artificial Intelligence. José A. Carballo, Javier Bonilla, Jesús Fernández-Reche, Jesús Ballestrín and Loreto Valenzuela. *SolarPACES 2023 International Symposium. Sydney, Australia, 2023. (Oral presentation).*
- Concentrated Solar Flux Measurements Intercomparison of 3 Heat Flux Gauges and a Water Calorimeter. Emmanuel Guillot, Jean-Louis Sans, Jesús Ballestrín, Christian Willsh. *SolarPACES 2023 International Symposium. Sydney, Australia, 2023. (Poster presentation).*
- Testing and Validation of Innovative on-Site Solar Field Measurement Techniques to Increase Power Tower Plant Performance: The LEIA Project. A. Avila-Marín, J. Fernández-Reche, R. Monterreal, J. Ballestrín, J. F. Gallego, M. Casanova, S. Escorza, A. Mutuberria, A. Kämpgen, A. Macke, M. Röger, J.

J. Krauth, S. Schlau, A. Barenbruegge, J. M. Blázquez, A. Zurita. *SolarPACES 2023 International Symposium. Sydney, Australia, 2023. (Oral)*.

- CLOUD BASE HEIGHT CHARACTERIZATION COMBINING VISIBLE / THERMAL SKY CAMERAS AND CEILOMETER DATA. J. Alonso-Montesinos, E. García-Campos, J. Barbero. *SolarPACES 2023 International Symposium. Sydney, Australia, 2023 (Poster)*.
- La química como enseñanza centralizada en proyectos desarrollados en el centro de investigación de energía solar (Ciesol). M .Márquez, J. Alonso-Montesinos. *II Congreso Internacional de Innovación Docente, Educación y Transferencia del Conocimiento, Online, 2023 (Oral)*.
- A combination of visible and infrared sky camera for improving cloud detection and forecasting. J. Alonso-Montesinos, J. Barbero, *International Conference on Time Series and Forecasting, Gran Canaria, España, 2023 (Póster)*.
- Plantas solares y sistemas de predicción a través de teledetección espacial. Joaquín Alonso-Montesinos. *PhDay´s CONGRESO ENERGÍA SOLAR, Antofagasta, Chile, 2023 (Oral)*.
- Técnicas de inteligencia artificial aplicadas al ámbito de la energía solar. Joaquín Alonso-Montesinos. *WORKSHOP INTERNACIONAL "DESAFÍOS TÉCNICOS Y DE TALENTO HUMANO DE LA INDUSTRIA SOLAR EN EL NORTE DE CHILE". Antofagasta, Chile, 2023 (Oral)*.
- Estudio de la variabilidad de la cubierta nubosa en la Ciudad de México. Román Damián Mondragón Rodríguez, Carlos Gay García, David Riveros Rosas, Joaquín Alonso Montesinos. *RAUGM 2023, Ciudad de México, México, 2023 (Oral)*.

5.6 DESALINATION AND PHOSTOSYNTHESIS

Articles without collaboration with other CIESOL research groups

- Biological treatment and microbial composition of landfill leachate using a compost process in an airlift bioreactor. Elena H. del Amo, Rodrigo Poblete, Olga Sánchez, Manuel I. Maldonado. *Journal of Cleaner Production 415, 137748, 2023. DOI: 10.1016/j.jclepro.2023.137748.*
- Use of vinasse and coffee waste as chelating agent of photo-Fenton landfill leachate treatment. Rodrigo Poblete, Ernesto Cortés, Norma Pérez, Manuel I. Maldonado. *Environmental Science and Pollution Research 30:5037–5046, 2023. DOI: 10.1007/s11356-022-22573-0.*
- Membrane distillation of high salinity feeds: Steady-state modelling and optimization of a pilot-scale module in vacuum-assisted air gap operation. J.A. Andrés-Mañas, I. Requena, G. Zaragoza. *Desalination, 553 116449, 2023. DOI: 10.1016/j.desal.2023.116449*
- Co-generation of Fresh Water and Electricity with High-Temperature Power Cycles: Comparative Assessment of Multi-Effect Distillation and Reverse Osmosis. P. Palenzuela, D.-C. Alarcón-Padilla, B. Ortega-Delgado, G. Zaragoza. *Processes 11 1181, 2023. DOI: 10.3390/pr11041181*
- Production of Arthrospira platensis BEA 005B: Biomass characterisation and use as a colouring additive in macarons. Villaró, Silvia; Acien-Fernandez, Francisco Gabriel; González-López, Cynthia Victoria; Clagnan, Elisa; Lafarga, Tomas. *LWT-Food Science and Technology (2023) 182 (114843). DOI: 10.1016/j.lwt.2023.114843*
- Identification of Marine Biotechnology Value Chains with High Potential in the Northern Mediterranean Region. Acien-Fernandez, Francisco Gabriel; Aguilera, Cristobal. *Marine Drugs (2023) 21(7) 416. DOI: 10.3390/md21070416*
- Use of airfoils for enhancement of photosynthesis rate of microalgae in raceways. Acien-Fernandez, Francisco Gabriel; Román, Sergio; Fernández-Sevilla, José María. *Journal of Applied Phycology (2023) 81: 459-473. DOI: 10.1007/s10811-023-02996-z.*
- Assessment of the mixotrophic production of Chlorella vulgaris using milk whey as a nutrient source. Acien-Fernandez, Francisco Gabriel; Sánchez, Ana; Villaró, Silvia; Ciardi, Martina; Fernández-Sevilla, José María; Lafarga, Tomas. *Journal of Applied Phycology (2023). DOI: 10.1007/s10811-023-03142-5.*
- Impact of photobioreactor design on microalgae-bacteria communities grown on wastewater: Differences between thin-layer cascade and thin-layer raceway ponds. Acien-Fernandez, Francisco Gabriel; Clagnan, Elisa; Dell'orto, Marta; Sterbova, Karolina; Grivalsky, Tomas; Camara Manoel, Joao Artur; Masojidek, Jiri; D'imporzano, Giuliana; Adani, Fabrizio. *Bioresource Technology (2023) 374:128781. DOI: 10.1016/j.biortech.2023.128781.*
- Optimization of thin-layer photobioreactors for the production of microalgae by integrating fluid-dynamic and photosynthesis rate aspects. Acien-Fernandez, Francisco Gabriel; Cristian Inostroza; Fernández-Sevilla, José María. *Journal of Applied Phycology (2023) 35:2111-2123. DOI:10.1007/s10811-023-03050-8.*
- Online tools to support teaching and training activities in chemical engineering: enzymatic proteolysis. Villaró, Silvia; Lafarga, Tomas. *Frontiers in Education (2023) 8:1290287. DOI: 10.3389/feduc.2023.1290287.*
- Effect of seawater on the biomass composition of Spirulina produced at a pilot-scale. Villaró, Silvia; Lafarga, Tomas. *New Biotechnology (2023) 78:173-179. DOI: 10.1016/j.nbt.2023.11.002.*
- Production of enzymatic hydrolysates with in vitro antioxidant, antihypertensive, and antidiabetic properties from proteins derived from Arthrospira platensis. Bermejo-Román, Ruperto; Villaró, Silvia; Lafarga, Tomas. *Food Research International (2023) 163:112270. DOI: 10.1016/j.foodres.2022.112270.*
- An overall analysis of CO2 demand and utilization of microalgal cultures in pilot-scale raceway reactors. Barceló-Villalobos, Marta; Lafarga, Tomas; Acien-Fernandez, Francisco Gabriel. *Algal Research (2023) 74 (103197). DOI: 10.1016/j.algal.2023.103197.*

Articles in collaboration with other CIESOL research groups

- Influence of culture media composition on the rheology of microalgae concentrates on a large scale. Belachqer, Solaima; Morillas, Ainoa; Sánchez, Ana; Cavalcanti -pessôa, Luiggi ; Pinna-Hernandez, Maria Guadalupe; De Jesus Assis, Denilson ; Casas-Lopez, Jose Luis; Acien-Fernandez, Francisco Gabriel. *New Biotechnology (2023) 77(25):90-99. DOI: 10.1016/j.nbt.2023.07.005.*
- Application of Machine Learning to Characterize the Permeate Quality in Pilot-Scale Vacuum-Assisted Air Gap Membrane Distillation Operation. I. Requena, J.A. Andrés-Mañas, J.D. Gil and G. Zaragoza. *Membranes, 13(11), 857, 2023. DOI: 10.3390/membranes13110857.*
- Cloud Detection and Tracking Based on Object Detection with Convolutional Neural Networks. Carballo J.A., Bonilla J., Fernández-Reche J., Nouri B., Avila-Marin A., Fabel Y., Alarcón-Padilla D.C. *Algorithms 16(10):487, 2023. DOI: 10.3390/a16100487*
- Membrane distillation for high salinity feeds: Steady-state modelling and optimization of a pilot-scale module in vacuum-assisted air gap operation. Juan Antonio Andrés Mañas; Requena, Isabel María; Zaragoza-Del Águila, Guillermo. *Desalination (2023) 553:116449. DOI: 10.1016/j.desal.2023.116449.*
- Thermochemical valorization of greenhouse cucumber, tomato and pepper as biofuel. Pinna-Hernandez, Maria Guadalupe; Díaz-Villanueva, Manuel Jesus; Cortés-Izurdiaga, Manuel; Jimenez-Becker, Silvia; Casas-Lopez, Jose Luis; Acien-Fernandez, Francisco Gabriel. *Heliyon (2023) 9-12. DOI: 10.1016/j.heliyon.2023.e22513.*
- Data-Driven pH Model in Raceway Reactors for Freshwater and Wastewater Cultures. Acien-Fernandez, Francisco Gabriel; Otálora, Pablo; Guzman, Jose Luis; Berenguel, Manuel . *Mathematics (2023) 11(7):1614. DOI: 10.3390/math11071614.*
- An artificial intelligence approach for identification of microalgae cultures. Acien-Fernandez, Francisco Gabriel; Otálora, Pablo; Guzman, Jose Luis; Berenguel, Manuel; Reul-, Andreas. *New Biotechnology (2023) 77:58-67. DOI: 10.1016/j.nbt.2023.07.003.*
- Modelado y control del pH en la producción de microalgas en reactores raceway usando técnicas de adaptación de parámetros. Caparroz, Malena; Otálora, Pablo; Guzman, Jose Luis; Berenguel, Manuel; Acien-Fernandez, Francisco Gabriel. *Revista Iberoamericana de Automática e Informática Industrial (2023) 1-8. DOI: 10.4995/riai.2023.19103.*
- Technical and economic viability of using solar thermal energy for microalgae drying. López Pastor, Rubén; Pinna-Hernandez, Maria Guadalupe; Acien-Fernandez, Francisco Gabriel. *Energy Reports (2023) 10 (989-1003). DOI: 10.1016/j.egyr.2023.07.040.*
- Influence of pH and dissolved oxygen control strategies on the performance of pilot-scale microalgae raceways using fertilizer or wastewater as the nutrient source. Nordio, Rebecca; Viviano, Emanuele; Sánchez, Ana; González, Jose; Rodríguez, Enrique; Guzman, Jose Luis; Acien-Fernandez, Francisco Gabriel. *Journal of Environmental Management (2023) 345 (118899). DOI: 10.1016/j.jenvman.2023.118899.*

Participation in congresses

- Jornadas Grupo Interplataformas Agroalimentarias, Valladolid, España, 2023
- ProFutureEU: Should I Use Microalgae in My Next Food product, Amsterdam, Holanda, 2023
- BioRural Knowledge-exchange Workshop: Advancing the European Rural Bioeconomy - Microalgae related processes for nutrients recovery from wastes. Bruselas, Bélgica, 2023
- REALM General Meeting Agenda – M17 - Work Package status (WP3), Bruselas, Bélgica, 2023
- EU4Algae General Meeting - WG6 of EU4ALGAE. Bruselas, Bélgica, 2023
- II Encuentro de Biotecnología de Andalucía EBA 2023, Almería, España, 2023
- EABA European Algae Biomass Association Member`s Day Webinar - Development and demonstration of microalgae based processes, Florencia, Italia, 2023
- EU4algae workshop at ESNI conference - 1st Mission Arena - Standardise algae circular products to market in agricultural applications, Gothenburg, Alemania 2023

- ParAqua MC-Network meeting and WG3 Workshop - Training on monitoring of microalgae cultures in large scale production facilities, Almería, España, 2023
- REALM General Meeting Agenda – M11, Newcastle, Reino Unido, 2023
- ELOBIO-REALM General Meeting Agenda, Newcastle, Reino Unido, 2023
- EU4Algae Info Session on EU Algae Initiative, Tulcea, Rumania, 2023
- Nutrient Recycling Community - Working Group on Technologies for nutrient recycling 1th introductory meeting - Microalgae based nutrients recycling processes, Ghent, Bélgica, 2023
- EABA - WEBINAR Biostimulants and biofertilizers from algae for agriculture, Bruselas, Bélgica 2023
- EBIC Virtual Workshop "Innovation & safety of EU Fertilising Products: REACH & FPR", Bruselas, Bélgica, 2023
- "LA CAIXA" Foundation Postgraduate Abroad Fellowships 2023 Barcelona, España, 2023
- WEBINAR Biorefinery and applications for Rugulopteryx, Bruselas, Bélgica, 2023
- COST Action ParAqua funded by the European Union - Share and improve knowledge on aquatic microbial parasites that can be used for control strategies and valorisation of research for application in algal biotech and water systems monitoring, Bruselas, Bélgica, 2023
- WP1: Failure tests in microalgal photobioreactors. Acién-Fernández, Francisco Gabriel. Developing early warning systems for improved microalgae PRODuction and anaerobic DIGestIon (PRODIGIO) meeting Agenda. Institute of Marine Sciences (ICM) Barcelona, España, 2023
- Conferencia de experto invitado en la Universidad Federal Uberlandia, Uberlando, Brasil 2023
- Seminar on potencials and challenges in micrialgae biotechnology - Technology Institute, Taastrup, Dinamarca 2023
- SUNNERGY Suner-C WP2 Workshop, Bruselas, Bélgica, 2023
- International Journal of Engineering Education (IJEE)- McMaster University. Chicago, Illinois, EEUU & Toronto, Canada, 2023
- STP 2023 6th IWA International Conference on eco-Technologies for Wastewater Treatment. Girona, España, 2023
- Edición de Aportando Valor al CO2, organizado de manera conjunta por las Plataformas Tecnológicas y de Innovación Españolas del CO2 (PTECO2) y de Química Sostenible (SusChem-España). Bilbao, España, 2023
- 3rd International Workshop on Membrane Distillation and Innovating Membrane Operations in Desalination and Water Reuse. Sorrento (Italy), 23-27 abril 2023.
- Desalination for the Environment: Clean Water and Energy. Limassol (Cyprus), 22-26 mayo 2023.
- XIII Congreso Internacional de la Asociación Española de Desalación y Reutilización. Granada (España), 13-15 junio 2023.
- Reunión bienal de la Sociedad Española de Catálisis SECAT 2023. Torremolinos (España), 20-23 junio 2023.
- ECOS 2023 - the 36th international conference on efficiency, cost, optimization, simulation and environmental impact of energy systems, Las Palmas de Gran Canaria (España), 25-30 junio 2023.
- VII International Conference on Polygeneration. Bali (Indonesia), 26-28 julio 2023.
- International Conference on Resource Sustainability. Guildford (UK), 7-9 agosto 2023.
- 15th European Congress on Catalysis, EuropaCat 2023. Praga (República Checa), 27 agosto-1 septiembre 2023.
- 14th annual International Sustainability Transitions conference. Responsibility and Reflexivity in Transitions. Utrecht (NL), 30 agosto – 1 septiembre 2023.
- XLIV Jornadas de Automática 2023, Zaragoza (España), 6-8 septiembre 2023.
- 4th SFERA-III and 17th SOLLAB Doctoral Colloquium 2023, Cologne (Germany), 11-13 septiembre 2023.

- 8th International Conference on Semiconductor Photochemistry (SP8), Estrasburgo (Francia), 11-15 septiembre 2023.
- 29th Concentrating Solar Power and Chemical Energy Systems (SolarPaces) Sydney (Australia), Oct 10 - 13, 2023.
- The International Association Desalination (IDA) Seville summit on Water and Climate Change, Seville (Spain), Oct 15 - 18, 2023.
- 6th International Conference on Desalination using Membrane Technology, Sitges (Spain), 19-22 noviembre 2023.
- Summit of Organic and Organo-Mineral Fertilisers Industries in Europe Brussels & hybrid. Bruselas, Bélgica 2023

Contributions to conferences

- Functional foods based on extra virgin olive oil enriched with carotenoids. Bermejo-Román, Ruperto; Murillo-Cruz, Mª Del Carmen; Carmona , Raquel; Chova, Mariela; Fernández-Sevilla, José María; Acien-Fernandez, Francisco Gabriel. *2nd Global Summit on Food Science and Technology, Roma, Italia, 2023 (Presentación Oral)*.
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- Jornadas de Difusión de Resultados GREENFARM, Almería, España, 17 Noviembre 2023
- Jornada de presentación de resultados del proyecto AVA. IFAPA. Almería, España, 15 Mayo 2023

- 1º Workshop Climate Farm Demo, Almería, España, 8 Septiembre 2023
- I Congreso Iberoamericano Jóvenes Investigadores Del Mar & IV Congreso Internacional Jóvenes Investigadores Del Mar, Almería, España 6-9 Septiembre 2023
- HORTICULTURAE ISHS International Society for Hortocultursl Science, Almería, España, 11 Mayo 2023
- Desalación y cultivos marinos, para el proceso participativo de la Estrategia Andaluza de Economía Azul Sostenible. Almería, España 19 Abril 2023
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