CIESOL ANNUAL REPORT 2022

CIESOL

Solar Energy Research Centre

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

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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...

Edificio CIESOL

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, 7 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 3, where we expose the infrastructures in detail.

During 2021, 92 researchers have participated in projects and contracts assigned to CIESOL (51 men and 41 women), 27 of them (13 men and 14 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), 4 contracts with companies and institutions, 14 European projects and 11 networks (7 national and 4 international).

On the other hand, the units of the center have had 6 stays of international researchers from 4 different countries, Argentina, Brazil, Iran and the United Kingdom.

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.

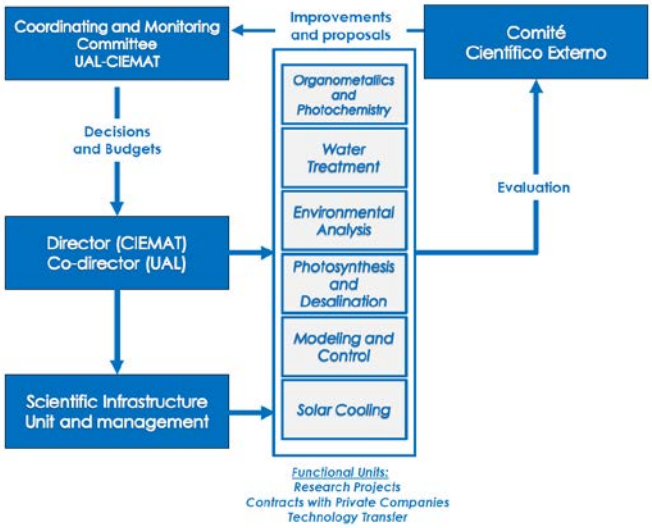
Triple TOF 5600

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?

The 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 Follow-up Committee, CCS, is made up of two researchers from the UAL, one of them being the Vice-rector for Research, Development and Innovation of the university and two researchers from the PSA, one of them being the Director of the Solar Platform from Almeria. Currently, the CCS is made up of

Diego Valera (Vice-Rector for Research) and Manuel Berenguel from the UAL and Julián Blanco (Director of the Almería Solar Platform) and Eduardo Zarza 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 2022 the director of CIESOL has been José Antonio Sánchez Pérez (from January 2023 it will be José Luis Casas López due to the appointment of José Antonio Sánchez Pérez as Vice-Rector for Research at the University of Almeria) and Sixto Malato Rodríguez of the PSA is deputy director. They are responsible for the allocation of spaces 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 made up of Ana María Amat Payá, Professor at the Polytechnic University of Valencia, Ángela Fernández Curto, Deputy General Director of Large Scientific-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 CEE is responsible for evaluating the scientific quality of CIESOL and proposing improvement actions. Among its functions is 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 CEE 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).

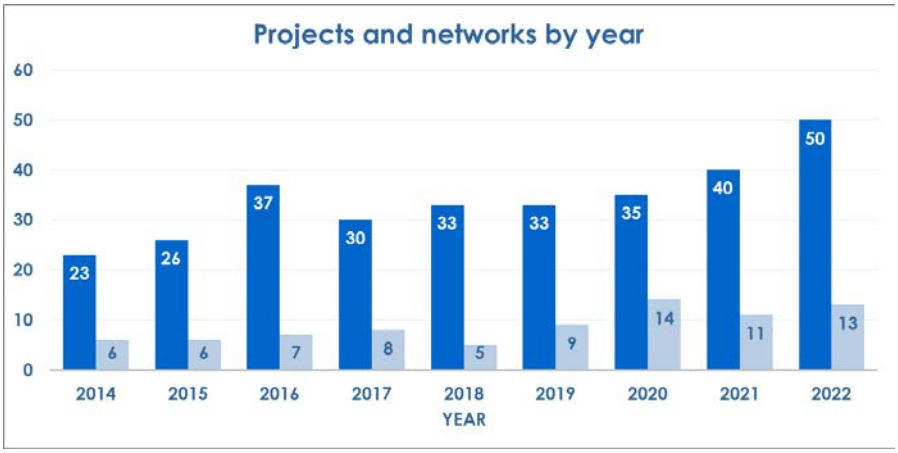
Environmental Analysis. It is focused on the development of advanced analytical methods in complex effluents and their application to the monitoring of organic micropollutants as well as the identification of transformation products generated during water treatment. The main researchers are Ana Agüera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

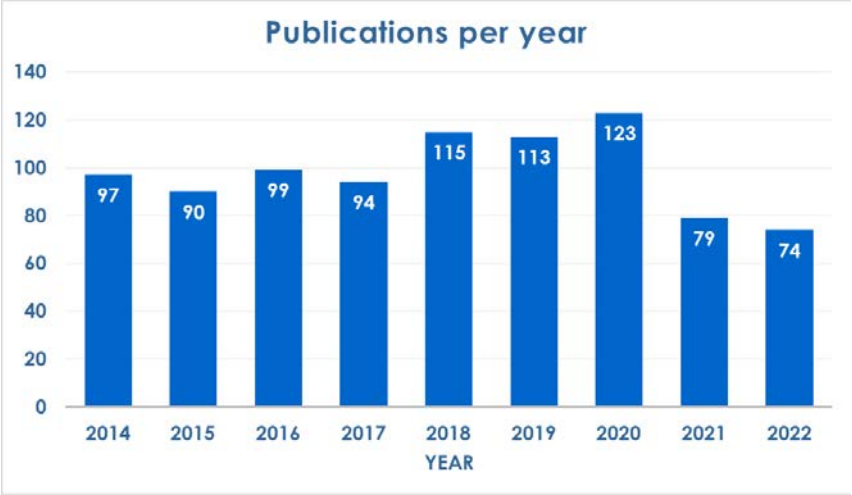
1.5 ACTIVITIES OF THE CENTRE IN 2022

In 2022, the renovation of the monitoring and energy control system at the centre has continued, through the implementation of an infrastructure grant from the Andalusian Regional Government (Junta de Andalucía). In this sense, 2022 has also been marked by the installation and start-up of the infrastructures belonging to the Agroconnect project, in the facilities shared with the IFAPA at its headquarters in La Cañada, adjacent to the university campus.

During the year 2022, 3 extracurricular internships have been offered for master's degree students with the intention of promoting initiation in research in the field of CIESOL, these internships are established for a duration of 6 months and on an annual basis. We have received 3 students who have joined the Environmental Analysis, Water Regeneration and Solar Resources and Solar Cooling research groups. These internships have had a cost of 9000 € per year.



Ciesol has maintained its research activity during 2022 through the 50 research projects in progress. The figure shows the evolution of the number of projects over the last eight years, with an average of 34 projects being carried out per year, with an upward trend over the last three years. In terms of networks, we have participated in 8 national and 5 international networks.



Regarding scientific production in 2022, a total of 82 publications with CIESOL affiliation have been achieved [63 in Q1 (77%), 9 in Q2 (11%), 3 in Q3 (4%) and 4 in Q4 (5%)] of which 42 with international collaboration, which represents 51% of the total, as an indicator of the international nature of the centre. All units have participated in national (16) and international (42) congresses and scientific meetings, with a total of 155 contributions. The figure shows the evolution of the number of international scientific publications in JCR over the last eight years. An average of 99 articles per year can be observed.

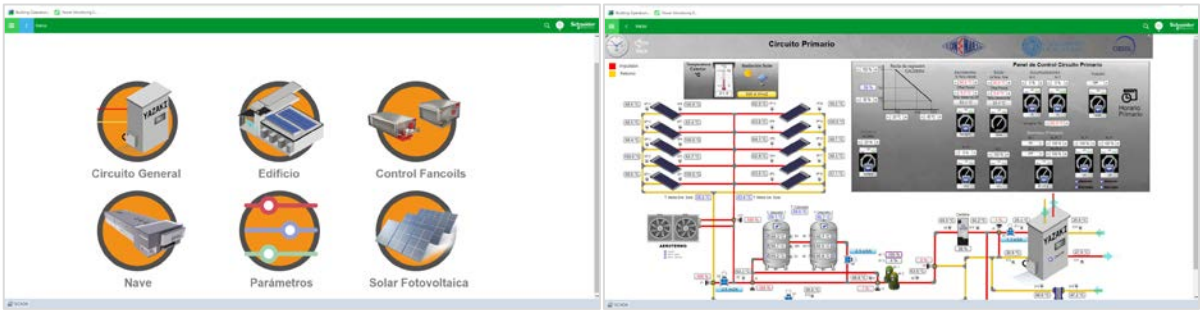
With regard to doctoral theses, 2 doctoral theses were defended in the UAL-PSA collaboration in 2022.

Regarding 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 courses and conferences, as shown in the activity of the different functional units.

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

2.1 ACTIONS IN 2022

In 2022, the building's climate control system was further upgraded and adjusted and last year's refurbished laboratories were fully equipped.

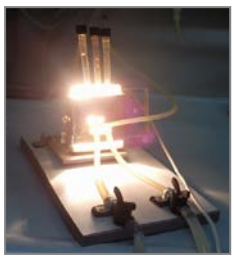


2.2 FACILITIES AND INFRASTRUCTURES IN THE AREA OF CHEMICAL ENERGY UTILISATION

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.

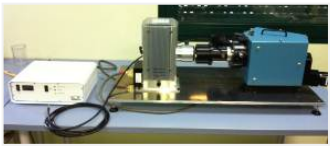


The micromolar photochemical reactor is a system that allows the controlled irradiation of a small volume of a reactive chemical system, both homogeneous and heterogeneous, using sunlight or, in its absence, artificial halogen lamps as a source of radiation. This avoids any disturbance of the reaction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

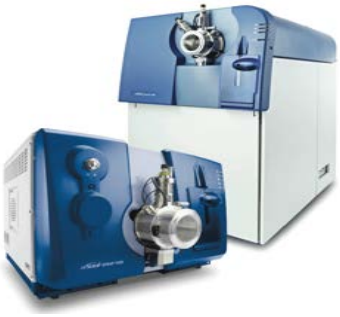
It allows the study of the redox properties of a solution and of the different solutes in it. The instrument available consists of a thermostatised chamber and a whole battery of possibilities that allow a detailed study of how a sample exchanges electrons.

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).

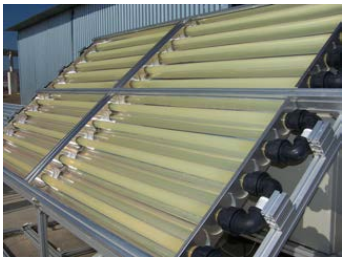
Total organic carbón analysers (TOC).

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.

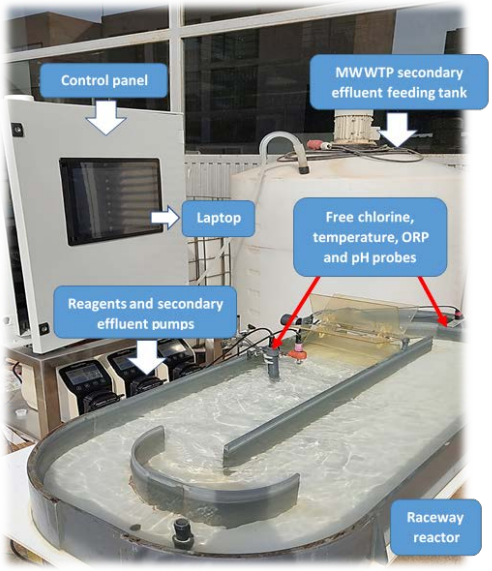
Atlas Suntest cPS+ solar simulator.

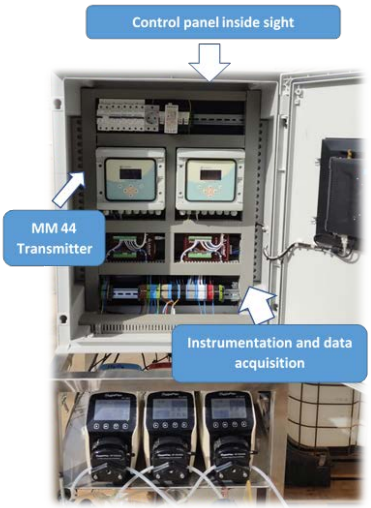
This device simulates the solar spectrum, allowing experimentation on a laboratory scale, making it essential in initial tests prior to pilot scale.

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.





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.

Demostration plants.

We have three demonstration plants for the regeneration of secondary WWTP effluents using the photo-Fenton process. They operate with direct solar irradiation and have radiometers to record the incident radiation in each case. They are based on raceway technology and are fully equipped for automatic operation in continuous mode. Their treatment capacities are between 5 y 25 m^3/h.

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

2.3 FACILITIES AND INFRASTRUCTURES IN THE AREA OF SOLAR ENERGY USE

Solar termal power plant. Solar heating/cooling system.

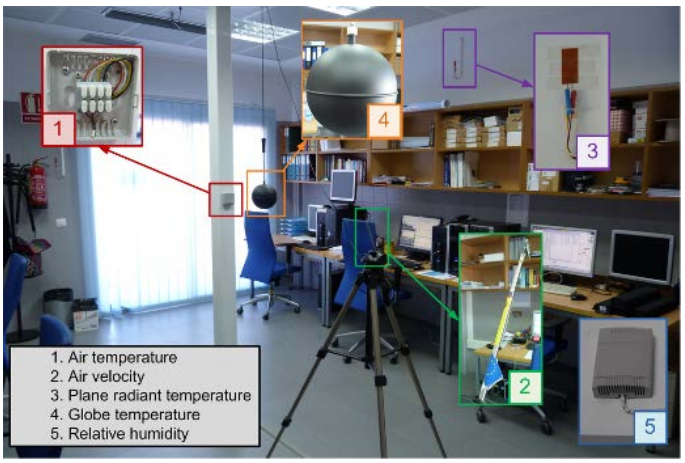
The installation has a collector field which is responsible for collecting the energy from solar radiation to heat water which is stored in tanks, this water can be used in the cooling system or for phytosanitary purposes.

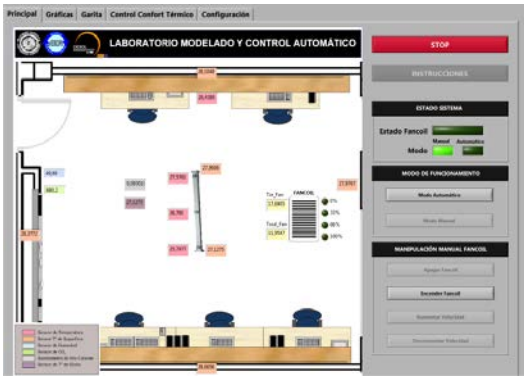
Solar collector field

Yazaki adsorption machine and hot water storage tanks

Building monitoing system.

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





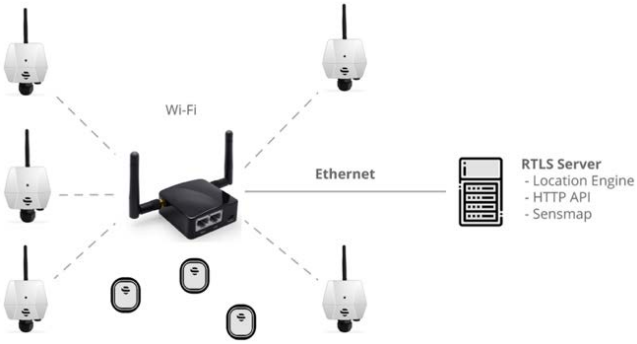
Comfort monitoring infrastructure in CIESOL laboratories and SCADA monitoring system screen and actuator examples.

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

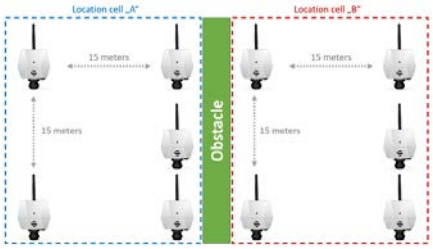
Different rooms on the ground floor and first floor of the building have a system of ultra-wideband components for locating the building's users in real time. This system is made up of radio beacons anchors, which form an internal network apart from CIESOL's own, through which they send the location 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.

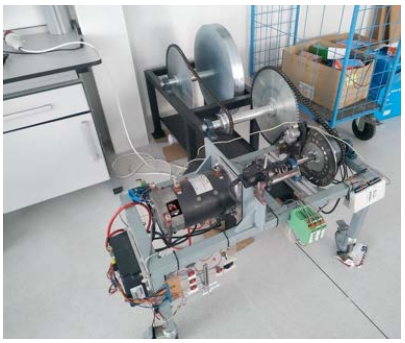
The centre has an alternative current charging point for electric vehicles on the west side of the courtyard. This charging point is connected to a row of photovoltaic panels which feeds the charging point. In the event that there is not enough radiation to cover the demand of the connected car, the 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.

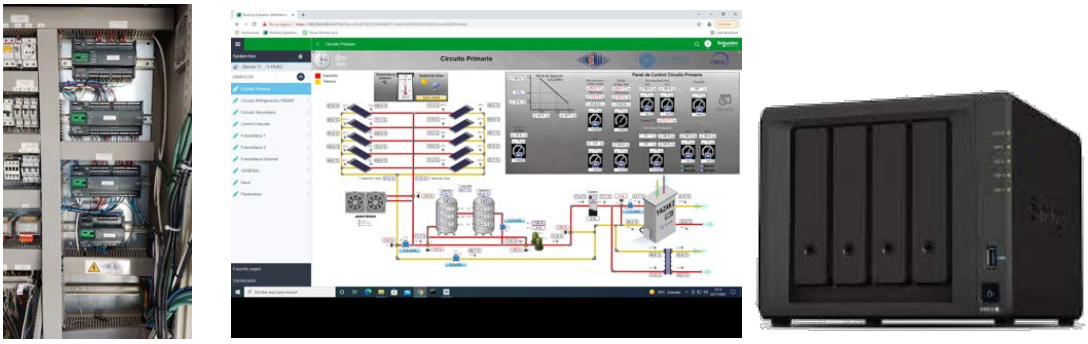
Greenhouse system.

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.

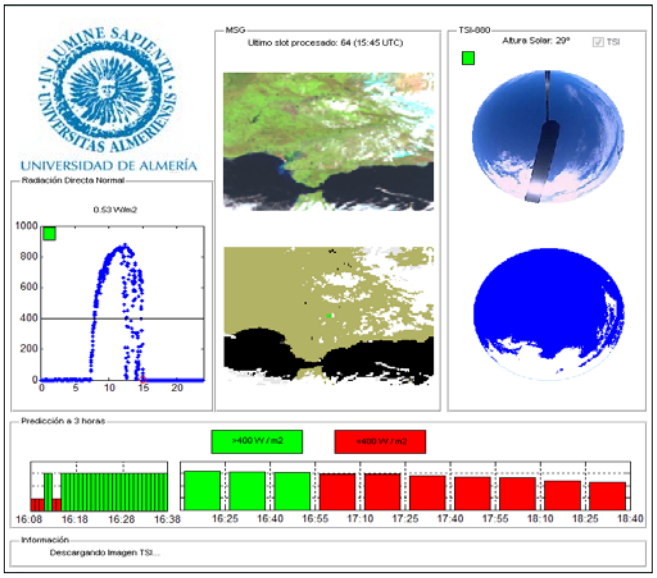
Radiometric station.

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).

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 OF CIESOL

3.1 ACTIVITIES OF "ORGANOMETALLICS AND PHOTOCHEMISTRY"

3.1.1 Funtioinal unit description

In 2022 the unit was constituted by 9 members (three university professors, two researchers, three predoctoral contract and one postdoctoral contract) most of then pertaining to the research team FQM-317 entitled "Coordination/Organometallic Chemistry and Photochemistry " that is constituted by researchers from U. Almeria, La Laguna and Cádiz and a researcher at the German Aerospace Centre - Plataforma Solar de Almeria (DLR-PSA-CIEMAT). The group has research collaborations with PAI (Andalusian Research Plan) groups and CIESOL groups as well as with other Andalusian universities. The unit has not stopped growing in both projects (regional, national and international) and scientific production (> 220 articles in international journals chemical impact). The initial interest of the team, the synthesis of metal catalysts for photochemical reactions in water, has been extended to other areas such as photo-hydrogen-generation, conversion of small molecules by solar radiation and production of electricity by solar light.

3.1.2 Main research lines

- New water-soluble homo- and hetero-metal-polymers with photocatalytic activity in the synthesis of high-impact molecules and production of electricity.
- White phosphorus transformation mediated by visible-light irradiation.

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 (Universitat Autonoma de Barcelona) in January 1992. In the same year, he undertook postdoctoral research at the former ISSECC CNR, now ICCOM CNR, (Florence, Italy), before becoming a Lecture Professor (1997) and finally Full Professor (2009) at the University of Almeria (Spain). His research interests range from homogeneous catalysis and organometallic chemistry in water, phosphorus chemistry, photo-inorganic chemistry, bioinorganic chemistry and natural stones. He has authored of more than 156 international refereed papers, 15 Spanish and international patents and made more than 260 presentations at national and international meetings. He has been responsible for more than 23 national research regional and European projects, was supervisor of 19 PhD and is supervising 3 more. He is responsible of the Junta de Andalucía research team FQM-317.

Christoph Richter (ORCID ID = 0000-0001-8386-1882; Scopus Author 55439554100)
PhD in Physical Chemistry from the University of Cologne in 1993. In 1994 he began to work in the Department DLR (German Aerospace Center) is at the Plataforma Solar de Almería (PSA-CIEMAT) in Spain, the largest test center for research and development in solar concentrating technologies at high temperatures. Initially working as a project manager in the area of solar chemistry in development projects photochemical applications of solar energy in water treatment and fine chemical synthesis. Currently working on different aspects of the operation of solar thermal plants, including heat storage, cooling and environmental impact, and is responsible for administration and infrastructure department of DLR in Almeria. Since March 2008, he is the Secretary General of Solar PACES. In 2011 he created the company Solarway SLNE, with a special dedication to the management of SolarPACES and its annual conference. Since June 2022 he left DLR and concentrates fully to SolarPACES as Director of Solarway, apart from participation in research projects.

3.1.4 Summary of the functional unit's activities carried out in CIESOL during 2022

During 2022 the research team has been partially renewed due to the arrival of new BSc and MSc students and two researchers hired through "youth employment" funding. The group also followed the training of PhD students. The group's main activities were the student training, the publication of articles in the best journals in the area of chemistry, inorganic chemistry and materials, and the realization of invention patents.

3.1.5 Colaboration with other functional units of CIESOL during 2022

During 2022 the unit has collaborated with the Water Regeneration unit, and it is intended to collaborate with units of the solar platform to design and use suitable reactors to develop photochemical reactions under inert conditions.

3.1.6 Human resources

Visits and research stays in CIESOL:

- La Dr. Nazanin Kordestani, Universidad de Isfahan (IRAN).
- La Dr. Patricia Camargo Solozano, Universidad de Córdoba (Argentina)

Research stays of CIESOL researchers in other institutions:

- María Belén López Sánchez, Universidad de Debrecen (Hungría).
- Andres Alguazil Alarcón, Universidad Técnica de Lisboa (Portugal)

Students in curricular internships

- Belen Lopez Sanchez, Doctorado en Química
- Jose Veiga del Pino, Doctorado en Química
- Andrés Alguacil Alarcón, Doctorado en Química
- Cesar Fernandez Perez, TFG en Ciencias Químicas
- Alvaro Martínez Aguilera, TFG en Ciencias Químicas
- Jose Jesus Martínez Garcia, TFG en Ciencias Químicas
- Victoria Moreno Vera, TFG en Ciencias Químicas
- Fernando Bonilla Millan, TFM en Laboratorio Avanzado de Química
- Juan José Burgos Morata, TFM en Laboratorio Avanzado de Química
- Judit Cano Asensio, TFM en Laboratorio Avanzado de Química

3.1.7 Scientific production

Number of papers	Numer of papers in each queartile				Number of papers with international collaborations
	Q_1	Q_2	Q_3	Q_4	
4	4				

Papers

- Nazanin Kordestani, Elisa Abas, Laura Grasa, Andres Alguacil, Franco Scalambra, Antonio Romerosa. The SignificantInfluenceof a SecondMetalon theAntiproliferativePropertiesof the Complex [Ru(η6C10H14)(Cl2)(dmoPTA)]. Chem.Eur.J. 2022,28,3, e202103048 (1 of 12) CLAVE: A, DOI: doi.org/10.1002/chem.202103048

- Andres Alguacil, Franco Scalambra, Antonio Romerosa. Insights into the κ-P,N-Coordination of 1,3,5-Triaza-7-2 phosphaadamantane and Derivatives: κ-P,N-Heterometallic Complexes and a 15N Nuclear Magnetic Resonance Survey. Inorg. Chem. 2022, 61, 5779−5791. DOI: doi.org/10.1021/acs.inorgchem.1c03831
- Franco Scalambra, Ismael , Antonio Romerosa. Photo-generation of H_2 by Heterometallic Complexes. Dalton Trans., 2022, 51, 14022–14031. DOI: 10.1039/D2DT01870E
- Belén López-Sánchez, Ana Belén Bohome-Espinosa, Franco Scalambra, Antonio Romerosa. Ru complexes containing N-methyl-1,3,5-triaza-7-phosphaadamantane (mPTA) as catalysts for the isomerization of 2-cyclohexen-1-ol. Appl Organomet Chem. 2022. e6971. DOI: doi.org/10.1002/aoc.6971

Participation in congresses

- XIX Reunión del Grupo Especializado de Química Inorgánica/XIII Reunión del Grupo Especializado de Química de Estado Sólido. Sevilla. 30 enero - 2 febrero 2022.
- 8th Latin American Symposium on Coordination and Organometallic Chemistry. On-line.10-11 marzo 2022.
- XXXVIII Reunión bienal de la Sociedad Española de Química. Granada del 27-30 junio 2022.
- X International Meeting of the Spanish Society on Neutron Techniques. SENT2022. Almería. 18-20 julio 2022.
- XXII International symposium on homogeneous catalysis Lisbon. 24-29 julio 2022.
- 2nd Spanish Workshop on Phosphorus Chemistry. On-line. 20-21 junio 2022.
- 44th International Conference on Coordination Chemistry. Rimini, Italia. 28 agosto - 2 septiembre 2022.
- XL GEQO conference Organometallic Chemistry Group. Barcelona 7-9 septiembre 2022.

Congress assistance and contribution

- New insight on the κ-P,N coordination of 1,3,5-triaza-7-phosphaadamantane and derivatives and their complexes: new κ-P,Nheterometal complexes and a ^{15}N NMR survey. Andrés Alguacil, Franco Scalambra and Antonio Manuel Romerosa Nievas. QIES22 (XIX Reunión del Grupo Especializado de Química Inorgánica/XIII Reunión del Grupo Especializado de Química de Estado Sólido) 30 enero - 2 febrero 2022. Sevilla. Oral. O21.
- Important advance about catalytic isomerization of allylic alcohols in water. Belén López-Sáncchez, Franco Scalambra and Antonio Manuel Romerosa Nievas. QIES22 (XIX Reunión del Grupo Especializado de Química Inorgánica/XIII Reunión del Grupo Especializado de Química de Estado Sólido) 30 enero - 2 febrero 2022. Sevilla. Oral Flash. F-B5.
- Bis-heterometallic RAPTA type complexes as antiproliferative agents. Nazanin Kordestani, Elisa Abas, Laura Grasa, Andres Alguacil, Franco Scalambra and Antonio Manuel Romerosa Nievas. QIES22 (XIX Reunión del Grupo Especializado de Química Inorgánica/XIII Reunión del Grupo Especializado de Química de Estado Sólido) 30 enero - 2 febrero 2022. Sevilla. Oral Flash. F-B7.
- Una perspectiva de los complejos metálicos con el ligando 1,3,5-triaza-7-phosphatricycle[3.3.1.13,7]decane (PTA). Antonio Romerosa, Franco Scalambra, Belen Sánchez-Pérez,

José Veiga, Andrés Alguacil, Ismael Diaz Ortega. QIES22 (XIX Reunión del Grupo Especializado de Química Inorgánica/XIII Reunión del Grupo Especializado de Química de Estado Sólido) 30 enero - 2 febrero 2022. Sevilla. Oral Flash. F-B11.

- Catalytic isomerization and oxidation of 3-methyl-2-cyclohexen-1-ol in water. Belen López-Sánchez, Franco Scalambra, Antonio Romerosa. QIES22 (XIX Reunión del Grupo Especializado de Química Inorgánica/XIII Reunión del Grupo Especializado de Química de Estado Sólido) 30 enero - 2 febrero 2022. Sevilla. Poster. P12.
- Synthesis, characterization and antiproliferative properties of new bisheterometallic Ruthenium complexes with tetrameric strcuture. A. Alguacil, Z. Mendoza, P. Lorenzo-Luis, F. Scalambra, A. Romerosa. QIES22 (XIX Reunión del Grupo Especializado de Química Inorgánica/XIII Reunión del Grupo Especializado de Química de Estado Sólido) 30 enero - 2 febrero 2022. Sevilla. Poster. P26.
- Interaction between plasmid DNA (pKSII) and Bipyridil-Ru(II) complexes containing 1,3,5-Triaza-7-phosphaadamantane (PTA). J. M. Veiga del Pino, A. Romerosa Nievas, F. Scalambra, F. García Maroto, A. Hernández Zanoletty. QIES22 (XIX Reunión del Grupo Especializado de Química Inorgánica/XIII Reunión del Grupo Especializado de Química de Estado Sólido) 30 enero - 2 febrero 2022. Sevilla. Poster. P32.
- New Strategy for the Design of Poly-heterometallic complexes: Synthesis, Characterization and Antiproliferative Activity. Nazanin Kordestani, Franco Scalambra, Antonio Romerosa. QIES22 (XIX Reunión del Grupo Especializado de Química Inorgánica/XIII Reunión del Grupo Especializado de Química de Estado Sólido) 30 enero - 2 febrero 2022. Sevilla. Poster. P33.

Internationals

- New heterometallic Ruthenium complexes with tetrameric structure and their antiproliferative activities. A. Alguacil, Z. Mendoza, P. Lorenzo-Luis, F. Scalambra, A. Romerosa. 8th Latin American Symposium on Coordination and Organometallic Chemistry. 10-11th March, 2022. Poster. Virtual.
- Catalytic isomerization of allylic alcohols: Role of water. B. López-Sánchez, F. Scalambra and A. Romerosa. 8th Latin American Symposium on Coordination and Organometallic Chemistry. 10-11th March, 2022. Poster. Virtual.
- A study on the behavior of [RuCp(OH2-□O)(PTA)2](CF3SO3) in the catalytic isomerization of branched allylic alcohols. Cano-Asensio, J., López-Sánchez, B., Scalambra, F. and Romerosa-Nievas, A. XXXVIII Reunión bienal de la sociedad española de química. Granada del 27 al 30 de junio de 2022. Poster. PP-001.Poster session A - 28/06/2022.
- Catalytic activity of aqueous complexes of Ru(II) in the isomerization, oxidation, and 1,3-transposition reactions of the pheromone 3-methylcyclohex-2-enol. Belen López-Sánchez, Franco Scalambra, Antonio Romerosa. XXXVIII Reunión bienal de la sociedad española de química. Granada del 27 al 30 de junio de 2022. Poster. PP-018. Poster session A - 28/06/2022.
- Study of the biological activity of bipyridyl-Ru(II) complexes containing 1,3,5--triaza-7-phospaadamantane (PTA). J.M. Veiga Del Pino, A.M. Romerosa Nievas, F. Scalambra, F. García Maroto. XXXVIII Reunión bienal de la sociedad española de química. Granada del 27 al 30 de junio de 2022. Poster.PP-640. Poster session C - 30/06/2022.
- New series of bis-heterometallic rapta complexes as novel antiproliferative agents. Nazanin Kordestani, Franco Scalambra and Antonio Romerosa. XXXVIII Reunión bienal de la sociedad española de química.

Granada del 27 al 30 de junio de 2022. Comunicación Flash. S06. New Frontiers in Organometallic Chemistry - 30/06 - 15:00

- Evaluation of the biological properties of mono and hetero-bimetallic ruthenium complexes. Andrés Alguacil, Franco Scalambra, Fernanda Marques, Ana Isabel Tomaz, Andreia Valente, Antonio Romerosa. XXXVIII Reunión bienal de la sociedad española de química. Granada del 27 al 30 de junio de 2022. Comunicación Flash. S07. Chemical Tools for Chemical Biology - 29/06 - 16:00.
- Study of □2-allylic alcohol intermediates in water by NMR spectroscopy and Neutron Scattering. Belén López Sánchez, Franco Scalambra, Antonio Romerosa Nievas, Nicole Holzmann and Leonardo Bernasconi. Xth International Meeting of the Spanish Society on Neutron Techniques. SENT2022. 18th to 20th July 2022, University of Almeria. O20. Pp 13.
- Future Insights and deeply studies of a new family of water-soluble lanthanides complexes: ainteresting family of compounds to be studied by neutron scattering techniques. V. Moreno-Vera, I. F. Díaz-Ortega and A. Romerosa. Xth International Meeting of the Spanish Society on Neutron Techniques. SENT2022. 18th to 20th July 2022, University of Almeria. P8. Pp 62.
- Isomerization of allylic alcohols in water catalyzed by water-soluble ruthenium complexes. Belen López-Sánchez, Judith Cano-Asensio, Franco Scalambra, Antonio Romerosa. XXII International symposium on homogeneous catalysis Lisbon, July 24-29-2022. Invited Session. IL14.
- The role of water in homogeneous catalytic processes mediated by water soluble ruthenium complexes. 2nd Spanish Workshop on Phosphorus Chemistry. 20th and 21st June 2022. Virtual. Oral Presentation.
- 3,7-dimethyl-1,3,7-triaza-5-phosphabicyclo[3.3.1]nonane (dmoPTA): A versatile ligand for the synthesis of antiproliferative polymetallic complexes. Andrés Alguacil, Nazanin Kordestani, Franco Scalambra, P. Lorenzo, Isaac de los Rios, A. Romerosa. 44th International Conference on Coordination Chemistry. Rimini, Italia. August 28th - September 2nd 2022. Invited Lecture; T8.2 Metals in medicine, therapeutics, and diagnostics. Invited Lecture. IL106.
- Neutron Scattering: a valuable technique to study metal-mediated processes in water. Antonio Romerosa, Franco Scalambra, Belén López-Sánchez, Nicole Holzmann, Leonardo Bernasconi. XL GEQO conference Organometallic Chemistry Group, Barcelona 7th- 9th, September 2022. Oral Presentation. OC16

Congress organization

- X International Meeting of the Spanish Society on Neutron Techniques (SETN). Universidad de Almería 18-20 julio 2022.
- 28th International SolarPACES Conference, Albuquerque, USA, 27-30 Septiembre 2022.

3.1.8 Functional unit members

Antonio Manuel Romerosa Nievas

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Univ. Cádiz

Ismael Diaz Ortega

PhD Researcher
UAL

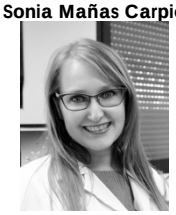
Franco Scalambra

PhD researcher
UAL

Cristóbal Saraiba Bello

PhD researcher
UAL

Sonia Mañas Carpio



PhD researcher
UAL

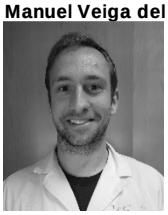
Belén López Sánchez

PhD Student
UAL

Lourdes Sánchez

PhD researcher
UAL-CTAP

José Manuel Veiga del Pino



PhD Student
UAL

Andrés Alguacil Alarcón

PhD Student
UAL

Nazanin Kordestani

PhD Researcher
UAL

3.1.9 Ongoing projects in 2022

3.1.9.1 Heterometallic Complexes as Antiproliferative Agents: Moving Towards New Drugs Against Cancer.

Participants:

Funtional Units "Organometallics and photochemistry"

Contacts:

A. Romerosa Nievas (romerosa@ual.es)

Funds:

Proyectos de Excelencia Junta de Andalucía (PY20_00791)

Time Period:

05/10/2021 – 30/06/2023

Current Situation:

In progress

Summary

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

Objectives.

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

3.1.9.2 Production and Storage of Hydrogen Catalyzed by Metal Complexes Photo Activated.

Participants:

Funtional Units "Organometallics and Photochemistry"

Contacts:

A. Romerosa Nievas (romerosa@ual.es)

Funds:

University of Almeria -FEDER (UAL2020-RNM-B2084)

Time Period:

01/11/2021 – 30/06/2023.

Current Situation:

In progress.

Summary

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

Objectives

Develop a practical process to produce hydrogen from water induced by solar radiation.

3.1.10 Network participation during 2022

The research network "REDESMA" (www.redesma.es) evolve 15 research teams involved in the study of metal complexes in wáter.

3.1.11 Transfer and Complementary Activities

Patent: Antonio Manuel Romerosa Nievas, Franco Scalambra, Nazanin Kordestani Mahani. Complejos de rutenio solubles en agua con los ligandos 3,7-H-3,7-dimetil-1,3,7-Triaza-5-phosphabiciclo[3.3.1]nonano (HdmoPTA), 3,7-dimetil-1,3,7-triaza-5-Phosphabiciclo[3.3.1]nonano (dmopta) e indenilo. P202030718 (2005009-ESP) (13/06/2020); Publicación: ES 2891137 A1 (26/01/2022); 2005009-WOPP (Europea). SOLICITUD DE APLICACIÓN: PCT/ES2021/070509 (12/07/2021), Publicación: WO 2022/013467 A1 (20/01/2022)

3.1.12 Dissemination activities

Night of the researchers -2022. Universidad de Almería. Almería. 24-09-2021. Devoted to the Sun and H_2.

3.1.13 Project's applications in 2022

One Project was asked to the Spanish Ministery

3.1.14 Others

Final degree and master projects:

- Alvaro Martinez Aguilera. (Grado en Química). Síntesis y caracterización de complejos tipo rapta con el ligando DMOPTA.
- Fernando Bonilla Millan. Máster en Laboratorio Avanzado de Química. In silico evaluation of compounds [RU(N6-C10H14)(CL2)-¿-DMOPTA-1KP:2K2N,N¿-ZNCL2] and [RU(N6-C10H14)(CL2)(DMOPTA)]: identification of their intermolecular interactions with DNA and a histone octamer.

Doctoral thesis in progress

- Belén López Sánchez, PhD in Chemistry. Supervisors: Antonio Manuel Romerosa Nievas, Franco Scalambra.
- Jose Veiga del Pino, PhD in Chemistry. Supervisors: Antonio Manuel Romerosa Nievas, Franco Scalambra.
- Andrés Alguacil Alarcón, PhD in Chemistry. Supervisors: Antonio Manuel Romerosa Nievas, Franco Scalambra

Other scientific activities

NEUTRONS, ELECTRONS AND X-RAY TECHNIQUES. UAL-Summer Course. (https://www.eventos.eidual.com/program/). 20-22/07/2022. UNIVERSIDAD DE ALMERIA

3.2 ACTIVITIES OF "ENVIRONMENTAL ANALYSIS"

3.2.1 Functional unit description

The staff of the Unit is made up of researchers from the Department of Chemistry and Physics at the University of Almeria and the Unit of Solar Water Treatments from the Plataforma Solar de Almería (CIEMAT). The collaboration between the two centres dates back to 1998, the year in which the first joint work is published. Since then the group has been actively involved in national and international projects and has more than 40 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 is focused on the development, optimization and analytical assessment of advanced wastewater treatment processes applied to complex effluents in order to get their regeneration and enable their reuse. The strategic lines of action include:

- Development of advanced analytical methods for characterizing complex effluents and its application to monitoring of organic micro-contaminants during wastewater treatment to ensure its elimination.
- Identification of transformation products generated during wastewater treatments and establishment of routes of degradation.
- Study of the influence of treatments on the quality of reclaimed water and evaluating the impact of their reuse in agriculture and in 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). PhD in Chemistry (1995). She has 30 years of experience working in the development and validation of analytical method based on chromatographic technique coupled to mass spectrometry for the analysis of organic contaminants in food and environmental matrices. She has participated in 40 national and international competitive R&D Projects. She is co-author of 2 patents and 172 scientific publications in indexed international journals (h-index = 64, March 2023). She has also co-authored more than 172 conference papers, 3 books and 12 book chapters, and has participated in the organization of 8 international conferences. She has supervised 10 doctoral theses.

Isabel Oller Alberola (ORCID ID: 0000-0002-9893-6207; Scopus Author 8415190600)
Researcher at the Solar Treatment of Water Unit at the Plataforma Solar de Almería (CIEMAT), degree in Chemical Engineering (2002) and PhD in Chemical Engineering (2008). Dr. Isabel Oller scientific career is focused in the industrial and urban wastewater treatment and reuse by using advanced oxidation processes (with and without solar energy) and their combination with physic-chemical pre-treatment systems and advanced biological processes. She has developed this activity under her participation in several I+D national and European Projects (5th, 6th & 7th EU Framework programs). Her scientific production it is worthy to mention she is author of 4 National Editorial book and co-author of 18 International Editorial books chapters. Furthermore, she is co-author of 165 publications in indexed scientific international journals and more than 180 contributions to different International Congresses and Symposiums (until April 2023). She has also participated as teacher in some national and international curses and masters related with Advanced Treatment of Wastewater. H-index (April 2023): 46.

3.2.4 Summary at the functional unit's activities carried out in CIESOL during 2022

In July 2022, the ANBAGENS project (UAL18-FQM-B001-B) ended, and the final report was completed. On December 2, the MODITRAGUA project (PROYEXCEL_00585) began, from the call for Excellence Projects of the Junta de Andalucía. Likewise, the extension of the execution period of the LIFE PureAgroH2O Water project (LIFE17 ENV/GR/000387) has been approved, until 12/31/2023. An important advance has been made in this project, with the receipt of the pre-pilot scale photocatalytic nanofiltration reactor (PNFR), designed and built by the DEMOKRITOS research center group (NCSR DEMOKRITOS), project partner. During this period works have been carried out on the set-up and operation of the reactor, which has given rise to a first joint publication. Within the framework of the LIFE ULISES project (LIFE18 ENV/ES/000165), the work on evaluation of the solar photo-Fenton process in continuous mode at demonstrative scale, using the reactor built at the El Bobar WWTP facilities, has been completed and published. In the PANI WATER project (Third party Amendment Reference No AMD-820718-11), work has been done on the quantification and monitoring of the elimination of micro-pollutants and disinfection by-products (trihalomethanes), generated from the application of ozone as a tertiary treatment for the regeneration of simulated urban wastewater from India with the ultimate goal of its reuse in crop irrigation.
In the LIFE PHOENIX project (LIFE19 ENV/ES/000278), the Functional Unit has completed the task corresponding to the monitoring of 8 selected WWTPs and WWRPs in the province of Almería, in order to know their degree of compliance with the new European Regulation on reuse. Two intense sampling campaigns (summer and winter) have been carried out, in which organic micro-pollutants, hormones and antibiotics have been determined. Finally, in the NAVIA project (PID2019-110441RB-C31) the study on the degradation of thiabendazole and its transformation products through two photo-assisted processes in a raceway reactor using iron-based catalysts (magnetic fraction of a mineral of titanium, MFTO) has been completed and published. Work has also been completed on the combination of solar photo-Fenton with continuous flow NaOCl as a tertiary treatment, in which the Environmental Analysis Unit has monitored the elimination of organic micro-pollutants, as well as the formation and elimination of disinfection by-products (trihalomethanes).
Finally, the DIGI4WATER and INTEGRASOL projects approved in the 2021 call for Projects oriented to the Ecological Transition and Digital Transition, of the Plan Estatal de Investigación Científica, Técnica y de Innovación 2021-2023, within the framework of the Plan de Recuperación, Transformación y Resiliencia. Although the DIGI4WATER project is not linked to CIESOL, it is included here, since the functional unit is closely involved on it, the two main researchers being coordinator (I. Oller) and member of the research team (A. Agüera).

3.2.5 Collaboration with other Funtional Units of CIESOL during 2022

In 2022 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) and NAVIA (PID2019-110441RB-C31). There are also collaboration with the Modeling and Control Unit (MODITRAGUA project)

3.2.6 Human resources

Throughout 2022, the following members have left the Functional Unit due to the end of their contracts:

- Angela González García
- Dennis Deemter
- Melina Rocamante
- Azahara Martínez García

New researchers have been incorporated;

- Ms. Sara Guerrero

Students in extracurricular internships

- Agustín Manuel París Reche.

Students in curricular internships

- José Javier Flores Morales. Grado en Química.
- Vanesa Rubira. Grado en Química.

Research Stays and Visits

- Dra. Dimitra Lambropoulou. Full professor. Aristotle University of Thessaloniki (AUTH). SFERA III Project
- Kyriaki Anagnostopoulou, PhD Student. Aristotle University of Thessaloniki (AUTH). SFERA III Project
- Dr. Javier Ferrer Valenzuela. University of Concepción (Chile). Erasmus+ Program.

3.2.7 Scientific production

Number of papers	Number of papers in each quartile				Number of papers with international collaborations
	Q_1	Q_2	Q_3	Q_4	
13	11	2			8

Papers

- Sulfate radical anion: Laser flash photolysis study and application in water disinfection and decontamination. Berruti, I., Polo-López, M.I., Oller, I., Flores, J., Marin, M.L., Bosca, F. Applied Catalysis B: Environmental, (2022) 315, 121519, https://doi.org/10.1016/j.apcatb.2022.121519.
- Recent advances in solar photochemical processes for water and wastewater disinfection. Berruti, I., Nahim-Granados, S., Abeledo-Lameiro, M.J., Oller, I., Polo-López, M.I. (2022) Chemical Engineering Journal Advances, 10, 100248, . https://doi.org/10.1016/j.ceja.2022.100248.
- Evaluation of commercial zerovalent iron sources in combination with solar energy to remove microcontaminants from natural water at circumneutral pH. Roccamante, M., Miralles-Cuevas, S., Cabrera-Reina, A., Oller, I., Malato, S. (2022) Chemosphere, 286, 131557, https://doi.org/10.1016/j.chemosphere.2021.131557.
- Natural solar activation of modified zinc oxides with rare earth elements (Ce, Yb) and Fe for the simultaneous disinfection and decontamination of urban wastewater. Berruti, I., Gonçalves, N.P.F., Calza, P., Paganini, M.C., Oller, I., Polo-López, M.I. (2022) Chemosphere, 303, 135017, https://doi.org/10.1016/j.chemosphere.2022.135017
- Simultaneous disinfection and microcontaminants elimination of urban wastewater secondary effluent by solar advanced oxidation sequential treatment at pilot scale. Maniakova, G., Polo-López, M.I., Oller, I., Abeledo-Lameiro, M.J., Malato, S., Rizzo, L. (2022) Journal of Hazardous Materials, 436, 129134, https://doi.org/10.1016/j.jhazmat.2022.129134
- Advanced microbiological tools for tracking complex wastewater treatment efficiency through the combination of physicochemical and biological technologies. Ruíz-Delgado, A., Ponce-Robles, L.,

Salmerón, I., Oller, I., Polo-López, M.I., Malato, S. (2022) Journal of Environmental Chemical Engineering, 10, 108651, https://doi.org/10.1016/j.jece.2022.108651

- EEM-PARAFAC as a convenient methodology to study fluorescent emerging pollutants degradation: (fluoro)quinolones oxidation in different water matrices. Sciscenko, I., Mora, M., Micó, P., Escudero-Oñate, C., Oller, I., Arqués, A. (2022) Science of the Total Environment, 852, 158338, http://dx.doi.org/10.1016/j.scitotenv.2022.158338
- Removal of microcontaminants by zero-valent iron solar processes at natural pH: Water matrix and oxidant agent's effect. Roccamante, M., Ruiz-Delgado, A., Cabrera-Reina, A., Oller, I., Malato, S., Miralles-Cuevas, S. (2022) Science of the Total Environment, 819, 153152., http://dx.doi.org/10.1016/j.scitotenv.2022.153152.
- Large-scale raceway pond reactor for CEC removal from municipal WWTP effluents by solar photo-Fenton. Gualda-Alonso, E., Soriano-Molina, P., Casas López, J.L., García Sánchez, J.L., Plaza-Bolaños, P., Agüera, A., Sánchez Pérez, J.A. (2022) Applied Catalysis B: Environmental, 319, art. no. 121908. DOI: 10.1016/j.apcatb.2022.121908
- Nutritional inter-dependencies and a carbazole-dioxygenase are key elements of a bacterial consortium relying on a Sphingomonas for the degradation of the fungicide thiabendazole. Vasileiadis, S., Perruchon, C., Scheer, B., Adrian, L., Steinbach, N., Trevisan, M., Plaza-Bolaños, P., Agüera, A., Chatzinotas, A., Karpouzas, D.G. (2022) Environmental Microbiology, 24 (11), pp. 5105-5122. DOI: 10.1111/1462-2920.16116
- A critical review of trends in advanced oxidation processes for the removal of benzophenone-3, fipronil, and propylparaben from aqueous matrices: Pathways and toxicity changes. Ricardo, I.A., Paniagua, C.E.S., Alberto, E.A., Starling, M.C.V.M., Agüera, A., Trovó, A.G. (2022) Journal of Water Process Engineering, 49, art. no. 102973. DOI: 10.1016/j.jwpe.2022.102973
- Degradation of Thiabendazole and Its Transformation Products by Two Photo-Assisted Iron-Based Processes in a Raceway Pond Reactor. Portilla-Sangabriel, M., Martínez-Piernas, A.B., Agüera, A., Arzate, S., Sánchez Pérez, J.A., Ramírez-Zamora, R.-M. (2022) Topics in Catalysis, 65 (9-12), pp. 1113-1127. DOI: 10.1007/s11244-022-01638-x
- Polystyrene nanoplastics and wastewater displayed antagonistic toxic effects due to the sorption of wastewater micropollutants. Verdú, I., Amariei, G., Plaza-Bolaños, P., Agüera, A., Leganés, F., Rosal, R., Fernández-Piñas, F. (2022) Science of the Total Environment, 819, art. no. 153063. DOI: 10.1016/j.scitotenv.2022.153063

Congress contributions

- Antimicrobial resistance and wastewater reuse: a field study in the intensive agriculture of Spain. S. Nahim-Granados, M.J. Abeledo-Lameiro, A. González, I. Oller, S. Malato, P. Plaza-Bolaños, Ana Agüera, M.I. Polo-López. 3rd IWA Specialized International Conference on Disinfection and DBPs 2022. Milan (Italy) 27June– 1 July, 2022. Oral.
- Solar treatments for urban wastewater effluent reclamation: the experience at Plataforma Solar de Almeria. M. I. Polo-López, I. Oller, S. Malato, S. Nahim-Granados, M. J. Abeledo-Lameiro, A. Ruiz-Aguirre, S. Miralles-Cuevas. 3rd International Conference on Disinfection and DBPs (IWA DDBPs 2022)-PRIMA DSWAP WORKSHOP, Milan (Italy), 27 June –1 July, 2022. Oral.

- Procesos solares y ozonización para la reutilización de agua de lavado de la industria de IV gama: evaluación global. S. Nahim-Granados, P. Plaza-Bolaños, I. Oller, S. Malato, A. Agüera, J.A. Sánchez-Pérez, M.I. Polo-López. XIV Congreso Español de Tratamiento de Aguas META 2022. Sevilla (España) 1-3 June 2022. Oral.
- Simultaneous micropollutant removal and pathogen inactivation by advanced oxidation technologies for wastewater recovery. I. Oller, M.I. Polo-López, S. Nahim-Granados, S. Malato, M.J. Abeledo Lameiro, S. Miralles, A. Agüera. Keynote in 11th European Conference on Solar Chemistry and Photocatalysis: Environmental Applications (SPEA), Turin (Italy), 6-10 June, 2022. Oral.
- Evaluation of new immobilized photocatalyst for simultaneous wastewater decontamination and disinfection. A. Hernández-Zanoletty, I. Oller, M.I. Polo-López, S. Malato, J. Flores, O. Cabezuelo, M.L. Marín, F. Boscá. 11th European Conference on Solar Chemistry and Photocatalysis: Environmental Applications (SPEA). Turin (Italy) 6-10 June, 2022.
- Sulfate Radical-based Advanced Oxidation Processes for wastewater disinfection. I. Berruti, S. Nahim-Granados, M.J. Abeledo-Lameiro, I. Oller, M.I. Polo-López. 3rd IWA Specialized International Conference on Disinfection and DBPs 2022. Milan (Italy), 27 June– 1 July, 2022.
- Enhancement Effect of H_2O_2 And Dissolved Oxygen on Solar Water Disinfection. A. Martínez-García, S. Nahim-Granados, M. J. Abeledo-Lameiro, I. Oller, M. I. Polo-López. 12th Micropol & Ecohazard Conference. Santiago de Compostela (Spain), 6-10 June 2022.
- Comprehensive evaluation of a real water reuse scenery in agricultural irrigation: monitoring of antibiotics, bacteria and resistant genes. Ana Agüera; S. Nahim-Granados; A. González; M. J. Abeledo-Lameiro; I. Oller; S. Malato; I. Polo-López; P. Plaza-Bolaños. 12th Micropol & Ecohazard Conference. Santiago de Compostela (España), 6-10 June 2022. Oral..
- Solar Oxidation Processes to Fight Against the Silent Global Health Emergency: Simultaneous Removal of Antibiotics and Antibiotic-resistant Bacteria in Urban Wastewater. S. Nahim-Granados, M. J. Abeledo-Lameiro, I. Oller, S. Malato, I. Polo-López. 12th Micropol & Ecohazard Conference. Santiago de Compostela (Spain), 6-10 June 2022.
- Solar photo-Fenton process using zero valent iron obtained from olive mill wastewater for microcontaminants removal: A pilot plant scale assessment. S. Malato, S. Miralles, M. Roccamante, I. Oller, A. Cabrera, A. Ruiz-Delgado. 11th European Conference on Solar Chemistry and Photocatalysis: Environmental Applications (SPEA). Turin (Italy) 6-10 June, 2022.
- Diseño de un controlador multivariable para la regeneración de aguas con nanofiltración. Roca, L., Serrano, J.M., Rodríguez, F., Laconis, F., Oller, I., Malato S. (2022). XLIII Jornadas de Automática. Logroño, 7, 8 y 9 September, 2022.
- Close the water-food-energy nexus by renewable energy: reuse of agro-industrial wastewater treated by solar processes. S. Nahim-Granados, P. Plaza-Bolaños, I. Oller, S. Malato, A. Agüera, J.A. Sánchez-Pérez, M.I. Polo-López. ISES and IEA SHC International Conference on Solar Energy for Buildings and Industry (EUROSUN 2022). Kassel (Germany) 25 - 29 September 2022.
- Determination of 31 antibiotics in real agricultural soils and leaves by ultrahigh-performance liquid chromatography coupled to mass spectrometry using a QUECHERS approach. F. X. Cadena

Aponte; A. González; P. Plaza-Bolaños; I. Polo; A. Agüera. XXI Meeting of the Spanish Society of Chromatography and Related Techniques. Almería, 25-27 October, 2022.

- Determination of trihalomethanes in reclaimed water by headspace and gas chromatography coupled to mass spectrometry. Agustín París Reche; Solaima Belachqer El Attar; Paula Soriano-Molina; P. Plaza-Bolaños; José Antonio Sánchez-Pérez; A. Agüera. XXI Meeting of the Spanish Society of Chromatography and Related Techniques. Almería, 25-27 October, 2022
- Fast and sensitive direct injection analysis of 229 organic microocontaminats in environmental water samples using ultra-high performance liquid chromatography-mass spectrometry. Eva Jambrina-Hernández; P. Plaza-Bolaños; I. Oller; A. Agüera. XXI Meeting of the Spanish Society of Chromatography and Related Techniques. Almería, 25-27 October, 2022.
- Monitoring of antibiotics in a real water reuse agricultural environment: Almeria greenhouses irrigated with reclaimed water. F. X. Cadena Aponte; S. Nahim-Granados; A. González; A. Agüera; P. Plaza-Bolaños. XXI Meeting of the Spanish Society of Chromatography and Related Techniques. Almería, 25-27 October, 2022
- Sensitive determination of estrogens in drinking water and secondary/tertiary wastewater effluents using solid-phase extraction (SPE) and ultra-high performance liquid chromatography-mass spectrometry. Eva Jambrina-Hernández; P. Plaza-Bolaños; I. Oller; A. Agüera. XXI Meeting of the Spanish Society of Chromatography and Related Techniques. Almería, 25-27 October, 2022

Book Chapters

- Sixto Malato, S. Miralles-Cuevas and A. Cabrera-Reina. Solar photocatalysis for water decontamination and disinfection (2017–2020). In: Photochemistry, Stefano Crespi and Stefano Protti (eds.), The Royal Society of Chemistry, Vol. 49, 236–269, 2022

Conferences Organization

- XXI Meeting of the Spanish Society of Chromatography and Related Techniques (SECyTA 2022). Almería 25-27 octubre 2022. Ana Agüera (Chair).

3.2.8 Functional unit members

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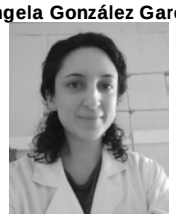

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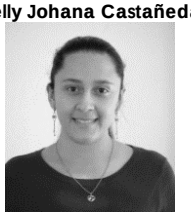

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3.2.9 Ongoing projects in 2022

3.2.9.1 Pollutant Photo-NF remediation of Agro-Water (LIFE PureAgroH2O)

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 – December 2023

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 fruit-industry, the prevention of losses of various inorganic and organic contaminants to the environment and the recycle/reuse of the purified water. To achieve the objective, a close-to market, patented water purification system with the ability to effectively recycle 15 m3/day of

real agro-wastewater will be developed and commercialized. The novel Photo-NF reactor (PNFR) system integrates synergistically state-of-the-art technologies such as nanofiltration (NF) with photocatalysis, resulting in applicability extension, minimization 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 the transmembrane pressure (energy efficiency), ii) significant extension of the process lifetime (2-fold) and iii) enhanced rejection performance (+99.5%) and 95% waste reduction.

Objectives:

- The PureAgroH2O project is expected to deliver a novel solution on two key issues: the purification of agro-industrial effluents by means of detoxification of contaminants/reduction of the total organic load and the cost-effective reclaim of the treated water.

3.2.9.2 Reuse of reclaimed water in real crops of intensive agriculture: evaluation of antibiotics, bacteria and resistant genes transmission in the water-soil-plant nexus (ANBAGENS)

Participants:

Functional Unit"Environmental Analysis"

Contact:

A. Agüera (aaguera@ual.es)

Funds:

Programa Operativo FEDER-Andalucía 2014-2020

Time Period:
01/10/2019-30/07/2022
Current Situation:
Finalized
Summary:
The water scarcity is especially noticeable in arid and semi-arid areas such as southern Spain and Andalusia. In the search for alternative resources, unconventional resources such as urban wastewater, represent an effective alternative that can be used in various activities. However, it has been shown that regenerated WW may contain relevant concentrations of antibiotics and their transformation products (TPs), while acting as propagators of resistant bacteria and genes (ARB and ARG). It is necessary, therefore, an adequate evaluation of reuse practices, especially in applications as sensitive as the irrigation of crops intended for consumption, to ensure the protection of both the environment and the consumer. The ANBAGENS project will address the study of chemical and microbiological contamination in a complete reuse scheme under real field conditions, by monitoring an intensive tomato crop, typical of the province of Almería irrigated with real regenerated WW. The project encompasses the development of analysis methods for the determination of antibiotics and their TPs, ARB and ARG. Antibiotics widely used in Spain and reported in treated WWTPs will be considered; as well as the WHO Priority Pathogen List for bacteria and antibiotics that have Critical or High Priority, such as Acinetobacter baumannii (resistant to carbapenems), Pseudomonas aeruginosa (resistant to carbapenems), Enterobacteriaceae (resistant to carbapenems and cephalosporins of 3rd generation). The results obtained will contribute to fill the current information gap in aspects such as the effectiveness of the regeneration treatments in the elimination of ARB and ARG and the possible regrowth along the irrigation system (storage and transport), the effect of long term exposure to mixtures of antibiotics or to their potentially toxic TPs or the behavior of pollutants under real culture conditions.
Objectives:

- Provide validated and standardized analytical protocols for the detection and quantification of antibiotics, ARB and ARG in water, soil and plant, which guarantee the quality of the results obtained.
- Contribute to the improvement of WW treatments and reuse schemes, detecting critical points and contributing to a better chemical and microbiological quality of irrigation waters.
- Provide solid and realistic information on the possible risks to public health arising from the reuse of reclaimed water for irrigation, by conducting field studies in real growing conditions.

3.2.9.3 Upgrading wastewater treatment plants by Low-cost Innovative technologies for energy Self-Sufficiency and full recycling. (LIFE ULISES)

Participants:
Functional Units “Water Treatments” and “Environmental Analysis”
Contacts:
J. L. Casas López (jlcasas@ual.es)
Funds:
LIFE Environment and Resource Efficiency, EU. (LIFE18 ENV/ES/000165)
Time Period:
July 2019 – June 2023 (extended)
Current Situation:
In progress
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 biofuel, 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 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 be reused 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, minimize its environmental impact and carbon footprint.

Objectives:

The main objective of the LIFE ULISES project is to demonstrate the viability of a set of technologies to improve the resources efficiency of the wastewater treatment plants. This will include: an anaerobic aeration pretreatment process to reduce energy demand, an upgrade process to increase biogas production, an enzymatic hydrolysis and membrane-based struvite precipitation for the use of sludge as fertilizer and a tertiary treatment based in solar energy for water reuse.

All these processes will be tested and validated in a pilot plant located in El Bobar, Almera, Spain.

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

Participants:

Functional Units “Environmental Analysis” and “Water regeneration”

Contact:

A. Agüera (aaguera@ual.es); I. Oller (ioller@psa.es)

Funds:

H2020 EU Program

Time Period:

01/02/2019-31/01/2023

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 deployed on site and in relation with 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.

Objectives:

- 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.

3.2.9.5 Innovative cost-effective multibarrier treatments for reusing water for agricultural irrigation (LIFE PHOENIX)

Participants:
Functional Units "Environmental Analysis" and "Water regeneration"
Contact:
L.J. Casas (jlcasas@ual.es)
Funds:
LIFE Environment and Resource Efficiency project application, 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.

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

Participants:
Functional Units "Water treatment" and "Environmental analysis"
Contacts:
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I. Polo (inmaculada.polo@psa.es)
Funds:
Ministry of Science and Innovation (PID2019-110441RB-C31)
Time Period:
01/06/2020-31/05/2023
Current Situation:
In progress
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 peroxides

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 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 six-months operation of the selected reclamation technology at 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

3.2.9.7 Demostration of solar photo-Fenton continuous reactors for WWTP secondary effluent reclamation (ANUKIS)

Participants:
Functional Units "Water treatment" and "Environmental analysis"
Contacts:
J.A. Sánchez Pérez (jsanchez@ual.es); A. Agüera (aaguera@ual.es)
Funds:
Ministry of Science and Innovation (PDC2021-121772-I00)
Time Period:
01/12/2021-30/11/2023
Current Situation:
In progress
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 (IP1 J. A. Sánchez Pérez).
- Construction and operation of a demonstration-scale RPR prototype as tertiary treatment in a WWTP located in a rural area (IP2 A. Agüera).
- Establishment of the procedure for technological knowledge protection (IP2 A. Agüera).
- Establishment of a business plan to transfer the technology to the water industry or create a spin-off (IP1 J. A. Sánchez Pérez).

3.2.9.8 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:
Functional Unit "Environmental analysis"
Contacts:
A. Agüera (aaguera@ual.es)
I. Oller (isabel.oller@psa.es)
Funds:

Junta de Andalucía (Regional Goverment)

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, which make 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.
- Proposal 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.

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

Participants:

Functional Units “Water treatment” and “Environmental analysis”

Contacts:

J.L. Casas López (jlcasas@ual.es)

Funds:

Ministry of Science and Innovation (TED2021-130458B-I00)

Time Period:

02/12/2022-31/12/2024

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, its combination has not been assayed until now and some aspects regarding the operational conditions need to be studied focused on, in the case of wastewater treatment priority by (i) maximizing the wastewater treatment capacity, (ii) by minimizing the energy consumption and reagents 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 by (i) optimizing the quality of produced biomass to produce biostimulants/biopesticides and (ii) by 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 be focused 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 be focused on the maximization of the water treatment capacity and the minimization of the ammonium, phosphates, and carbonates concentration in the secondary effluent. Raceway pond reactors will be used for both treatment step although in the case of secondary treatment with microalgae, membranes will be used to improve the treatment capacity and to reduce the ammonium, phosphates and carbonates concentration 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.

3.2.9.10 Hacia la mejora de la Resiliencia del Ciclo Urbano del Agua a través de la implementación de herramientas digitales basadas en modelos de "Machine Learning" y Tecnologías de Regeneración de Aguas (DIGI4WATER).

Participants:

Functional Units "Water treatment" and "Environmental analysis"

Contacts:

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Funds:

Ministry of Science and Innovation (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.

3.2.10 Dissemination activities

Members of the "Environmental Analysis" Functional Unit participated in the technical exhibition of the PANIWATER project organized during the IWA World Water Congress & Exhibition. Copenhagen (Denmark). September 11-15, 2022.

3.2.11 Projects requested during 2022

- "Tratamientos terciarios avanzados basados en la combinación de procesos de reducción/oxidación y materiales fotocatalíticos novedosos aplicados a la desinfección y simultánea eliminación de compuestos móviles y persistentes en agua residual urbana (ANDROMEDA)". Proyectos coordinados de la AEI. Convocatoria 2022 - «Proyectos de Generación de Conocimiento». Pendiente de resolución.
- "Development of an integrated database for the systematic identification of transformation products of organic contaminants in water – CECTPBD". WATER 4 ALL, JOINT TRANSNATIONAL CALL 2022: "Management of water resources: resilience, adaptation and mitigation to hydroclimatic extreme events and management tools".

3.2.12 Others

Final degree projects

- Ana Anguís Morillas (Degree in Chemistry). "Determination of estrone (E1), 17β-estradiol (E2) and 17α-ethinylestradiol (EE2) in treated wastewater and drinking water using UHPLC-MS/MS.".
- Rosa Miranda Calvache (Degree in Chemistry). "Determination of antibiotics in soil irrigated with reclaimed water by liquid chromatography coupled to mass spectrometry ".
- Agustín M. París Reche (Máster in Advanced Chemistry Laboratory). "Determination of trihalomethanes in water for human consumption and reclaimed water by headspace and gas chromatography coupled to mass spectrometry (GC-MS)"

PhD Theses (under development)

- Azahara Martínez (Supervisors: Inmaculada Polo and Isabel Oller)
- Dennis Deemter (Supervisors: Sixto Malato and Ana M. Amat)
- 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).

Attendance at Transfer and Dissemination Workshops

- Isabel Oller: XXIII Summer Course of the University of Almería: New sources of water: desalination and regeneration towards the sustainability of the integral water cycle with the presentation "Advanced Oxidation Processes for Water Regeneration: elimination of contaminants of emerging concern and inactivation of pathogens". July 14, 2022 in Almería.
- Isabel Oller: "Fight against water scarcity: Integration of (solar) technologies for the treatment and recovery of wastewater at the Plataforma Solar de Almería (Spain)" at the Workshop on Solar Energy for the Water Industry organized in a virtual by the University of Melbourne (Australia) on November 28, 2022.

- Isabel Oller: "Solar Technologies for obtaining water in countries with limited resources and isolated areas" at the "Conference on the Value of Water" organized by the Academy of Mathematical, Physicochemical and Natural Sciences of Granada, the University of Granada and Junta de Andalucía. November 11, 2022 in Granada (Spain).
- Sixto Malato gave the conference "Advanced oxidation processes based on solar energy: the long experience in PSA" and Isabel Oller moderated and participated in the "Teamwork session on a specific case: Almería and Murcia (Spain): two areas next to each other: to reuse or not to reuse water? This is the question", at the International School of Water Reuse. September 19-21, 2022 in Turin (Italy).
- Participation of Sixto Malato as a Panelist in the Round Table entitled "Reuse of Wastewater Towards a Circular Economy" at the 5th Ibero-American Conference on Advanced Oxidation Technologies (CIPOA 2022). November 11, 2022 in Cusco, Peru.
- Sixto Malato has participated in the "National School of Environmental Processes (ENPA 2022)" with a presentation entitled "Regeneration of polluted water through advanced treatments to close the integral water cycle: an approach using solar radiation" at the n Univ. Guanajuato (Mexico) in online format on April 1, 2022.
- Sixto Malato has participated in the Life AMIA Conference with the presentation "Research in advanced treatments for water regeneration: current state" at CEBAS-CSIC, Murcia, on March 17, 2022.

3.3 ACTIVITIES OF "ADVANCED TECHNOLOGIES FOR WATER REGENERATION"

3.3.1 Functional unit description

In 2022, the Functional Unit was made up of 14 researchers, including two university professors, one researcher contracted by OPI, one university full professor, one doctor contracted by the project, one doctor contracted by CIEMAT-PSA, one doctor contracted by the Andalusian Regional Government PAIDI2020, two doctors contracted by Juan de la Cierva, four pre-doctoral researchers and one technician, as detailed in section 2.3.7. 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 180 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 3 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 90 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 2022

In 2022, work was 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 m^3/day of secondary effluent from the "El Bobar" WWTP in the

city of Almeria has been treated. It is a 100 m^2 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. 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, we have hosted Dr. Giorgos Vrod during 2022 in the framework of the SFERA III project (Grant Agreement No 823802), from 1 September to 30 September.

a)  b)  c) 

Figure 2.3.1. Channel 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 Almeria, (b) "El Toyo" in Almeria and (c) Uleila del Campo.

3.3.5 Colaboration with other functional units of CIESOL during 2022

There is close collaboration with the "Analytical evaluation of water treatment and 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/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) and Integrasol (TED2021-130458B-I00) projects. The "Desalination and Photosynthesis" Unit collaborates with the “Rayo” (PY20_00786) and “Integrasol” (TED2021-130458B-I00) projects.

3.3.6 Human resources

During 2022, Master's student Elena Olivares and laboratory technician Guillermo Sánchez have joined the group, and Dr. Natalia Pichel Mira, who has joined the Universidad Rey Juan Carlos as an Assistant Professor, has left the group.

Stays and visits at CIESOL:

- Dr. Giorgos Vrod in the framework of the SFERA III project (Grant Agreement No 823802), 1 September to 30 September. Technical University of Crete, School of Chemical and Environmental Engineering, University Campus, GR-73100 Chania, Greece.

Students on curricular internships:

- María Gabriela Álvarez Rodríguez (14/02/2022 – 13/05/2022). Degree of Biotechnology.
- Ayyoub Selmaoui (14/02/2022 – 13/05/2022). Degree of Biotechnology.
- Nerea López Serrano (28/03/2022 – 30/06/2022). Master's Degree in Chemical Engineering.
- 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 Chemistry.
- Ana Isabel Segovia Morales (14/11/2022-24/02/2023). Degree in Chemical Engineering

3.3.7 Scientific production

Number of papers	Number of papers in each queartile				Number of papers with international collaborations
	Q_1	Q_2	Q_3	Q_4	
13	10	2	1	0	7

Papers

- Large-scale raceway pond reactor for CEC removal from municipal WWTP effluents by solar photoFenton. E.Gualda-Alonso, P. Soriano-Molina, J.L. Casas López, J.L.García Sánchez, P.Plaza-Bolaños, A.Agüera, J.A.Sánchez Pérez. Applied Catalysis B. Environmental 319 (2022) 121908. https://doi.org/10.1016/j.apcatb.2022.121908
- Mechanistic modeling of solar photo-Fenton with Fe3+-NTA for microcontaminant removal. E.Gualda-Alonso, P. Soriano-Molina, J.L. García Sánchez, J.L.Casas López, J.A.Sánchez Pérez. Applied Catalysis B. Environmental 318 (2022) 121795. https://doi.org/10.1016/j.apcatb.2022.121795
- A new solar photo-Fenton strategy for wastewater reclamation based on simultaneous supply of H2O2 and NaOCl. S.Belachqer-El Attar, P. Soriano-Molina, I. de la Obra, J.A. Sánchez Pérez. Science of The Total Environment 834 (2022) 155273. https://doi.org/10.1016/j.scitotenv.2022.155273
- Rheology of microalgae concentrates and its influence in the power consumption of enzymatic hydrolysis processing. S.Belachqer-El Attar, A.Morillas-España, J.L.López Casas, M.G. Pinna-Hernández, G.Acien Fernández. New Biotechnology 72 (2022) 107-113. https://doi.org/10.1016/j.nbt.2022.10.005

- Virtual labs for the study of enzymatic stirred tank bioreactors. Sánchez Zurano, A., Fernández Sevilla, J.M., Esteban García, A.B., Pinna-Hernández, M.G., Casas López, J.L.. Computer Applications in Engineering Education, 2022;1–12. https://doi.org/10.1002/cae.22510
- Simultaneous disinfection and microcontaminants elimination of urban wastewater secondary effluent by solar advanced oxidation sequential treatment at pilot scale. G. Maniakova, M.I. Polo-López, I. Oller, M.J. Abeledo-Lameiro, S. Malato, L. Rizzo. Journal of Hazardous Materials, 436: 129134 (2022). https://doi.org/10.1016/j.jhazmat.2022.129134
- Recent advances in solar photochemical processes for water and wastewater disinfection. I. Berruti, S. Nahim-Granados, M.J. Abeledo-Lameiro, I. Oller, M.I. Polo-López. Chemical Engineering Journal Advances, 10: (2022) 100248. https://doi.org/10.1016/j.ceja.2022.100248
- Sulfate radical anion: Laser flash photolysis study and application in water disinfection and decontamination. I. Berruti, M.I. Polo-López, I. Oller, J. Flores, M.L. Marin, F. Bosca. Applied Catalysis B: Environmental, 315: 121519 (2022). https://doi.org/10.1016/j.apcatb.2022.121519
- Natural solar activation of modified zinc oxides with rare earth elements (Ce, Yb) and Fe for the simultaneous disinfection and decontamination of urban wastewater. I. Berruti, N.P.F. Gonçalves, P. Calza, M.C. Paganini, I. Oller, M.I. Polo-López. Chemosphere, 303: 135017 (2022). https://doi.org/10.1016/j.chemosphere.2022.135017
- Advanced microbiological tools for tracking complex wastewater treatment efficiency through the combination of physicochemical and biological technologies. A. Ruíz-Delgado, L. Ponce-Robles, I. Salmerón, I. Oller, M.I. Polo-López, S. Malato. Journal of Environmental Chemical Engineering, 10: 108651 (2022). https://doi.org/10.1016/j.jece.2022.108651
- Neutral (Fe3+-NTA) and acidic (Fe2+) pH solar photo-Fenton Vs chlorination: Effective urban wastewater disinfection does not mean control of antibiotic resistance. A. Fiorentino, P. Soriano-Molina, M.J. Abeledo-Lameiro, I. de la Obra, A. Proto, M.I. Polo-López, J. A. Sánchez Pérez, L. Rizzo. Journal of Environmental Chemical Engineering, 10: 108777 (2022). https://doi.org/10.1016/j.jece.2022.108777
- Effect of Iron Complex Source on MWWTP Effluent Treatment by Solar Photo-Fenton: Micropollutant Degradation, Toxicity Removal and Operating Costs. Marson, E.O., Ricardo, I.A., Paniagua, C.E.S., Malta, S.M., Ueira-Vieira, C., Starling, M.C.V.M., Sánchez Pérez, J.A., Trovó, A.G. (2022) Molecules, 27 (17), art. no. 5521, . https://doi.org/10.3390/molecules27175521
- Degradation of Thiabendazole and Its Transformation Products by Two Photo-Assisted Iron-Based Processes in a Raceway Pond Reactor. Portilla-Sangabriel, M., Martínez-Piernas, A.B., Agüera, A., Arzate, S., Sánchez Pérez, J.A., Ramírez-Zamora, R.-M. (2022) Topics in Catalysis, 65 (9-12), pp. 1113-1127. https://doi.org/10.1007/s11244-022-01638-x

Proceedings

- Solar processes to treat and reuse agro-industrial wastewater: close the water-food energy nexus in fresh-cut industries. S. Nahim-Granados, P. Plaza-Bolaños, I. Oller, S. Malato, A. Agüera, J.A. Sánchez-Pérez, M.I. Polo-López Proceedings of the 39th IAHR World Congress 19–24 June 2022, Granada, Spain. ISSN-L 2521-7119. 3461-3466. doi://10.3850/IAHR-39WC2521716X2022777.

Participation of congress

- Workshop on Photo-irradiation and Adsorption based Novel Innovations for Water-treatment, PANIWATER. Lecce, Italia, 4 mayo 2022
- XIV Congreso Español de Tratamiento de Aguas META 2022. Sevilla, España, 1-3 junio 2022
- 11th European Conference on Solar Chemistry and Photocatalysis: Environmental Applications (SPEA), Turin, Italia, 6-10 junio, 2022.
- 12th Micropol & Ecohazard Conference. Santiago de Compostela, España, 6-10 junio, 2022
- 39th IAHR World Congress, Granada, España, 19-24 junio, 2022
- 3rd IWA Specialized International Conference on Disinfection and DBPs 2022. Milan, Italia, 27 junio- 1 julio, 2022
- VI Congreso de Innovación Docente en Ingenieria Química,11-13 de julio 2022, Madrid
- ISES and IEA SHC International Conference on Solar Energy for Buildings and Industry (EUROSUN 2022). Kassel, Alemania, 25 - 29 septiembre, 2022
- XXI Reunión Científica de la Sociedad Española de Cromatografía y Técnicas Afines (SECyTA 2022). Almería, España, 25-27 octubre, 2022
- 5th Iberoamerican Conference on Advanced Oxidation Technologies (V CIPOA). Cuzco, Perú, 7-11 noviembre, 2022
- XI SIMPOSIO DE INVESTIGACIÓN-UAL. Almería, España, 15 noviembre, 2022
- III National Congress of International Water Association – Young Water Professional – Spanish Chapter. Valencia (España). 16 – 19 de noviembre de 2022.

Congress contributions

Spoken

- Simultaneous decontamination and disinfection of real urban wastewater using solar processes at pilot scale. M.J. Abeledo-Lameiro, A. Hernandez-Zanoletty, S. Nahim-Granados, M.I. Polo-López, I. Oller, P. Plaza-Bolaños, A. Agüera, S. Malato. Workshop on Photo-irradiation and Adsorption based Novel Innovations for Water-treatment, PANIWATER. Lecce, Italia, 4 Mayo 2022. (Oral)
- N. Pichel, S. Belachqer-El Attar, P. Soriano-Molina, M.G. Pinna-Hernández, J.L. Casas López, J.A. Sánchez Pérez. Foto-Fenton combinado con NaClO para el cumplimiento de los nuevos requisitos de desinfección establecidos por EU 2020/741. XIV Congreso de la Mesa Española de Tratamiento de Aguas META 2022. Sevilla (España). 1-3 Junio 2022. Oral.
- Procesos solares y ozonización para la reutilización de agua de lavado de la industria de IV gama: evaluación global. S. Nahim-Granados, P. Plaza-Bolaños, I. Oller, S. Malato, A. Aguera, J.A. Sánchez-Pérez, M.I. Polo-López. XIV Congreso Español de Tratamiento de Aguas META 2022. Sevilla, España, 1-3 junio 2022. (Oral)
- Simultaneous micropollutant removal and pathogen inactivation by advanced oxidation technologies for wastewater recovery. I. Oller, M.I. Polo-López, S. Nahim-Granados, S. Malato, M.J. Abeledo Lameiro, S. Miralles, A. Agüera. 11th European Conference on Solar Chemistry and Photocatalysis: Environmental Applications (SPEA), Turin, Italia, 6-10 junio. (Conferencia plenaria)
- Comprehensive Evaluation Of A Real Water Reuse Scenery In Agricultural Irrigation: Monitoring Of Antibiotics, Bacteria And Resistant Genes. M.I. Polo-López, A. Agüera, S. Nahim-Granados, A. González,

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3.3.8 Functional unit members

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3.3.9 Ongoing projects in 2022

3.3.9.1 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%).

Objectives:

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

Participants:

Functional Unit "Water Treatments"

Functional Unit "Environmental Analysis"

Functional Unit "Modeling and Control"

Contacts:

J. L. Casas López (jlcasas@ual.es)

Funds:

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

Time Period:

1/07/2019 – 30/06/2022. Extended0 30/06/2023.

Current Situation:

In Progress

Summary:
The LIFE ULISES project aims to revolutionise conventional wastewater treatment processes through a set of novel technologies to produce value-added resources, such as biofuel vehicles, agricultural biofertilisers and water suitable for reuse, from wastewater. The project aims to reduce energy consumption and the carbon footprint associated with water treatment by increasing the efficiency of a conventional wastewater treatment plant (WWTP) through the integration of different technologies in each of its main lines (water, gas and sludge). During the project, the following low-cost technologies will be implemented at the El Bobar WWTP (Almeria):

- Enrichment of biogas with ABAD Bioenergy® system to produce a renewable biofuel for vehicles (Aqualia, Energylab).
- PUSH anaerobic pretreatment combined with advanced aeration control to halve the energy consumption in the purification process (Aqualia)
- Solar photo-Fenton disinfection treatment to produce reclaimed water for reuse in irrigation (Ciesol - UAL).
- Enzymatic hydrolysis treatment of sludge to obtain a quality agricultural biofertiliser (CETIM, Aqualia).
- System for the recovery of struvite from concentrates using a process based on direct osmosis (CETIM).

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

Objectives:
The main objective of the LIFE ULISES project is to demonstrate the feasibility of a set of technologies to improve the resource efficiency of wastewater treatment plants. This will include: an anaerobic pretreatment and aeration process to reduce energy demand, an upgrading process to increase biogas production, an enzymatic hydrolysis and membrane-based struvite precipitation for the use of sludge as fertiliser and a tertiary treatment based on solar energy for water reuse.
All these processes will be tested and validated in a pilot plant located in El Bobar, Almera, Spain.

3.3.9.3 Regeneración de aguas para riego mediante energía solar en reactores de bajo coste operados en modo continuo (AQUELOO)

Participants:

Functional Unit “Water Treatments”

Contacts:

J. A. Sánchez (jsanchez@ual.es)

Funds:

R&D projects of the University of Almeria in the framework of the Andalusia FEDER Operational Programme 2014-2020, call 2018.

Time Period:

October 2019 – September 2021. Extended Dicember 2022.

Current Situation:

In Progress

Summary:

The AQUELOO project addresses the development of technical solutions based on the use of solar energy for the regeneration of irrigation water in agriculture, thus promoting the use of non-conventional water resources. In this project, the solar photo-Fenton process is considered due to its proven efficiency in eliminating up to 80% of micropollutants and 6 log CFU/mL of pathogenic microorganisms present in effluents from secondary WWTP treatments. On the other hand, the use of low-cost raceway pond reactors (RPR) helps to drastically reduce both investment and operating costs. It will address the disinfection of wastewater by solar photo-Fenton in continuous mode at HRT for 30 to 60 min, with a liquid depth of 5 to 15 cm (depending on local radiation) at pilot scale, as well as the reduction of operating costs by minimising the use of chemical reagents. The challenge will be to reduce the micropollutants present by up to 80% and to achieve inactivation of E. coli bacteria below the detection limit (1 CFU/mL) in accordance with the reuse requirements established for irrigation in Spain (RD 1620/2007). Likewise, the AQUELOO project will contribute to bridging the gap between the treatments validated at laboratory scale and their application in real conditions at pilot scale and in continuous flow.

Objetivos:

This project proposes the continuous operation of solar photocatalysis reactors with residence times (30 - 60 min) shorter than those currently used with chlorination (90 min). The general objectives of the project can be summarised as follows:

- To optimise the continuous operating variables of the "raceway" reactors for the regeneration of wastewater at pilot scale by means of solar photo-Fenton at neutral pH.
- To carry out the conceptual design of a commercial-scale reactor and cost estimation.

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

Participants:

Functional Unit “Water Treatments”

Functional Unit “Environmental Analysis”

Contacts:

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A. Agüera (aaguera@ual.es)

Funds:

Ministry of Science and Innovation (PID2019-110441RB-C31)

Time Period:

June 2020 – May 2023. Extended 31/12/2023.

Current Situation:

In Progress

Summary:

NAVIA is a coordinated project between the University of Almeria (coordinator), the “Plataforma Solar de Almeria” and the Polytechnic University of Valencia. Water stress is a growing global problem, aggravated by climate change. Spain is particularly threatened by water scarcity and freshwater availability is expected to deteriorate in the near future. Among the solutions against water stress, urban wastewater reclamation (UWW) can play a key role as a non-conventional water source for Spain's largest water consumer,

agricultural irrigation. To this end, new tertiary treatments must meet the main challenges of water reuse: acceptable quality, low cost and sustainability. The main objective of the NAVIA project is the development of new methods of UWW regeneration through the development of new photocatalysts and technologies based on solar advanced oxidation processes (AOP), operated in continuous flow in low-cost reactors. To ensure the quality and safety of reused water, the objectives of the processes will be the simultaneous removal of microbial pathogens, such as E. coli, total coliforms, coliphages (somatic and RNA-specific bacteriophages), antibiotic resistant bacteria and their genes (ARB and ARG), and the removal of organic micropollutants (OMC). The final objective is to comply with Spanish legislation (RD 1620/2007) and future regulations, such as the recent proposal of the European Parliament of February 2019 (EC COM 337 final, 2018/0169). Finally, grouping all the data obtained during the project, as well as from the most relevant literature, new physicochemical, energetic and microbiological indicators will be selected as a set of key parameters for a simple, fast and reliable monitoring of the performance of reclamation treatments, with the intention to generate a tool for end-user decision making, especially developed for agricultural irrigation.

Objectives:

Three distinct, but interspersed, areas of research will be explored:

The development of new heterogeneous photocatalysts with high efficiency for the decontamination and disinfection of UWW. The synthesis and characterisation of these organic and semiconductor-based photocatalysts will be carried out. Their efficiency and stability against simultaneous OMC degradation and microbial inactivation will be evaluated, with special attention to mechanistic studies as a basis for kinetic modelling of the processes.

The development of new solar AOPs at pilot plant scale as tertiary treatments of real WWTP effluents. Microbial disinfection and OMC removal will be evaluated using treatments such as the solar photo-Fenton process at neutral pH, both in batch and continuous mode. New sources of iron will be analysed together with the use of chelating agents, as well as the most efficient heterogeneous photocatalysts obtained in (i). Solar irradiation with low doses of oxidants (PDS/PMS, H_2O_2 y HClO/ClO-) for simultaneous disinfection and OMC removal will also be evaluated.

The development of effective and efficient solutions based on solar energy in continuous flow operation: the effects of hydraulic residence time (30-60 min), and liquid depth (5-10 cm) on the removal of target contaminants (bacteria, ARB and ARG, coliphages, OMC), in the processes developed in i) and ii) will be investigated.

3.3.9.5 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.

Objectives:

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.

3.3.9.6 Demostración de reactores continuos para foto-Fenton solar destinados a la regeneración de efluentes secundarios de EDAR (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 ($HO^{\bullet}$) 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.

Objectives:

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.

3.3.9.7 Regeneración de aguas mediante energía solar concentrada (RAYO)

Participants:

Functional Unit "Water Treatments"

Functional Unit "Desalination and Photosynthesis"

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.

3.3.9.8 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 (1º 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.

3.3.9.9 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.

Objectives:

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.

3.3.9.10. Regeneración de aguas residuales urbanas mediante la integración de tecnologías solares basadas en microalgas (tratamiento secundario) y foto-Fenton (tratamiento terciario) (INTEGRASOL)

Participantes:

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.

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 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.

3.3.10 Dissemination activities

As in previous years, the functional unit has participated in the European Researchers' Night 2022, 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 "New water sources: desalination and regeneration towards the sustainability of the integral water cycle". Almeria, from 12 to 14 July 2022. The course covers the main factors involved in desalination and water regeneration processes, which are key to promoting the sustainability of the integral water cycle, addressing aspects such as the circular economy, governance and advances in R&D&I. With regard to desalination, the main current technologies and those under development will be discussed, as well as the pros and cons of each one. In regeneration, special attention will be paid to compliance with the new European regulations for agricultural irrigation, which have a major impact on the Mediterranean basin.

Organisation of the course in the framework of the SFERA III: Short-term Training for technical staff and scientists. Wastewater disinfection and removal of organic microcontaminants using low-cost solar open photo-reactors. Date 6-7 September 2022.

Participation in the Science Week organised by the University of Almeria, from 7 to 11 November 2022, 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 2022), carrying out educational activities at the Francisco Montoy Secondary School in El Ejido, Almeria.

Organisation of the 14th CONFERENCE ON THE EUROPEAN UNION. "Innovation in Wastewater Treatment and Regeneration in the European Union" Almeria, 17-21 October 2022. Several members of the functional unit have attended and carried out dissemination activities through scientific-technical presentations:

- “Introducción a la I+D+I en materia de aguas” Dr. José Antonio Sánchez Pérez.
- “Nuevos retos en la regeneración de aguas depuradas” Dra. Paula Soriano Molina.

3.3.11 Others

Doctoral theses in progress:

- Elizabeth Gualda Alonso (Drs: José Luis Casas López y Paula Soriano Molina)
- Solaima Belachqer El Attar (Drs: José Antonio Sánchez Pérez y Paula Soriano Molina)

- Azahara Martínez García (Drs: Inmaculada Polo e Isabel Oller)
- Kelly Johana Castañeda Retavizca (Drs: Sixto Malato e Inmaculada Polo)
- Alba Hernández Zanoletty (Drs: Isabel Oller e Inmaculada Polo)
- Isabel Cristina Espinoza Pavón (Drs: Inmaculada Polo)
- José Vicente Reinoso Moreno (Drs: Gabriel Acien Fernández y Mª Guadalupe Pinna Hernández)

Adwards obtained during 2022

- Ilaria Berruti. "VIII Premio IIAMA2022" for the best doctoral thesis in the "Planet and Sustainable Development" category, awarded by the Universitat Politècnica de València, through the University Institute for Water and Environmental Engineering Research (IIAMA). 16 December 2022.
- Solaima Belachqer El Attar. Prize for the best oral communication, competing for the PhD in Biotechnology and Industrial Bioprocesses Applied to Agri-Food and the Environment. in XI SIMPOSIO DE INVESTIGACIÓN, organised for Faculty of Experimental Sciences and celebrated at the University of Almeria on 15 November 2022.
- Elena Olivares Ligero (Best Final Degree Project in Industrial Chemical Engineering). Curso 2022/2023.
- Daniel Rodriguez García, best record of the Degree in Industrial Chemical Engineering.

3.4 ACTIVITIES OF "MODELING AND AUTOMATIC CONTROL" RESEARCH GROUP

3.4.1 Functional unit description

This Research Group is composed by researchers of the group "Automatic Control, Robotics and Mechatronics (TEP197, arm.ual.es) of the University of Almería (UAL) and the Plataforma Solar de Almería (PSA). The group has among its areas of interest: intensive agriculture, solar energy, biotechnology and bioengineering, in addition to control education, mechanization and robotics in general. The group also has a research line linked to applications of control systems to achieve thermal, visual and air quality comfort and energy efficiency in buildings. Collaborative activities between the group and the PSA have been developing continuously over the past 25 years, with remarkable participation of UAL researchers in developing some of the SCADA (Supervisory Control And Data Acquisition) system involved in test facilities located in the PSA.
Additional info: https://arm.ual.es/arm-group/about-us/

3.4.2 Main research lines

- Modeling and control of thermosolar plants.
- Modeling, control and robotics in agro-industry.
- Energy efficiency and comfort control in buildings.
- Engineering education.
- Modeling and control of photobioreactors.
- Energy smart grids and electric vehicles
- Predictive, hierarchical and robust control.
- Supervisory systems and industrial communications.
- Artificial intelligence in solar energy applications.
- State estimators

More detailed information can be found in 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

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

José Domingo Álvarez is an Associate Professor at the University of Almería, Spain. He received the Computer Science Engineering degree from the University of Almería in 2003. In 2008, he obtained, from the same university, the Ph.D. degree focused on Automatic Control in Solar Plants which was performed in a leading research centre in this field: la Plataforma Solar de Almería (Solar Platform of Almería). After finishing his Ph.D., he was employed as a postdoctoral researcher in the University of Almería under the framework of the singular strategic project about bioclimatic architecture and solar cooling (PSE-ARFRISOL). Then, he spent two years in the University of Seville (Spain) with a Juan de la Cierva postdoctoral grant. After that, he had a Ramón y Cajal postdoctoral grant in the University of Almería. Currently, he has been promoted to Associate Professor (Profesor Titular de Universidad) in the same university. His research interests are focused on the fields of repetitive control, predictive control and classical PID control with applications to solar power plants, microgrids and energy efficient buildings. In the last ten years, as a result of his work in these research lines, it

is possible to highlight his co-authored in the book Comfort Control in Buildings (Springer, 2014). He is co-author of 47 regular papers published in referred journals, and more than 50 papers in international and national conferences. H-index: 21 (Google Scholar), 17 (Scopus), 15 (Web of Science). He has been director of 3 Ph.D. Thesis and has participated in several national and international R&D projects with public and private funding. Currently, he is a member of the "Automatic control, Robotics and Mechatronics" research group (https://arm.ual.es/arm-group/). He is also a member of the Comité Español de Automática (main Spanish Association in Automatic Control). He was one of the co-organizers of the XXVII Jornadas de Automática (the annual meeting of the Spanish Automatic Control Committee) in 2006, the II Simposio Nacional de Ingeniería Hortícola in 2016 and the XVI Simposio CEA de Ingeniería de Control in 2018. He is the coordinator of the Máster en Energía Solar in the UAL and the person in charge of the Modelling and Control functional unit in the CIESOL centre. He is reviewer of more than 20 renowned international journals (more than 100 reviews), ANEP, and ANECA. He is member of: i) the editorial board of the journal 'Mathematical Problems in Engineering' (1.305 JCR index), ii) the topic board of 'Energies' journal (3.004 JCR index) and, iii) the RP2 review panel of COST (European Cooperation in Science and Technology) actions
Additional info: https://arm.ual.es/arm-group/people/jose-domingo-alvarez-hervas/

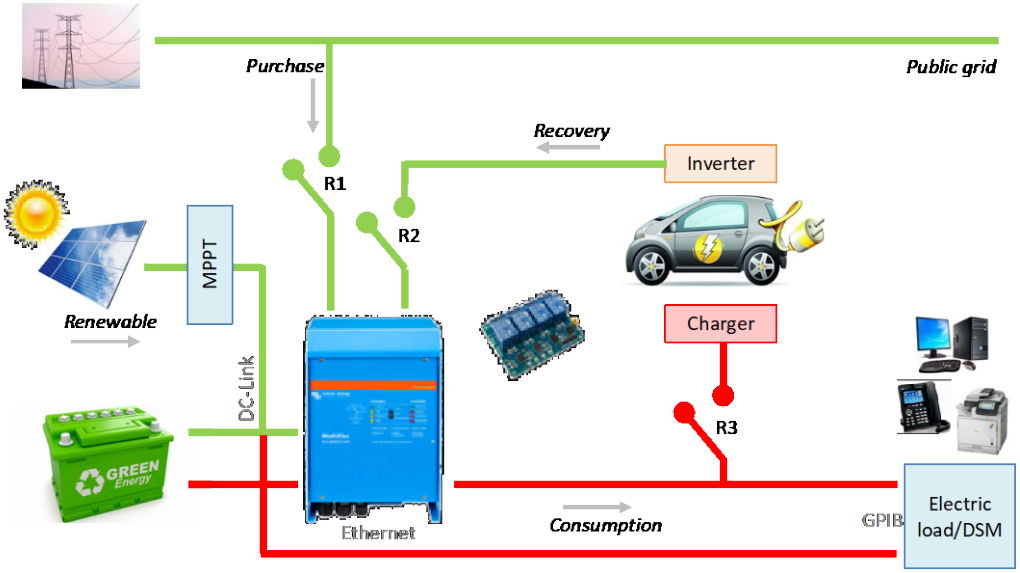
Lidia Roca Sobrino (ORCID 0000-0002-8724-5136, Scopus Author ID 23467603800)

Lidia Roca holds a researcher contract at CIEMAT since 2012. She received the academic degree in Electronic Engineering by the Faculty of Sciences at the University of Granada (2004), Master's in Solar Energy by the University of Almería (2007) and the PhD. degree in the University of Almería (2009), granted by the Extraordinary Doctorate Award in Engineering. Currently she belongs to the Solar Thermal Applications Unit at the Plataforma Solar de Almería. She has published 42 papers in scientific journals with impact index, 42 contributions to international conferences and 2 books. Her main research lines are the modelling, control and optimisation of systems powered by solar thermal energy, with more than 10 years of experience in this field and developing her activity through participation in 20 national and international R&D projects.
Additional info: 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 2022

- Design of energy management and control in productive environments with renewable energies, with special emphasis on agri-food districts.
- Modelling and control of the combined process of microalgae production and wastewater treatment with industrial reactors.
- Modeling and control of solar desalination plants. Modeling and optimization for efficient management of resources in solar desalination.
- Development of models and controllers for fertigation and humidity control in greenhouses and coupling to a solar desalination plant.
- Control of greenhouse crop growth optimizing sustainability, energy and economic criteria.
- Simulation and control of thermosolar plants with parabolic troughs in industrial and refrigeration applications.
- Modeling and optimization for efficient management of resources in solar thermal technology.
- Artificial intelligence for heliostat positioning in central receiver solar thermal systems.

- Control strategies for solar furnaces.
- Modeling and control of wastewater treatment processes.
- Kinematic and dynamic modeling and control of electrical vehicles focusing on energy efficiency using solar energy.
- Control of unmanned aerial vehicles (UAV).
- Development of interactive tools and virtual and remote laboratories for automatic control.
- Robot design and control.



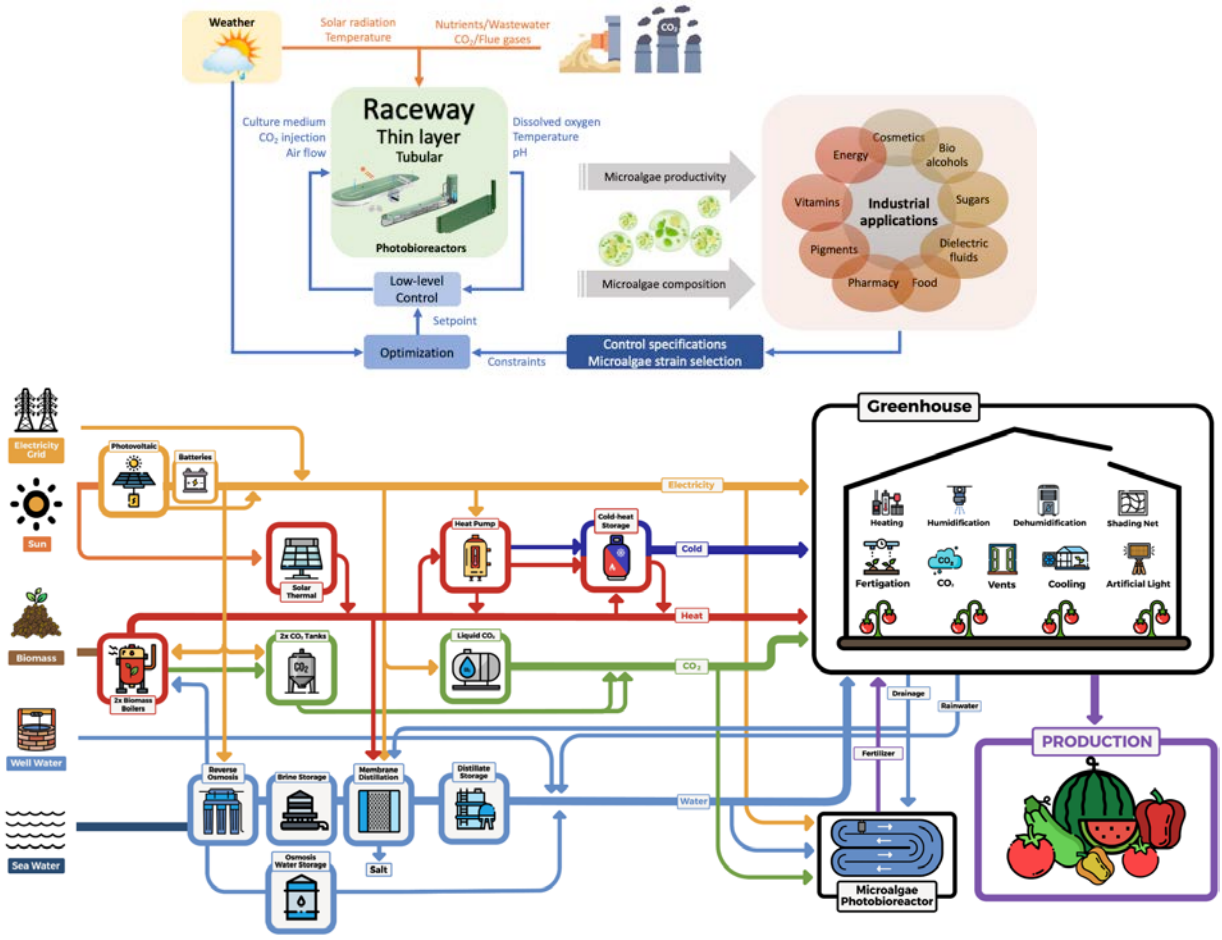


Fig. 2.X.1 Various examples of the activity of the modeling and control unit rol

3.4.5 Collaboration with other functional units of CIESOL during 2022

In 2022 the Modeling and Control Unit has maintained collaborations with the following CIESOL Research Groups:

- Desalination and Photosynthesis: European projects (IndiaH2O), national plan projects (HYCO2BIO, SOLHYCOOL), regional projects (Carbon4Green), joint publications (desalination, photobioreactors, greenhouses, ...) Joint management of TFG, TFM and Doctoral Theses. Collaboration within the scope of the Sfera 3 project.
- Environmental Analysis: collaboration at the joint management level of TFG and TFM. Appearance in local press. Planning of joint publications. Collaboration within the scope of the Sfera 3 project.
- Water Regeneration: collaboration at the joint management level of TFG and TFM. Planning of joint publications. Collaboration within the scope of the Sfera 3 project.
- Solar Resource Assessment and Solar Cooling: collaboration in regional projects (UrbanITA)

In addition, collaborations with PSA are maintained in the following areas:

- Master's in Solar Energy (http://www2.ual.es/master-solar/), coordinated by the main researcher of the Modeling and Control Research Group.
- The research group "Automatics, Robotics and Mechatronics" of the University of Almeria together with CIEMAT have collaborated in the research line of R+D of Automatics in solar thermal plants in

the framework of several national projects: DPI2004-07444-C04-04, DPI2007-66718-C04-04, DPI2010-21589-C05-02, DPI2014-56364-C2-R, DPI2017-85007-R.

- Collaboration with the CIEMAT Energy Efficiency in Buildings Unit UiE3. The collaboration established on the basis of the ARFRISOL project, already concluded, has opened up new options for the development of joint activities of common interest in the field of the dynamic characterisation of the thermal properties of materials and elements.
- Collaboration with the "Lineal Focusing Solar Thermal Technology" research group of CIEMAT-PSA in the scope of the project MICROPOD SOLAR (program CYTED P918PTE0258) about solar thermal applications in isolated and rural industrial processes located in Spain and Iberoamerican countries.

3.4.6 Human resources

Visits and research stays in CIESOL:

- Pataro, Igor. Universidad Federal de Bahía, Brasil (01/09/2020-31/08/2024).

Students in curricular internships:

- José Ruiz Capel. Grado en Ingeniería Electrónica Industrial (08/11/2021-23/01/2022).
- Alberto Martínez Segura. Grado en Ingeniería Informática (08/11/2022-23/01/2023).
- Sergio Rodríguez Perales. Grado en Ingeniería Electrónica Industrial (04/02/2022-18/04/2022).
- Manuel Roda Casas. Grado en Ingeniería Electrónica Industrial (04/02/2022-18/04/2022).
- Malena Caparroz - Grado en Ingeniería Electrónica Industrial (01/02/2022-15/04/2022).
- Delia Sola Molina - Grado en Matemáticas (18/04/2022 - 26/05/2022).
- Fátima Sánchez López - Máster Interuniversitario en Educación Ambiental (01/05/2022 - 30/06/2022).

3.4.7 Scientific production

Number of papers	Number of papers in each queartile				Number of papers with international collaborations
	Q_1	Q_2	Q_3	Q_4	
19	8	3	2	4	10

The publication history can be consulted at the following link:
https://arm.ual.es/arm-group/publications/

Papers

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Congress assistance

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- SFERA-III 3rd Doctoral Colloquium, Zurich, Suiza, 2022.
- Desalination for the Environment: Clean Water and Energy, Las Palmas de Gran Canaria, Las Palmas, España, Junio 2022.
- III Symposium Ibérico de Ingeniería Hortícola 2022 Smart Farming, Cartagena, España, 2022
- 13th IFAC Symposium on Advances in Control Education (ACE 2022), Hamburgo Bergedorf, Alemania, 2022
- XLIII Jornadas de Automática, Logroño, España, 2022
- XVIII Congreso Ibérico y XIV Congreso Iberoamericano de Energía Solar, Palma de Mallorca (España), 20 a 22 de junio de 2022
- Eurosun 22 ISES and IEA SHC International Conference on Solar Energy for Buildings and Industry, Kassel (Alemania), 25 a 29 de septiembre de 2022.
- Simposio Conjunto de los Grupos Temáticos de CEA: Modelado, Simulación, Optimización e Ingeniería de Control, Burgos, España, 2022
- 23rd Nordic Process Control Workshop, Luela, Sweden, 2022
- 13th IWA Specialist conference on Wastewater Ponds and Algal Technologies, Melbourne, Australia, 2022
- 26th International Conference on System Theory, Control and Computing (ICSTCC), Sinaia, Rumania, 2022.
- Nanofiltration 2022, Achalm, Reutlingen, Alemania, 2022.

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- Load Disaggregation Through Particle Filtering of Harmonic Features. A. Poyatos, V. Isanbaev, J.L. Blanco, E. Viciana, J. Ventura, F.M. Arrabal, R. Banos, A. Alcayde, F.G. Montoya. 20th International Conference on Harmonics & Quality of Power (ICHQP), 2022 (Oral).
- Desarrollo de una herramienta de caracterización geográfica para el apoyo al diseño de sistemas solares de calor de proceso en enclaves productivos en el ámbito rural M Pérez, M Frasquet, J A Romero-Ramos, J Aramburo XVIII Congreso Ibérico y XIV Congreso Iberoamericano de Energía Solar, Palma de Mallorca (España), 20 a 22 de junio de 2022 (Oral)
- Modelado y gestión energética de una microrred, basado en estrategias de control predictivo A. O. Topa-Gavilema, J. D. Gil, J. D. Álvarez-Hervás, J. L. Torres-Moreno, M. Pérez-García. XVIII Congreso Ibérico y XIV Congreso Iberoamericano de Energía Solar, Palma de Mallorca (España), 20 a 22 de junio de 2022 (Póster).
- Projeto simulado de um colector solar para fonte de energía de um sistema de secagem para artesanato de barro. M. F. Silva, M. Pérez, F. V. Silva, I. C. Silveira J. D. Álvarez. XVIII Congreso Ibérico y XIV Congreso Iberoamericano de Energía Solar, Palma de Mallorca (España), 20 a 22 de junio de 2022 (Póster).
- Hybrid Solar Thermal Field (FPC-PTC) Applied for Solar Heating and Cooling Process in the Agroindustry Sector. JF. Rosales-Pérez, A. Villarruel-Jaramillo, JD. Gil, M. Pérez-García , JM. Cardemil, R. Escobar Eurosun 22 ISES and IEA SHC International Conference on Solar Energy for Buildings and Industry, Kassel (Alemania), 25 a 29 de septiembre de 2022 (Póster)

PhD Theses

Adaptive modelling of greenhouse climate using metaheuristic algorithms and machine learning techniques. Mounir Guesbaya. University Mohamed Khider Biskra, 19 de diciembre de 2022, Sobresaliente cum Laude.

3.4.8 Functional unit members

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3.4.9 Ongoing projects in 2022

3.4.9.1 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 "Automation, Robotics and Mechatronics". University of Almeria (TEP 197)
Research group "Industrial Informatics". University of Murcia.

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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 mitigae 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 Next Generation Training on Intelligent Greenhouses NEGHTRA

Participants:

Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.
Research group "Automation, Robotics and Mechatronics". University of Almeria (TEP 197)

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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.

3.4.9.3 Micrrorredes para el autoabastecimiento solar de entornos productivos aislados MICROPROD-SOLAR

Participants:

CIESOL (Spain), a joint UAL-CIEMAT centre.
Centro de Tecnologías para Energía Solar CSET (Chile) joint centre Fundación Fraunhofer Inventive Power (México).

Contacts:

Manuel Pérez (mperez@ual.es)

Sources of funding:

Call for Projects on Strategic Themes 2018 ERANET LAC. P918PTE0258

Duration:

January 2019 – December 2022

Status:

Under development

Summary:

The objective of this project is to develop a set of analysis and decision-making tools that justify and favor the implementation of distributed energy micro-grids for the self-supply of isolated productive enclaves in Ibero-America. The type of supply to be considered will include both electricity and process heat and industrial cold, in both cases of solar origin, without prejudice to other renewable contributions in those cases where the available resource permits. This objective will be developed through an initial intensification in the following productive activities, selected based on the experience and capabilities of the consortium members: 1) the energy self-sufficiency of small industries or communities dedicated to the elaboration of wine and spirits, 2) cattle farms dedicated to the treatment and conservation of milk and its derivatives and 3) canning industries traditional crops (asparagus, beans, ...).

Additional info: http://www.cyted.org/es/microprod_solar

3.4.9.4 Agricultural Collaborative Robot Inside IoT (AGRICOBIOT)

Participants:

Research group "Automation, Robotics and Mechatronics". University of Almeria (TEP 197)
Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.

Contacts:

Antonio Giménez Fernández (agimfer@ual.es)
José Carlos Moreno Úbeda (jcmoreno@ual.es)

Source of funding:

Proyectos de investigación orientados a los retos de la Sociedad Andaluza. Programa Operativo FEDER Andalucía 2014-2020. Convocatoria 2020 de Proyectos I+D+i en el Marco del Programa Operativo FEDER-Andalucía 2014-2020.

Duration:

January 2021 – December 2022

Status:

Finalized

Summary:

This project aims to develop an autonomous collaborative platform 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 robot 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 robot inside the greenhouse and the 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. To this end, the robot will implement the recent ISO 11783 standard for communication between electronic devices in agricultural machinery. Also, in order to take advantage of the interoperability benefits offered by the "Internet of Things" (IoT), the experience in the FI-WARE platform will be used to provide the system with a feature that will allow the farmer to know at all times and in real time the status of the greenhouse and the workers (amount of product harvested, crop areas worked, vehicle status, ...). In addition the robot can be equipped with sensors to acquire information about the state of the greenhouse and the crop, in order to use this information in its displacement or to share it with the farmer in real time. The key element of the proposed work architecture is the robot. For this reason, and taking into account that there is currently no development that meets the required needs, the main focus of this project will be the design and manufacture of the mobile platform, leaving the rest of the system as work for a future project.

3.4.9.5 Agricultural Collaborative Robot Inside IoT (AGRICOBIOT II)

Participants:

Research group "Automation, Robotics and Mechatronics". University of Almeria (TEP 197)
Centro de Investigaciones en Energía Solar CIESOL (España), joint centre UAL-CIEMAT

Contacts:

Antonio Giménez Fernández (agimfer@ual.es)
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.

3.4.9.6 Analysis and design of a multifunctional solar concentrator (MULTISOL)

Participants:

Research group "Automation, Robotics and Mechatronics". University of Almeria (TEP 197)
CIESOL (España), centro mixto UAL-CIEMAT

Contacts:

José Domingo Álvarez Hervás (jhervas@ual.es)
Manuel Pérez García (mperez@ual.es)

Source of funding:

Proyectos de I+D en el marco del Programa Operativo FEDER Andalucía 2014-2020. Proyectos de Fomento y Generación de Conocimiento "Frontera". Convocatoria 2020 de Proyectos I+D+i en el Marco del Programa Operativo FEDER-Andalucía 2014-2020 (resolución de 31 de enero de 2020, del Rector de la Universidad de Almería, BOJA nº 30 de 13 de febrero de 2020). Referencia UAL2020-TEP-A2003.

Duration:

January 2021 – June 2023

Status:

Under development

Summary:

This project's objective is to design and analyze the operation of a new concept of solar concentrator with the capacity to produce, through a single element, electricity and high and low range solar heat. Such multifunctionality would make it possible to deal with highly variable annual demand curves caused by seasonal dependencies or by programming according to process, typical of solar applications of an industrial nature. The experiences and advances in the project must also be oriented towards obtaining the international design patent and its dissemination in specialized forums (national and international project working groups and industrial groups). Thus, in a subsequent phase, address its manufacture and testing and promote and achieve commercial exploitation.

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

Participants:

CIESOL (Spain), a joint UAL-CIEMAT centre.
Research group "Automática, Robótica y Mecatrónica". Universidad de Almería (TEP 197)
Association of Fruit and Vegetable Producers' Organisations of Almeria, COEXPHAL
Association of fruit and vegetable producers and exporters of the region of murcia, PROEXPORT
ANECOOP SCA
Group Hispatec Informática Empresarial, S.A.
Fundation Cajamar
Agroplanning Agricultura Inteligente, S.L

Contacts:

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.

3.4.9.8 SOLWARIS - Solving Water Issues for CSP Plants.

Participants:

CIESOL (Spain), a joint UAL-CIEMAT centre.
Almeria Solar Platform
Research group "Automation, Robotics and Mechatronics". University of Almeria (TEP 197)

Contacts:

Manuel Berenguel (beren@ual.es)
Lidia Roca (lidia.roca@psa.es)

Source of funding:

Horizon 2020 Framework Programme. Grant Agreement number: 792103.

Duration:

30/09/2019-30/04/2022.

Status:

Finalized

Summary:

SOLWARIS is a project funded by the European Union's Horizon 2020 research and innovation programme, coordinated by TSK ELECTRÓNICA Y ELECTRICIDAD SA, Spain.

The objective of SOLWARIS is to significantly reduce the water used by CSP plants. The project aims to demonstrate the efficiency of innovations in solar field cleaning, power block cooling, water recycling system and plant operation strategy.

Additional info: https://solwaris.eu/

3.4.9.9 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

Source of funding:

Proyecto PID2021-122560OB-I00 financiado por MCIN/ AEI /10.13039/501100011033/ y por FEDER Una manera de hacer Europa

Duration:

September 2022 – August 2025

Status:

Under development

Summary:

The main objective of this proposal is to develop optimized control and management framework which, through the generation, storage, reuse and use of water, energy, and carbon to control the climate, enrichment, and fertigation. Moreover, the study of the capabilities and protocols aimed at integrating these heterogeneous elements will play an important role. To this end, it is necessary to design and implement the cyber-physical architecture, from the automatic control perspective, as a framework within which all future developments will be performed. To analyse and understand the physical components, the intersection, and the computational components to integrate the hierarchy, the data fluxes, and the capabilities. To develop the most appropriate control and optimization strategies for the nexus, the changing process conditions

during the operation horizon, and the crop demands – so as to improve the sustainability (energy, water, and carbon footprint) and economic profitability of the greenhouse production. To implement and validate through field trials and to evaluate the benefits resulting from its use. For this purpose, the developed algorithms will be implemented and evaluated under different operating conditions over an agricultural season along with the environmental and economic benefit to the farmers of the developed technology.

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

Participants:

Centro de Investigaciones en Energía Solar CIESOL (España), centro mixto UAL-CIEMAT
Research group "Automation, Robotics and Mechatronics". University of Almeria (TEP 197)

Contacts:

José Domingo Álvarez Hervás (jhervas@ual.es)
Manuel Pérez García (mperez@ual.es)

Source of funding:

Proyecto PID2021-126889OB-I00 financiado por MCIN/ AEI /10.13039/501100011033/ y por FEDER Una manera de hacer Europa

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.

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

Participants:

CIESOL (España), centro mixto UAL-CIEMAT
Research group "Automation, Robotics and Mechatronics". University of Almeria (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.

3.4.9.12 PARTICIPACIÓN – SFERA III Solar Facilities for the European Research Area

Participants:

Centro de Investigaciones en Energía Solar CIESOL (España), centro mixto 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.

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

Participants:

CIESOL-Universidad de Almería
Research group "Automation, Robotics and Mechatronics". University of Almeria (TEP 197)
Functional Unit. "Desalination andPhostosynthesis". University of Almería (BIO 352).

Contacts:

José Luis Guzmán Sánchez (joseluis.guzman@ual.es)
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.

3.4.9.14 PARTICIPACIÓN – Soluciones de refrigeración híbrida para ahorro de agua en aplicaciones solares térmicas (SOLHYCOOL)

Participants:

Plataforma Solar de Almería - CIEMAT
CIESOL-Universidad de Almería
Universidad de Huddersfield (Reino Unido)
Research group "Automation, Robotics and Mechatronics". University of Almeria (TEP 197)
Functional Unit. "Desalination andPhostosynthesis". University of Almería (BIO 352).

Contacts:

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

Source of funding:

Convocatoria de Proyectos de Generación de Conocimiento 2021. Agencia Estatal de Investigación. Ministerio de Ciencia e Innovación y por FEDER Una manera de hacer Europa.

Duration:

September 2022 – August 2025

Status:

Under development

Summary:

The object of this project is to advance in the hybrid cooling technology forits use in solar thermal applications at comercial scale, like are the Concentrating SolarPower plants and the multi-effect distillation plants driven by solar energy and locatedinland, to thus achieve a reduction in water consumption in such applications. Throughthe use of methods in automatic control, it should be achieved an optimum managementof the operation of the hybrid cooling systemsin terms of water consumption avoidingthe penalty in the efficiency of the solar thermal applications in which the cooling systemsare integrated, thus making the technology feasible from the technical and economicalpoint of views.

3.4.10 Network participation during 2022

https://arm.ual.es/arm-group/networks-operating-groups/

- Solarconcentra – Concentrated Solar Power Technology PlatformExpediente PTR-2018-001094. Under development (http://www.solarconcentra.org/)
- CO2 Technology Platform. Expediente PTR2018-001099. Under development (https://www.pteco2.es/es)
- Hisparob – Spanish Robotics Technology Platform. Expediente PTR2018-001073. Under development (https://www.pteco2.es/es)

- Automática ES Network. Acciones de Dinamización "Redes de Investigación". Ministerio de Ciencia, Innovación y Universidades. RED2018-102688-T. IP. Carlos Balaguer Bernaldo de Quirós (UC3M) Under development
- Control Engineering Thematic Network. Acciones de Dinamización "Redes de Excelencia". Ministerio de Economía, Industria y Competitividad. DPI2017-90823-REDT. IP Ramón Vilanova i Arbós (UAB). Under development
- Control Education Thematic Network. Acciones de Dinamización "Redes de Excelencia". Ministerio de Economía, Industria y Competitividad. Under development
- Robotics National Network. Acciones de Dinamización "Redes de Investigación". Ministerio de Ciencia, Innovación y Universidades. DPI2017-90853-REDT. IP. Miguel Ángel Salichs Sánchez-Caballero. Under development

Operating groups

- Go Invernconnec: From the crop to the final consumer. https://www.coexphal.es/wp-content/uploads/2018/10/GOINVERCONEC_Cartel.pdf
- ES-Agri – Sustainable energy for protected agriculture. http://www.coexphal.es/grupos-operativos-autonomicos/
- A4P. Agrodata 4 Prediction. http://www.coexphal.es/grupos-operativos-autonomicos/
- RENTIA: Artificial Intelligence and Big Data to improve the profitability of the Andalusian farmer. https://unicagroup.es/bigdata/

3.4.11 Transfer and Complementary Activities

Contracts with companies

- Contract with Dirección General de Producciones y Mercados Agrarios of the Ministery of Agricultura, Pesca y Alimentación (Spain): "Proyecto piloto para la determinación del momento óptimo de recolección para la mejora de la calidad en el sector del aceite de oliva". Budget: 18.150,00 €. The objective of the Project is the developmet of a mathematical model that allows determining the optimal moment of harvesting the olive.
- Contract with Albedo Solar, S.L. Budget: 28.100,00 €. This contract is based on a system (patent ES2514090) which recovers the CO_2 contained in the combustion gases generated in heating systems to be used in carbon enrichment systems of atmospheres, as in greenhouses. This contract is part of the Call "UALTransfiere" and the objective is to adapt the prototype to commercial crop conditions. To achieve this, three milestones have been stablished: (i) to analyze options to scale the system to ten times the size of current prototypes, (ii) analyze the appropriate components to perform the scale, (iii) modify the supervisor and control system to commercial plants and (iv) assess the system under real operating conditions.
- Contract with the company Sercom Automation S.L. The budget of the minor contract is 33,500.00 €. The starting point of this contract is a Service Provision signed between the company "SERCOM Automation S.L." and the Research Group of the UAL "Automatics, Robotics and Mechatronics TEP-197" developed on "Feasibility study of the pecan nut as fuel for biomass boilers", whose results have been evaluated by the company. It is important to highlight that agro-food systems are suitable for the implementation of combined cycle technologies for heating and electricity generation for two main reasons: (i) it is one of the economic engines of the province of Almeria; (ii) it reduces

dependence on external energy sources to reduce the impact on the bill in an unstable market situation. Therefore, the objective of the "CHPTransfer" contract linked to the "Transfiere 2022" call is to study the economic viability of the implementation of this type of technologies in agro-industrial systems. This project focuses on the techno-economic analysis of a combined cycle installation for agro-industry using pecan nut waste as fuel. In this line, this new proposal requested in the "UALTransfiere" call aims to adapt the proposal to the needs of a pilot plant proposed by the company SERCOM Automation S.L. For this purpose, three milestones must be met: (i) Study of the current situation of the pilot company; (ii) sizing of the thermal/electrical cogeneration system and (iii) techno-economic analysis of the proposed solution. Therefore, the co-participation of researchers from the University of Almeria and the test center, and the company SERCOM Automation S.L., which has extensive experience in the application of renewable systems, is important for the development of the contract.

- Contract with the company Teladoc Health Inc. In this contract, consulting and software engineering tasks are being carried out within the framework of the development of a prototype of a mobile robot for hospital environments

The history of transfer activities can be consulted at the following link:
https://arm.ual.es/arm-group/knowledge-transfer/

Agreement with Universities

- Agreement between the Andalusian Institute for Agricultural, Fisheries, Food and Ecological Production Research and Training (IFAPA) and the University of Almeria for the shared management of the cultivation system (Agroconnect) - IFAPA File 116/2020, 25 November 2020. The Modelling and Control unit has promoted an agreement whose objective is to regulate the collaboration between UAL and IFAPA for the installation of the AGROCONNECT Infrastructure, in order to have a testing and demonstration infrastructure for research on a real scale and functionality, with the capacity to generate a public data bank that can be used to verify and evaluate operational characteristics and the efficiency of the technologies, and thus obtain maximum performance in the greenhouse crop production phase, which traditionally has less technological development. Solar thermal and photovoltaic systems have been installed to provide process heat and cooling and water desalination for use in greenhouse cultivation.
- Agreement with University of Brescia. The agreement includes co-tutela of Thesis, exchange of Erasmus students, double degree in Mechatronics for industrial automation, etc. As a result of the agreement, Prof. Manuel Berenguel has co-directed, together with Prof. Antonio Visioli, the thesis of Manuel Beschi and Prof. José Luis Guzmán is co-directing with Prof. Visioli the doctoral thesis of Enrique Rodríguez Miranda. The group of the University of Brescia made a stay (Domenico Gorni and Antonio Visioli) in the scope of the Sfera II project, dedicated to the simplified modeling of rooms in buildings and another room (Luca Merigo) dedicated to the development of event-based control algorithms.

Collaboration with programmes

- Collaboration in ERASMUS+ KA 107 Programme. The Erasmus + KA 107 program is a student and teacher exchange program aimed at collaborating with partner countries. In it, stays of professors and students of master's and doctorate that include research activities are admitted.
- Collaboration with PIMA Programme. Exchange of students from the UAL and the Federal University of Santa Catarina (Brazil).

Collaboration with another institutions

- Collaboration with the Schneider Electric Agreement. Training of teachers and students in digital technologies for energy management and automation.

3.4.12 Dissemination activities

Summary: https://arm.ual.es/arm-group/dissemination-of-results/ and https://arm.ual.es/arm-group/news/

- European Night of the Researchers, Almería
- Week of Science, Almería
- Robotics Club
- European Robotics Week
- 11F. Una científica visita tu centro (A woman scientist visits your center)
- FIRST LEGO League
- Desafío del Club de Robótica de la UAL (UAL Robotics Club Challenge)

3.4.13 Others

Final degree projects:

- Marina Guil Torres (Grado en Ingeniería Electrónica Industrial). Desarrollo de una herramienta scada en codesys para fotobiorreactores industriales, 2022.
- Alejandro Dimas Rodríguez (Grado en Ingeniería Electrónica Industrial). Diseño y desarrollo de una herramienta scada sobre pantallas hmi para fotobiorreactores industriales, 2022.
- Davide Coltri (Grado en Ingeniería Electrónica Industrial). Técnicas de mantenimiento predictivo y sus aplicaciones en la fabricación de acero, 2022.
- Francisco Marin Martínez (Máster en Ingeniería Industrial). Diseño y construcción de un sistema para la realización de respirometría en cultivos de microalgas, 2022.
- Álvaro Rozas Teruel (Máster en Ingeniería Industrial). Programación de autómata programable schneider m221 para el control de grupos evaporativos en instalaciones de renovación de aire y supervisión mediante sistema SCADA wincc por protocolo Modbus, 2022.
- José González Hernández (Máster en Ingeniería Industrial). Diseño de un estimador de concentración de biomasa mediante la luminosidad obtenida por un sensor RGB, 2022.
- José Moya López (Máster en Ingeniería Industrial). Diseño y construcción de un sistema de desinfección por nebulización mediante atomización ultrasónica, para la prevención de la COVID-19, 2022.
- Malena Caparroz (Grado en Ingeniería Electrónica Industrial). Un nuevo enfoque de modelado y control para la regulación del pH en fotobiorreactores raceway. 2022.
- Andrés López Palenzuela (Grado en Ingeniería Electrónica Industrial). Modelado y control no lineal de

un horno solar. 2022.

- Ginés Martínez García (Grado en Ingeniería Electrónica Industrial). Estrategias de modelado de una máquina enfriadora de agua por absorción de H20/LiBr con agua recibida de una planta solar. 2022.
- Manuel Roda Casas (Grado en Ingeniería Electrónica Industrial). Optimal design of membrane distillation plants powered by solar energy based on techno-economic criteria. 2022.
- Davide Beccalossi (Grado en Ingeniería Electrónica Industrial). Modeling and Development of Portfolio Allocation Algorithm. 2022.
- Michele Francesco Arrighini (Grado en Ingeniería Electrónica Industrial). A genetic algorithm based climate change control. 2022.
- Alejandro Bueso Sánchez (Máster en Ingeniería Industrial). Técnicas de control libre de modelo aplicadas a plantas de destilación por membranas operando en modo Batch. 2022.
- Marta leal Rueda (Máster en Energía Solar). Análisis del control automático de una planta de tratamiento de aguas alimentada con energía fotovoltaica de bajo coste. 2022.
- Guillermo Martínez Martínez (Grado en Ingeniería Electrónica Industrial). Desarrollo de un sistema de localización en interiores basado en balizas UWB con aplicación en robótica móvil. 2022.
- David París Góngora (Grado en Ingeniería Electrónica Industrial). Implementación eficiente en C++ del algoritmo de los cinco puntos para emparejamiento robusto de imágenes en visión artificial. 2022.
- Radu Berbbec (Grado en Ingeniería Electrónica Industrial). Designing and development of a robotic cell for steel bars tagging. 2022.
- Ángel López Gázquez (Grado en Ingeniería Electrónica Industrial). Simulación del robot Husky para aplicaciones colaborativas en un invernadero. 2022.
- Juan Modesto Espinosa Bogas (Grado en Ingeniería Electrónica Industrial). Desarrollo de un HRI basado en OpenBCI para el control básico de robots. 2022.
- Pablo Marín Molina (Grado en Ingeniería Electrónica Industrial). Desarrollo de un simulador para la Duckietown de la UAL. 2022.
- Mario Rosendo Pérez García (Grado en Ingeniería Electrónica Industrial). Modelado y simulación de producción de energía mediante Matlab y Simscape
- María del Mar López Gámez (Grado en Ingeniería Electrónica Industrial). Desarrollo de un huerto automatizado tipo Farmbot
- Marcos Barranco Moreno (Máster Universitario en Transformación Digital de Empresas). Diseño de paneles descriptivos con Power BI para Agrodolores.
- Eduardo Joya Peña (Grado en Ingeniería Electrónica Industrial). Prototipo Hardware in the Loop para el diseño de benchmarks en la enseñanza de la automatización y el control automático.
- Beatriz Pérez Gil (Grado en Ingeniería Electrónica Industrial). Asistente de operación y mantenimiento eléctrico mediante realidad aumentada.
- Eduardo Jesús Machuca Moreno (Máster en Energía Solar). Caracterización energética experimental de envolventes en edificios. Aplicación al edificio Taller del LECE en la PSA.

- Alba Manzanares Boga (Grado en Ingeniería Electrónica Industrial). Diseño de estimadores para abaratar la red de sensores necesarios para la estimación del confort térmico en edificios bioclimáticos.
- Pablo Marín Molina (Grado en Ingeniería Electrónica Industrial). Desarrollo de un simulador para la Duckietown de la UAL.
- Pablo Bernardez Plaza (Grado en Ingeniería Mecánica). Estudio para la eficiencia energética en las plantas de producción de silestone.
- Carlos Villegas Ramos (Grado en Ingeniería Mecánica). Proyecto de mejora para estanterías de enfriamiento prometec en fábricas de silestone
- Angel Acien Zapata (Grado en Ingeniería Mecánica). Desarrollo de un entorno de simulación para la optimización de un proceso de mezclado de piedra artificial
- Jose Lopez Gonzalez (Grado en Ingeniería Mecánica). Diseño de un prototipo de sistema de auto limpieza en reactores de microalgas
- Jose Luis Montoya Lopez (Grado en Ingeniería Mecánica). Diseño y construcción de maqueta de invernadero adaptable para el estudio experimental de la ventilación natural.
- Jose Luis Montoya Viñolo (Grado en Ingeniería Mecánica). Diseño de un sistema de sombreado de invernaderos basado en vehículos aéreos no tripulados
- Alejandro Manuel Salvador Ortega (Grado en Ingeniería Mecánica). Reducción de tiempos de parada de producción en la planta industrial de dekton de la empresa cosentino s.a.
- Juan Pablo Grosso Tarazaga (Grado en Ingeniería Informática). Implementación de un sistema de control inteligente en un cultivo doméstico
- Jorge Perez Cano (Grado en Ingeniería Electrónica Industrial). Maqueta con 4 motores para la enseñanza de conceptos básicos de automática
- Estibaliz Segura Diaz (Grado en Ingeniería Electrónica Industrial). Puesta en marcha de un sistema de cultivo inteligente basado en arduino
- Juan Jose Cano Rodriguez (Grado en Ingeniería Electrónica Industrial). Diseño e implementación de un sistema de control y adquisición de datos para la gestión automatizada de la ventilación natural en un invernadero experimental
- Almudena Gutierrez Roman (Grado en Ingeniería Electrónica Industrial). Diseño e implementación de un sistema barra-bola para el aprendizaje de los conceptos fundamentales de los controladores tipo pid

PhD Theses under development

- Artero Carrillo, Francisco (supervisor Manuel Pérez García).
- Carreño Zagarra, José (supervisors José Carlos Moreno, José Luis Guzmán).
- García Mañas, Francisco (supervisores Francisco Rodríguez, Manuel Berenguel).
- García Ruiz, Rubén Antonio (supervisores José Luis Blanco Claraco, Javier López Martínez).
- González Hernández, Jose (supervisores José Luis Guzmán, José Carlos Moreno).

- González, Rubén (supervisores Francisco Rodríguez, Jerónimo Ramos)
- Hoyo Sánchez, Ángeles (supervisores José Luis Guzmán, José Carlos Moreno Úbeda).
- Muñoz Rodríguez, Manuel (supervisores Jorge Antonio Sánchez-Molina, Manuel Torres).
- Otálora Berenguel, Pablo (supervisor José Luis Guzmán).
- Pataro, Igor (supervisores José Luis Guzmán, Juan Diego Gil, Manuel Berenguel).
- Ran, Liu (supervisores José Luis Guzmán, Li Ming).
- Romero Ramos, Jose Alfonso (supervisor Pérez García, Manuel).
- Serrano Rodríguez, Juan Miguel (supervisores Lidia Roca, Patricia Palenzuela, Manuel Berenguel)
- Topa Gavilema, Alex Omar (supervisores José Domingo Álvarez, José Luis Torres).

Attendance at Transfer and Dissemination Workshops

- Courses of the PhD in Computer Science 2022. https://sites.google.com/ual.es/cursosdoctoradoinformatica2022
- Nuevas fuentes de agua: desalación y regeneración hacia la sostenibilidad del ciclo integral del agua (New water sources: desalination and regeneration towards the sustainability of the water cycle), Almería, España, 2022.

Awards obtained during 2022 (https://arm.ual.es/arm-group/awards/)

M. Caparroz, P. Otálora, J.L. Guzmán, M. Berenguel. Award to the best work in Control Engineering in XXLII Jornadas de Automática, La Rioja, Spain. 2022.

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 optimising 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. With regard to 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 the area of 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 2022

During 2022, it is worth highlighting the active participation of all the members of the functional unit in the evaluation and application of the solar resource. Three new research projects have been obtained with different organisations and different researchers from UAL, CIEMAT-PSA, the University of Huelva and the University of Granada have joined the unit, with whom we are working on applications related to CIESOL and its competences in the field of solar resources and solar cooling. During this year, we have been able to carry out numerous developments (some presented at conferences and others currently under review in high impact scientific journals) concerning the creation of maps from geographic information systems, using Copernicus databases and others such as those of CIESOL and the State Meteorological Agency (AEMET). All these new studies are making it possible to strategically define optimal locations for installing photovoltaic solar energy plants throughout Spain, with special interest in the areas of Almeria and the Costa del Sol. As a result of this, we have been able to count on the collaboration of a student on company internships who has been able to enter a doctoral programme at the University of Almeria to continue with this important line of research over the next few years.

In the research line of solar refrigeration and heating, we have continued servicing the building, using the full capabilities of the facility, including the low temperature heat storage systems, based on water and phase change materials (PCM) installed previously.
In September 2021, a LIFE project (COOLSPACES 4 LIFE) started. The project is led by Prof. Sabina Rosiek from the Wroclaw University of Science and Technology (Poland), and is participated by a few members of the unit, forming the UAL node. During 2022, we have started the study of individual PCM nodules. A commercial PCM was been selected for the range of temperatures expected, and a pilot storage tank, with a volume of 60 liters, has been also installed. Although these studies are carried out in the laboratories of Physics, in a different building, the results derived from them will be used in the facilities that will be installed in CIESOL, within the project.
On the other hand, three refrigeration chambers, equipped with a PV-driven conventional refrigeration system and thermal storage based on PCMs, have been re-started, after several years out of operation. The whole system and chambers have been reconditioned and put in order. A master student, from the Solar

Energy Master, did his master thesis work, supervised by profs. María Jesús Ariza and Manuel S. Romero, both of them members of the unit. Also, one of the chambers (where refrigeration is provided by a conventional system) is giving service to other units, for low temperature storing of products.

On the other hand, the refrigeration chambers installed in the CIESOL courtyard have begun to be overhauled, after several years of stoppage. As a result of this overhaul, a student from the Master's Degree in Solar Energy completed the Master's Thesis, directed by professors María Jesús Ariza Camacho and Manuel S. Romero Cano, both members of the unit. In addition, one of the chambers (powered by a conventional refrigeration system) is serving other units for storing products at low temperatures.
At present, individual nodules of a commercial PCM with a melting temperature of 3ºC, with different geometries and under different conditions, have already been studied. A 60-litre pilot tank is also being used to analyse the optimal mode of operation of a thermal storage system based on PCMs. This pilot tank is fed by a cooling system with an 80-litre buffer tank, which can be cooled down to -12ºC. PCMs with different geometries and in different orientations have been tested in the tank.
On the other hand, in February 2022, a graduate in Mechanical Engineering, who subsequently completed the Master's degree in Solar Energy and has enrolled in the PhD programme "Applied Environmental Sciences", under the direction of Antonio M. Puertas, was hired for the project.

3.5.5 Collaboration with other functional units of CIESOL during 2022

In line with the Andalusian Regional Government project, Proyecto I+D UrbanITA, ref. P20_00809, on energy efficiency in building and modelling, the TEP165 and TEP 197 research groups are collaborating, linked to the solar resources and solar cooling units; and modelling and control, respectively. In fact, in 2022 a project has been awarded by the Ministry of Science and Innovation (Ecological and Digital Transition) in which members of these two units are working together.

3.5.6 Human resources

Students in curricular internships:

- Andreea Castillo Cucura. Degree in Computer Engineering (08/11/2021-21/01/2022).
- David Camacho Jurado. Degree in Computer Engineering (30/11/2021-11/02/2022).
- José Manuel Lajara Lázaro. Degree in Law (18/03/2022-02/06/2022).

Students in extra-curricular internships:

- Noelia Simal Pérez. Master in Industrial Engineering (10/01/2022-09/07/2022).

PhD students:

- Noelia Simal Pérez. PhD Program in Applied Environmental Sciences.
- Álvaro Castro Vizcaíno. PhD Program in Applied Environmental Sciences.

3.5.7 Scientific procduction

Number of papers	Number of papers in each queartile				Number of papers with international collaborations
	Q_1	Q_2	Q_3	Q_4	
7	6	1			7

Papers

- World map of low-layer atmospheric extinction values for solar power tower plants projects. Aloïs Salmon, Aitor Marzo, Jesús Polo, Jesús Ballestrín, Elena Carra, Joaquín Alonso-Montesinos. *Renewable Energy, 201, 876–888, 2022. https://doi.org/10.1016/j.renene.2022.11.003*
- Multivariate Analysis for Solar Resource Assessment Using Unsupervised Learning on Images from the GOES-13 Satellite. Jared D. Salinas-González, Alejandra García-Hernández, David Riveros-Rosas, Gamaliel Moreno-Chávez, Luis F. Zarzalejo, Joaquín Alonso-Montesinos, Carlos E. Galván-Tejada, Alejandro Mauricio-González, Adriana E. González-Cabrera. Remote Sensing, 14, 2203, 2022. https://doi.org/10.3390/rs14092203
- A comparative analysis of opto-thermal figures of merit for high temperatura solar thermal absorber coatings. Simon Caron, Jorge Garrido, Jesús Ballestrín, Florian Sutter, Marc Röger, Francisco Manzano-Agugliaro. *Renewable and Sustainable Energy Reviews, 154, 111818, 2022. https://doi.org/10.1016/j.rser.2021.111818*
- Soiling Forecasting of Solar Plants: A Combined Heuristic Approach and Autoregressive Model. Jesús Ballestrín, Jesús Polo, Nuria Martín-Chivelet, Javier Barbero, Elena Carra, Joaquín Alonso-Montesinos, Aitor Marzo. Energy, 239, 122442, 2022. https://doi.org/10.1016/j.energy.2021.122442
- Interannual variation of measured atmospheric solar radiation extinction levels. Elena Carra, Jesús Ballestrín, Rafael Monterreal, Raúl Enrique, Jesús Polo, Jesús Fernández-Reche, Javier Barbero, Aitor Marzo, Joaquín Alonso-Montesinos, Gabriel López, Blas Díaz. *Sustainable Energy Technologies and Assessments, 51, 101991, 2022. https://doi.org/10.1016/j.seta.2022.101991*
- Nowcasting System Based on Sky Camera Images to Predict the Solar Flux on the Receiver of a Concentrated Solar Plant. Joaquín Alonso-Montesinos, Rafael Monterreal, Jesús Fernández-Reche, Jesús Ballestrín, Gabriel López, Jesús Polo, Francisco Javier Barbero, Aitor Marzo, Carlos Portillo, Francisco Javier Batlles. *Remote Sensing, 14, 1602, 2022. https://doi.org/10.3390/rs14071602*
- Improvements in the measurement of high solar irradiance on a 300 kWth volumetric receiver. M. Casanova, J. Ballestrín, R. Monterreal, J. Fernández-Reche, R. Enrique, A. Ávila-Marín. Renewable *Energy, 201, 441–449, 2022. https://doi.org/10.1016/j.renene.2022.10.080*

Participation in Congresses

- CIES2022, Palma de Mallorca, España, 2022.
- EuroSun 2022, Kassel, Alemania, 2022.
- X Congreso Andaluz de Ciencias Ambientales, Sevilla, España, 2022.
- 10ª Asamblea Hispano-Portuguesa de Geodesía y Geofísica, Toledo, España, 2022.
- XVI Congreso Nacional de Materiales - CNMat2022, Ciudad Real, España, 2022.
- CEA-INES, Le Bourget-du-Lac, Francia, 2022.

Congress contributions

- Capacidad de suelo disponible para instalaciones solares fotovoltaicas en el sur de España (Andalucía). Luis Martínez-Amate, Joaquín Alonso Montesinos. CIES2022, Palma de Mallorca, España, 20 – 22 junio 2022.
- UrbanITA: un modelo de referencia de servicios IoT abiertos dirigido a estrategias de eficiencia energética en edificios públicos inteligentes. J. Alonso-Montesinos, M. A. García-Fuentes, M. Pérez, N. Padilla, J. Criado, R. Ayala, A. Corral, A. J. Fernández, M. Mena, J. A. Llopis, L. Iribarne. CIES2022, Palma de Mallorca, España, 20 – 22 junio 2022.
- Experimental Device to Measure the Spectral Transmittance of Soiling on Photovoltaic Covers under Outdoor Performance Conditions. Gabriel López, Joaquín Alonso-Montesinos, Aitor Marzo, Jesús Polo, Jesús Ballestrín, Nuria Martín-Chivelet, Elena Carra, Francisco J. Batlles, Javier Barbero. EuroSun 2022, Kassel, Alemania, 25 – 26 septiembre 2022.
- An extreme dust episode under COVID-19 time in the south of Spain 2022: effect in PV panels. Noelia Simal Pérez, Joaquín Alonso-Montesinos, Jesús Polo, Gabriel López. EuroSun 2022, Kassel, Alemania, 25 – 26 septiembre 2022.
- Automatic discrimination between haze and cloudiness in all-sky camera images. Martha Isabel Escalona-Llaguno, Gabriel López, Joaquín Alonso-Montesinos, Jesús Polo, Jesús Ballestrín. 10ª Asamblea Hispano-Portuguesa de Geodesía y Geofísica, Toledo, España, 28/11-01/12 2022.
- *Development of an annual average map of losses caused by dust deposition in photovoltaic systems in Spain*. Noelia Simal Pérez, Joaquín Alonso-Montesinos. 10ª Asamblea Hispano-Portuguesa de Geodesía y Geofísica, Toledo, España, 28/11-01/12 2022.
- Desarrollo De Un Mapa De Andalucía Sobre Las Toneladas Métricas de Co_2 Ahorradas Por Kwh Al Año Haciendo Uso De Sistemas Fotovoltaicos. Noelia Simal Pérez, Joaquín Alonso-Montesinos. X Congreso Andaluz de Ciencias Ambientales, Sevilla, España, 3 – 4 de noviembre 2022.
- Banco de ensayo de envejecimiento acelerado de muestras cerámicas mediante energía solar concentrada. I. Cañadas, J. Fernández-Reche, J. Rodríguez, J. Ballestrín, J. Galindo. XVI Congreso Nacional de Materiales - CNMat2022. Ciudad Real (Spain), 28/06-01/07 2022. Presentación oral.
- Pyrometric method for measuring emittances at high temperatures. Jesús Ballestrín. Workshop on Measurement of temperature dependent emissivity/emittance. CEA-INES, Le Bourget-du-Lac, Francia, 18 Octubre 2022. Presentación oral.
-

PhD Theses

Caracterización, modelización y predicción a corto plazo de la producción de la potencia de una planta fotovoltaica, utilizando cámara de cielo y Técnica de Inteligencia Artificial. Mauricio Trigo González, Doctorado en Ciencias Aplicadas al Medio Ambiente. Sobresaliente. 12/12/2022.
Directores: Francisco Javier Batlles Garrido, Joaquín Alonso Montesinos, Aitor Marzo Rosa.

3.5.8 Functional unit members

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Associate Professor
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Juan Luis Bosch Saldaña

Associate Professor
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María Jesús Ariza Camacho

Associate Professor
UAL

Gabriel López Rodríguez

Associate Professor
UHU

Sabina Rosiek-Pawlowska

Posdoctoral researcher
Wroclaw University of Science and Technology

Aitor Marzo Rosa

Ramón y Cajal reseracher
UGR

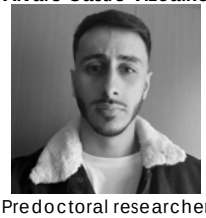
María Elena Carra

Posdoctoral researcher
CIEMAT-PSA

Noelia Simal Pérez

Predoctoral researcher
UAL

Álvaro Castro Vizcaino



Predoctoral researcher
UAL

3.5.9 Ongoing projects in 2022

3.5.9.1 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).
Source of funding:
Ministerio de Ciencia e Innovación.
Duration:
November 2021 – October 2024.
Status:
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.

3.5.9.2 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:
In Progress
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 latter 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.

3.5.9.3 An open IoT services reference model for energy efficiency strategies (UrbanITA)

Participants:

University of Almería

Technology centre CARTIF

University of Thessaly, Volos (Grecia)

Contacts:

Luis Iribarne Martínez (luis.iribarne@ual.es)– PI project

Joaquín Alonso Montesinos (joaquin.alonso@ual.es)

Manuel Pérez García (mperez@ual.es)

Source of funding:

Dirección General de Investigación y Transferencia del Conocimiento, Junta de Andalucía.

Duration:

October 2021 – March 2023

Status:

In Progress

Summary:

We are immersed in a drastic change of the energy model in our buildings, increasing their energy efficiency and making better use of resources. On the other hand, we are also witnessing a remarkable increase of ICT solutions in the built environment. Smart Building strategies are a crucial element in improving the energy performance of buildings, as the integration and optimisation of systems, energy storage and flexible consumption require intelligent, interoperable and integrated technologies. In this sense, the particularities of the public buildings in the building stock (use profiles, energy systems, materials used for their construction, etc.) represent, at the same time, a major challenge compared to newly constructed buildings, and an area with a great potential for optimising resources and increasing their energy efficiency in order to achieve Nearly Zero Energy Consumption Buildings (NCEB). The main objective of this project is the development of a reference model that allows the integration of services for energy management based on software platforms that enable the integration of relevant technologies such as the Internet of Things (IoT) and the Web of Things (WoT). This model will be developed based on a previous selection of pilot buildings of the University of Almeria where the study will be carried out, establishing a methodology that allows the characterisation of their energy behaviour and the potential for improvement through automation strategies and the integration of Information Technologies (TIN). The project also seeks to study an interoperable solution for a reference architecture that allows the development of open services. This model has great potential for replicability to other university buildings and, subsequently, to other public buildings in the city of Almeria. The development of the project is aligned with the social challenges in "Digital Economy and Society" and "Safe, clean and efficient energy" of the Andalusian Innovation Strategy 2020 (RIS3 Andalusia) and the Andalusian Plan for Research, Development and Innovation (PAIDI 2020). Given its interdisciplinary nature in Computer Science and Energy, this project is promoted by the research groups of the University of Almeria "Applied Computer Science" (TIC211), "Solar energy resources, climatology, physics of the atmosphere" (TEP165) and "Solar energy resources, climatology, physics of the atmosphere" (TEP166). (TEP165) and "Automatics, Robotics and Mechatronics" (TEP197). The project will have a duration of 24 months.

3.5.9.4 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:

In Progress

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 also 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.

3.5.9.5 More Efficient Heliostat Fields for Tower Solar Plants (HELIOSUN).

Participants:

CIEMAT, University of Palma de Mallorca

Contacts:

Jesús Ballestrín (jballestrin@psa.es))

Source of funding:

Ministerio de Ciencia e Innovación. PROYECTOS DE GENERACIÓN DE CONOCIMIENTO 2021.

Duration:

September 2022 – Auguts 2025

Status:

In Progress

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 as a whole, 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

3.5.9.6 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.

3.5.9.7 New TECHnologies FOR enhancing energy efficiency in BUILDings (NTech4Build).

Participants:
UAL, CIEMAT
Contacts:
José Domingo Álvarez Hervás (jhervas@ual.es)
María del Mar Castilla Nieto (mcastilla@ual.es)
Manuel Pérez García (mperez@ual.es)
Joaquín Alonso Montesinos (joaquin.alonso@ual.es)
Source of funding:
Ministerio de Ciencia e Innovación. TED 2021.
Duration:
December 2022 – November 2024
Status:
In Progress
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

Contracts with companies

- Worldwide marketing of a system for measuring solar extinction. Company BCB Informática y control 2018. Acquisition of the system by NOOR ENERGY 1 (Dubai) in 2022.

3.5.11 Dissemination activities

- COOLSPACES 4 LIFE: The Sun also makes us cold. European Researchers Night 2022 held on September 30, 2022 by the University of Almería. European Commission in the call HORIZON-MSCA-2022-CITIZENS 01.

3.5.12 Others

Final degree and master projects:

- Luis Martínez Amate (Degree in Electrical Engineering). Development of an economic profitability map for photovoltaic systems in Andalusia. (Joaquin Alonso Montesinos).

- Noelia Simal Pérez (Master in Industrial Engineering). Determination of an economic profitability map for photovoltaic systems in Spain. (Joaquín Alonso Montesinos and Manuel Pérez García).
- Alvaro Castro Vizcaíno (Master in Solar Energy). Thermal storage with phase change materials for cooling. Application to an industrial refrigeration chamber. (María Jesús Ariza Camacho and Manuel Servando Romero Cano).
- Miriam Correa López (Master in Secondary Education Teachers). Diráctic proposal on the relationship function, centered on the nervous system. (Joaquin Alonso Montesinos).

PhD Theses under development

- Noelia Simal Pérez (Director: Joaquín Alonso Montesinos).
- Álvaro Castro Vizcaino (Director: Antonio M. Puertas López).

Awards during 2022

- SAN ALBERTO RESEARCH AWARD 2021 for the best research articles published in Q1 in 2021. €250.00. Faculty of Experimental Sciences of the University of Almería. The University of Almería awarded the 2022 San Alberto Research Award to the article published with the title "Soiling forecasting of solar plants: A combined heuristic approach and autoregressive model". (https://www.ciemat.es/portal.do?IDM=61&NM=2&identificador=2646)

3.6 ACTIVITIES OF "DESALINATION AND PHOSTOSYNTHESIS"

3.6.1 Functional unit description

The "Desalination and Photosynthesis" unit is integrated by researchers from the Chemical Engineering Department of the Universidad de Almeria and from the Plataforma Solar de Almería who have started a new independent research group "Desalination and Photosynthesis" (BIO-352) with synergies from the two fields. Researchers of this unit are also adscribed to the Plan Andaluz de Investigación research groups "Desalación Solar, TEP026" and "Biotecnología de microalgas marinas, BIO173". This unit was started in 2014 and focused its activity on improving the sustainability of the water-energy-food nexus, beginning with the set up and operation of new installations and facilities dedicated to water desalination powered with solar energy and with the added value of brine valorisation, as well as the application of solar energy in biological microalgae-based depuration processes. Both lines present ample opportunities for synergy and for joint work with other R&D units within CIESOL which raise frequent collaborations.

3.6.2 Main research lines

The group works in two parallel lines dealing with solar energy application in desalination and brine concentration and microalgal cultivation particularly oriented to recycling by solar energy-driven synthesis of commodities such as biofertilizers or biodiesel and value products such as carotenoids and essential fatty acids. Seawater is the main raw material the research deals with although other types of feed, such as freshwater, brines, brackish waters or wastewaters are also considered. The main research lines ar:

- Development of membrane-based solar desalination and water treatment systems.
- Application of solar energy to the treatment of hypersaline media.
- Recovery of value compouds from brines and hypersaline effluents.
- Design of photobioreactors for the cultivation of microalgae.
- Applications of microalgae to the purification of wastewaters and industrial effluents
- Valorization of microalgal biomass obtained from wastewater.

3.6.3 Main researchers

Jose M. Fernández Sevilla (ORCID 0000-0002-0290-5810, Scopus Author 6602856181)

Is a Full Professor of Chemical Engineering at Universidad de Almeria, currently affiliated with the Engineering Department at University of Almería. He obtaines a Degree in Industrias Chemistry at Universidad de Granada in 1991 and a PhD. In Chemistry in 1995 at the Universidad de Almería. He has worked in in twelve I+D projects in the international and spanish national levels, as lead reseacher in five of them. He has participated also in 15 research contracts funded by companie, has also advised six PhD. Theses and is the co-author of seven patents and over one-hundred scientific publications in peer-reviewed international journals.

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

PhD in Applied Physics by the University of Granada, Spain (1996). Has held academic positions in the Consejo Superior de Investigaciones Científicas of Spain (CSIC), the University of Oxford, Estación Experimental "Las Palmerillas" (Fundación Cajamar) and is a Senior Researcher in the Department of Energy of Spanish CIEMAT (Centre for Energy, Environment and Technology Research), at the Plataforma Solar de Almería, where he is currently the head of the Solar Thermal Applications scientific unit. Has published more than 95 papers in peer-reviewed international journals, presented more than 150 papers on international conferences, authored 11 book chapters and co-authored 5 books. Teaches in international courses on Solar Desalination organized by the European Desalination Society (EDS) and on the Master Course on Solar Energy organized

by CIESOL. He is leading the Working Group on Renewable Energy Desalination in the Water Europe platform, of which he is also ambassador.

3.6.4 Summary of the functional unit's activities carried out in CIESOL during 2022

During 2022, different projects continue have been going on both in desalination with membranes and projects related to the production of microalgae for high-value applications, mainly food and feed, also the production of biostimulants and biopesticides, or those related to waste treatment, mainly wastewater, both urban and of animal origin, and combustion gases. The list of most relevant activities is as follows:

- Use of nanofiltration as a pre-treatment to improve efficiency of Multi-Effect Distillation plants by operating at higher temperatures and larger recovery ratios.
- Inauguration of the Sustainable Desalination Living Lab, focused on reducing carbon footprint of desalination and promoting circular economy by valorisation of the brine.
- Co-creation activities with the Community of Practice of the Living Lab to define ways of improving the sustainability of the water-energy-food nexus in relation to the use of solar desalination in greenhouse horticulture.
- Test of different membranes in a lab-scale Membrane Distillation unit to assess their suitability for brine concentration and valorisation.
- Evaluation of graphene-oxide doped membranes for Membrane Distillation.
- Evaluation of solar-powered Membrane Distillation at commercial scale for brine concentration operating in vacuum-assisted air-gap configuration.
- Evaluation of membrane for regeneration of exhausted passivation solutions from zinc electroplating with Membrane Distillation.
- Use of hybrid cooling systems to reduce the water consumption for refrigeration in different solar thermal applications (CSP plants, solar MED plants located inland).
- Water recovery from the effluents of a CSP plants by thermal desalination technologies.
- New advanced monitoring and control systems for large-scale microalgae systems
- Production and evaluation of food and feed end products based on algae
- Demonstration of technologies for large-scale production of macroalgae.
- Development of new technologies based on membranes for harvesting of algae cultures.

3.6.5 Collaboration with other Functional Units of CIESOL during 2022

During 2022 we have collaborated closely with the Functional Unit "Modelling and Control" in the framework of SOLWARIS project. We have finalized the tasks related with modelling, optimization and control, accomplishing with all the items of the proposed milestones. Likewise, in the framework of SOLHYCOOL project, we have completed an exhaustive experimental campaign of a hybrid cooling system that operates in different modes as a function of the ambient conditions in order to achieve a reduction in water and electricity consumption. This kind of systems can be used in different solar thermal applications with an important need for water consumption reduction, like the refrigeration of the power cycle in a CSP plant and the one of a solar MED plant located inland.

In 2022 we continue the close collaboration with the Function Unit "Modelling and Control" in the framework of different projects (National and EU Projects) such as CALRESI, DIGITALGAE, PRODIGIO and REALM. Activities are related to the development and implementation of advanced control technologies for microalgae-related processes.

3.6.6 Scientific production

Number os papers	Number of papers in each Quartile				Number of papers with international collaborations
	Q_1	Q_2	Q_3	Q_4	
29	27	1			10

Papers

- Ortega-Delgado, B., Palenzuela, P., Altaee, A., Alarcón-Padilla, D.C., Hawari. A.H., Zaragoza, G. Thermodynamic and techno-economic assessment of forward osmosis as pretreatment to boost the thermal efficiency and sustainability of multi-effect distillation for seawater desalination. Desalination 541 (2022) 115989. https://doi.org/10.1016/j.desal.2022.115989.
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- Z. Zhang, A.A. Atia, J.A. Andrés-Mañas, G. Zaragoza, V. Fthenakis. Comparative techno-economic assessment of osmotically-assisted reverse osmosis and batch-operated vacuum-air-gap membrane distillation for high-salinity water desalination. Desalination, 532, 115737, 2022. https://doi.org/10.1016/j.desal.2022.115737.
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Congress attendance

- International Conference on Advances in Water Treatment and Management (ICAWTM-22). Gandhinagar (India).
- Mesa Española de Tratamiento de Aguas (META 2022), 1-3 june 2022, Sevilla, España,.
- 11th European Photocatalyst, Conference on Environmental, Solar Chemistry and Applications. Turin (Italy), 6-10 June 2022.
- Desalination for the Environment: Clean Water and Energy. Las Palmas de Gran Canaria, Las Palmas, Spain. June 20–23 June, 2022
- Nanofiltration Conference 2022. 26-30 June 2022, Achalm (Germany)
- 3rd International Conference on Disinfection and DBPs (IWA DDBPs 2022)-PRIMA DSWAP Workshop, June 27 – July 1, 2022, Milano (Italy).
- 11th International Seminar on Thermodynamic Engineering of Fluids organized by Universitat Rovira i Virgili. 21 July. Tarragona.
- 16th SolLab and 3rd SFERA-III – Doctoral Colloquium. September 12th-14th, 2022. Zürich (Switzerland).
- Workshop on Renewable Energies and Energy Efficiency in Water Treatments (EERES4WATER). 26 de septiembre de 2022. Universidad de Sevilla.
- EuroSun 2022, International conference on solar energy for buildings and industry, 25-29 September 2022, Kassel (Germany).
- 28th Concentrating Solar Power and Chemical Energy Systems (SolarPaces), Sep 27 - 30, 2022, Albuquerque (USA)
- XI Simposio de investigación en ciencia experimentales 2022. 15 November 2022, Almeria (España),
- Euromembrane. Sorrento (Italy), 20-24 November 2022.

Congress contributions

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- Producción de Scenedesmus almeriensis a escala piloto: Efecto del tipo de agua sobre la calidad y composición de la biomasa producida. XIV Congreso Español de Tratamiento de Aguas. Sevilla, España. 01/06/2022. Silvia Villaró Cos; FRANCISCO GABRIEL ACIEN FERNANDEZ; JOSÉ MARÍA FERNÁNDEZ SEVILLA; Tomas Lafarga.
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3.6.7 Functional Unit members

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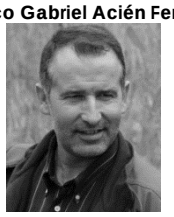

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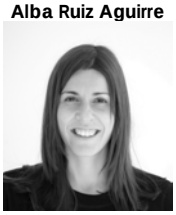

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3.6.8 Ongoing projects in 2022

3.6.8.1 Producción sostenible de bioproductos a partir de cianobacterias tratanDo efluentes residuales (CYAN2BIO).

Participants:

University of Almería

Polytechnical University of Cataluña.

Contacts:

Cynthia González López, UAL, (Coordinator) (cgl665@ual.es)

Ivet Ferrer, UPC, (Coordinated project)

Source of funding:

Ministerio de Economia, Industria y Competitividad

Time Period:

01/12/2022-31/11/2025.

Current Situation:

Started.

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 finally biogas. This approach calls for a multidisciplinary research group, which is better suited by combining the expertise of two complementary groups in a coordinated proposal the Environmental Engineering and Microbiology Research Group of the Universitat Politècnica de Catalunya (GEMMA-UPC, Subproject 1) and the Chemical Engineering Department of the Universidad de Almería (DIQUAL, Subproject 2).

Objectives:

Cyan2Bio project aims at producing bioproducts and bioplastic fron cyanobacteria in a sustainable process.

- **Exploration**: The bioplastics productivity is strain-specific and therefore a wide range of strains should be tested to find out highly productive microorganisms. Selected strains will contain pigments and bioactive molecules that must be considered as potential by-products.
- **Testing**: The selected strains will be produced at different culture conditions (both at laboratory and large scale) to identify the ones providing biomass richest in target compounds. For the production of biopolymers, the organic substrate added upon starvation under mixotrophic conditions should be an organic waste (e.g. a mixture of organic sugars from the food industry) to increase the circularity of the process, but this rationale can be extended to the utilization of waste streams as nutrients source also in autotrophic production mode.
- **Process development**: Adequate production and downstream processing of the biomass must be developed and validated, including the monitoring of the biological system and the utilization of cultures composed by several suitable strains that might be more capable of coping with environmental changes due to the waste effluents treated, and also with eventual competition/depredation relationships with microorganisms present in these waste streams. Furthermore, the development of biorefineries allowing to maximize the product yield then producing other by-products such as biostimulants, biofertilizers or pigments together with PHB will enhance the profitability of the process.

3.6.8.2 Eco-friendly and sustainable new family of biopesticides based on microalgae via circular economy approach (ALGAENAUTS)

Participants:

BIORIZON BIOTECH S.L., Spain.
UNIVERSIDAD DE ALMERIA, Spain.

Contacts:

F. Gabriel Acién (facien@ual.es)

Source of funding:

This project has received funding from the TEMFF-BEW-2020 — Blue Economy SME Window Call.

Time Period:

December 2021 – November 2023

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 optimized, as well as the yield and efficiency of large-scale production systems. Optimization of harvesting and downstream processing is mandatory to ensure the most efficient operating cost. Seawater and waste (sewage and swine manure) will be used to achieve sustainable processes. The optimized microalgae systems will be able to operate in continuous mode for six months without collapse, with productivities higher than 70 t/ha/year, with energy consumptions lower than 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 with a biomass production cost of less than 1.0 €/kg.

Objectives:

- **Optimization 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.

3.6.8.3 Producción sostenible de proteínas e hidrolizados bioactivos a partir de microalgas (SUSTPROT)

Participants:

University of Almería.

Contacts:

Tomás Lafarga Poyo (UAL), tomas.lafarga@ual.es

Source of funding:

BBVA Foundation

Time Period:

January 2021 – December 2022.

Current Situation:

Completed

Summary:

The SUSTPROT Project aims at developing a process to produce sustainable proteins using the cyanobacterium Arthrospira platensis at pre-industrial scale. The process aims at developing an optimised method to recover high-purity protein with increased technofunctional and bioactive properties for food applications.

3.6.8.4 Improvement of large scale production capacity of Spirulina platensis in open systems.

Participants:

University of Almería.

Algaria SrL.

Contacts:

F. Gabriel Acién Fernández (UAL), facien@ual.es

Source of funding:

Private contract.

Time Period:

October 2022– June 2023.

Current Situation:

In progress

Summary:

The objective of this project is to develop and evaluate different technologies to maximize the performance of Spirulina platensis cultures and to design the optimal reactors for the outdoor production of biomass if this strain for human-related uses. The challenge is to duplicate the current biomass productivity per unit surface (20 $g/m^2 \cdot day$) on an annual basis, at the same time minimizing the biomass production cost to achieve profitable industrial processes at scale up to 3 ha.

Objective:

- Maximization of the productivity of S. platensis for human consumption.
- Optimization of photobioreactors designed for human-related uses.
- Duplicate the current areal productivity of S. platensis

3.6.8.5 Valorization of leachate from plant residues for the production of biostimulants and biopesticides of agricultural interest through microalgae (VALIMA)

Participants:

University of Almeria

Contacts:

José María Fernández Sevilla (jfernand@ual.es)

Source of funding:

Junta de Andalucía. Convocatoria de subvenciones a «proyectos de I+D+i» universidades y entidades públicas de investigación (BOJA n.º 119, 23 de junio de 2020).

Time Period:

January 2021 – December 2022

Current Situation:

Completed.

Summary

The objective of the VALIMA project is to develop and demonstrate an integrated process for transforming leachate from the composting of plant waste into biostimulants and/or biopesticides for use in agriculture, using microalgae. The aim is to improve the profitability and sustainability of food production by the agricultural sector, in addition to offering an alternative to current vegetable waste management systems, as well as generating new tools to improve production and crop protection. All this through the development of bioprocesses based on microalgae that use simple and robust technologies for an unassisted operation. These types of processes are especially interesting for areas with high agricultural production, where small and medium-sized populations are normally located, and where there is a high availability of land and optimal environmental conditions, both for agricultural production and for microalgae. Through its implementation, different problems could be solved simultaneously, such as: (i) reduction of the cost of managing vegetable leachate for farmers, (ii) possibility of implementing new processes and job opportunities in rural environments, (iii) reduction of environmental problems and social rejection associated with plant leachate, (iv) increase in the availability of microalgae biomass for various applications, (v) improvement in the sustainability and profitability of agricultural production.

Objetives.

Development of new photobioreactors and processing technologies aimed at the purification and recovery of leachate from plant residues in the province of Almería.

3.6.8.6 Valorización de subproductos agroalimentarios mediante microalgas para la producción de alimentos y piensos animales (ALGA4FF)

Participants:

University of Almeria

Contacts:

Francisco Gabriel Acién Fernández (facien@ual.es)

Source of funding:

Junta de Andalucía. Convocatoria de subvenciones a «proyectos de I+D+i» universidades y entidades públicas de investigación (BOJA n.º 119, 23 de junio de 2020).

Time period:

Enero 2021 – Julio 2023

Current situation:

In Progress

Abstract

The ALGA4FF project aims to formulate different foods, mainly baked goods (salty and sweet), liquid products (soups, purees and juices) and snacks, and to study how the incorporation of biomass affects their formulations, but also to study the effect of adding different concentrations of biomass on consumer acceptance of the product, and also to know and increase consumer knowledge about microalgae as food additives. The objective of the ALGA4FF project is to develop and demonstrate an integrated process for the recovery of agri-food by-products using microalgae for the production of food and animal feed. The aim is to improve the profitability and sustainability of food production by the agri-food industry in addition to offering an alternative

to current by-product management systems. All this through the development of bioprocesses based on microalgae that use simple and robust technologies. The increasingly sustainable production of food is a priority objective, as well as guaranteeing the supply, quality and safety of said production. Through its implementation, different problems could be solved simultaneously, such as: (i) reduction in the cost of managing by-products, (ii) possibility of implementing new processes and job opportunities, (iii) increase in

the availability of microalgae biomass for various applications, (iv) improvement of the sustainability and profitability of food production.

Objectives.

Food formulation with microalgae biomass. Study the effect on the physical-chemical, functional, nutritional properties and on consumer acceptance.

3.6.8.7 Developing early-warning systems for improved microalgae PROduction and anaerobic DIGestIOn (PRODIGIO).

Participants:

University of Almeria.
Instituto de Ciencias del Mar (CSIC)
Centro Nacional de Biotecnología (CNB)
Instituto IMDEA
ARMINES/Mines Paris Tech (France)
Instituto Alfred Wegener Institute (Alemania)
University of Noruega de Ciencias de la Vida (Noruega)

Contacts:

Francisco Gabriel Acién Fernández (facien@ual.es)

Source of funding:

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 increases the performance of microalgae biomass production and anaerobic digestion systems and advance towards more favourable techno-economic, environmental and social performance to achieve more sustainable microalgae biomass.

Objetives.

- Characterization of microalgae cultures in photobioreactors.
- Identification of critical predictive parameters.
- Development of algorithms to prevent culture collapse.
- Maximizaton of microalgal productivity.

3.6.8.8 Water regeneration using concentrated solar energy (RAYO)

Participants:

Functional Unit “Water Treatments”
Functional Unit “Environmental Analysis”

Contacts:

J 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:

October 2021 – June 2023

Current Situation:

In progress

Summary:

On May 25, 2020, Regulation (EU) 2020/741 of the European Parliament was published regarding the minimum requirements for water reuse, applicable from June 2023. This regulation promotes the regeneration of wastewater in Europe for agricultural irrigation, of special importance in Almería, with a high water deficit and an economy linked to intensive agriculture. In addition, it must promote the development of sustainable technologies that meet these requirements in an environmentally safe manner. 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, in tubular photoreactors with compound parabolic solar collectors (CPC), or open channel reactors (raceway pond reactor, RPR) through 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. With this, it will operate at temperatures between 60 -70C and UV irradiances up to 150 W/m^2, accelerating the inactivation of microorganisms and the degradation of emerging contaminants. 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 water regeneration technology for agricultural irrigation.

Objectives:

This project proposes, for the first time, the disinfection of secondary WWTP effluents by means of concentrated solar radiation in photoreactors operated in continuous mode. The general objectives of the project, taking into account the funding available and the duration of two years, can be summarized as follows:

- Design and build a prototype solar photoreactor with concentration factors between 3 and 5, which can be operated in continuous flow.
- Study concentrated solar disinfection from the phenomenological and kinetic point of view. Determine the safe UV dose for all the pathogens included in the new European regulation: E. coli, coliphages and spores of sulfate-reducing bacteria.
- Optimize the variables of continuous operation of the photoreactor for the regeneration of wastewater on a pilot scale.
- Study the economic viability 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 special reference to agriculture and tourism.

3.6.8.9 A knowledge-based training network for digitalisation of photosynthetic bioprocesses (DIGITALGAE).

Participants:

University of Padova
University of Almeria

Contacts:

F. Gabriel Acién Fernández (UAL), facien@ual.es

Source of funding:
Innovative Training Networks (ITN) Call: H2020-MSCA-ITN-2020.

Time Period:
December 2021– June 2024.

Current situation:
In progress

Summary:

The objective of DigitAlgaesation is to propose a digitalisation approach to optimising control and operation of microalgae cultivation processes so as to maximise their light conversion efficiency and to drive the sustainable portfolio of microalgae-based processes towards commodities and energy markets. Artificial intelligence and automatic model-based control approaches can be a great help to understand, optimise, and in turn remedy, the gap between lab-scale observations and the industrial-scale reality.

Objective:

- Monitoring microalgae cultures key parameters.
- Create and maintain a database of culture conditions..
- Use advanced tools (IA, model-based control) to optimize microalgae culture mass production times and minimize downtime.

3.6.8.10 Next generation water-smart management systems: large scale demonstrations for a circular economy and society (WATER-MINING)

Participantes:

TECHNISCHE UNIVERSITEIT DELFT (NL)
SEALEAU BV (NL)
KWR WATER BV (NL)
FUNDACIÓN EURECAT (ES)
NATIONAL TECHNICAL UNIVERSITY OF ATHENS (HE)
S.EL.I.S. LAMPEDUSA SPA (IT)
CIEMAT-PSA (ES)
DECHEMA GESELLSCHAFT FUER CHEMISCHE TECHNIK UND BIOTECHNOLOGIE E.V. (DE)
BRUNEL UNIVERSITY LONDON (UK)
UNIVERSITY OF ABERDEEN (UK)
WATER EUROPE (BE)
RESOLUTION RESEARCH NEDERLAND BV (NL)
UNIVERSITA DEGLI STUDI DI PALERMO (IT)
WETSUS (NL)
UNIVERSIDAD AUTONOMA DE BARCELONA (ES)
STICHTING JOINT IMPLEMENTATION NETWORK (NL)
ACSA OBRAS E INFRAESTRUCTURAS SAU (ES)
INSTITUTE OF COMMUNICATION AND COMPUTER SYSTEMS (HE)
HASKONINGDHV NEDERLAND BV (NL)
KANZLER VERFAHRENSTECHNIK GMBH (AT)
LARNACA SEWERAGE AND DRAINAGE BOARD (CY)
STICHTING NATIONAAL CENTRUM VOOR WETENSCHAPS- EN TECHNOLOGIECOMMUNICATIE (NL)
ACCIONA AGUA SA (ES)
UNIVERSIDAD DE SANTIAGO DE COMPOSTELA (ES)
JERUSALEM INSTITUTE FOR ISRAELI STUDIES (IL)
AGUAS DO ALGARVE SA (PT)
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EUROPEAN NETWORK OF LIVING LABS IVZW (BE)
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Dr. Guillermo Zaragoza (guillermo.zaragoza@psa.es)
Funds:
European Commission, Horizon 2020 programme
Time Period:
Sep 2020 – Aug 2024
Current situation:
In Progress

Summary

Water security is among 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 exhibit and validate innovative next-generation water resource solutions at the pre-commercial demonstration-scale in accordance with relevant legislation, such as the Water Framework Directive, Circular Economy and EU Green Deal packages. It will combine water management services with the improvement of renewable resources such as mining water. It is envisaged that the value-added end products will offer supplies of regional resources to increase economic growth. The project will examine different designs proposed for urban wastewater treatment and seawater desalination and innovative service-based business models aiming to improve the engagement of private and public stakeholders.

Objectives

The Water Mining project aims to face the challenge of ensuring access to clean 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, consumable and as a durable good. To capture the full potential of the circular water economy, WATER-MINING project proposes different strategies for each of these three water forms, involving six sector-specific case studies (CS).

PSA-CIEMAT, together with UAL-CIESOL, is responsible for CS2, corresponding to one of the two sea-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 consumption of primary energy (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 by a nanofiltration (NF) system to retain the divalent ions (Mg^{2+}, Ca^{2+}, SO_4^{2-}), resulting in a sodium chloride (NaCl) rich and purified permeate stream. By using this as feed, the recovery of the MED plant can be increased, and also the operating temperature (typically limited to 70ºC to avoid scaling), enhancing the thermal efficiency significantly. The aim is to demonstrate the potential of reaching a record-breaking lowest energy consumption in thermal desalination (below 25 kWh_{th}/m^3) without exceeding 100ºC in the Top Brine Temperature. In addition, the use of polymeric materials in the MED plant replacing metallic evaporator tubes will be evaluated 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 crystallization. As the brine from the MED will be free from divalent ions, the salts produced in the crystallizer can be pure NaCl with higher added value. Furthermore, the brine from the NF system, with a larger concentration of divalent salts, will be used to remineralize the

distilled water produced in the MED and in the crystallizer, to be used for irrigation. The divalent ions are tolerated by crops and some act as fertilizers.

3.6.8.11 REUSING EFFLUENTS FROM AGRICULTURE TO UNLOCK THE POTENTIAL OF MICROALGAE (REALM)

Participants:

Necton – Companhia Portuguesa de Culturas Marinhas, S.A. (Necton) (Coordinator)
Biorizon Biotech, S.L. (BZN)
Wageningen University (WU)
Turun Yliopisto (UTU)
GreenColab – Associação Oceano Verde Laboratório Colaborativo para o Desenvolvimento de Tecnologias e Produtos Verdes do oceano (GCL)
Universiteit Twente (UT)
NAREC Distributed Energy Limited (Narec)
European Science Communication Institute GGMBH (ESCI)
Universidad de Cadiz (UCA)

Contacts:

F. Gabriel Acién Fernández (UAL), facien@ual.es

Funds:

HORIZON-CL6-2021-CIRCBIO-01-09—Unlocking the potential of algae for a thriving European blue bioeconomy

Time Period:

2022- 2025

Current situation:

Started

Summary:

The overall objective of REALM is to develop an innovative, sustainable, and highly efficient strategy for microalgae biomass production and processing, applicable to all European countries. This will be achieved by using a waste product, the drain water from soilless agriculture, rich in nutrients required for microalgal growth, combined with a continuous microalgae production mode, applied for the first time at industrial scale: the turbidostat mode. This cultivation mode allows microalgae to grow at maximum productivity, with continuous biomass harvesting and culture medium addition. Microalgal cultivation facilities will be installed next to greenhouses that will supply the drain water, whereas centralized processing facilities will upgrade the microalgal biomass into products.

Objectives:

- Validate and demonstrate, in different locations, the feasibility of growing microalgae in soilless drain water at industrial scale.
- Transforming waste into value, while bioremediating drain water for safe reuse or release
- Increase the overall profitability, security and versatility of microalgae producers, by reducing production costs.
- Develop a turbidostat growth mode (continuous harvesting) for a stable and higher productivity at industrial scale.
- Optimize microalgae production technologies, including photobioreactors, sensors, software, and harvesting. Reach a trade-off between productivity and running costs at industrial scale.
- Improve CO_2 capture from the air and utilization for biomass production.
- Develop novel products for aquaculture and agriculture, contributing to circular economy and waste upgrade.

Assess if the project results are cost-effective, with low environmental impact and positive social effects.

3.6.8.12 Desarrollo de estrategias de control avanzadas para la producción de microalgas (ECOALGA)

Participants:
BIORIZON BIOTECH S.L., Spain.
UNIVERSITY OF ALMERIA, Spain.

Contacts:
F. Gabriel Acién (facien@ual.es)

Source of funding:
PROYECTO UAL-TRANSFIERE TRFE-I-2021/014.

Time Period:
2021 –2022

Current situation:
Completed.

Summary:

This project is aimed at automation and control for the company Microalgas Carboneras S.L. Likewise, a technical evaluation of the available microalgae production plant is included, where various recommendations are collected regarding possible improvements that can be applied. Finally, a list of minimum materials necessary for the start-up of a plant at an industrial level for the production of microalgae biomass in the town of Carboneras (Almería) is collected.

Objectives:

- Technical advice for the setup o a microalgae producing installation.
- Development of a monitoring and control system for a new microalgae culture installation.
- Elaboration of a performance evaluation report.
- Suggestion of improvements.

3.6.8.13 Optimización del diseño y operación de la planta de Carboneras (ALGAVILLAGE)

Participants:
BIORIZON BIOTECH S.L., Spain.
UNIVERSITY OF ALMERIA, Spain.

Contacts:
F. Gabriel Acién (facien@ual.es)

Source of funding:
Private contract.

Time Period:
2022 –2023

Current situation:
In progress.

Summary:

This project is aimed at improving the design and operation of microalgae production plants, in the town of Carboneras (Almería), for the company ALGAVILLAGE. Is a follow-up of the project ECOALGA that will implement some of the recommendations reported after the eveluation of the initial design of the plant.

Objectives:

- Follow-up to le microalgae producing plant implemented in the project ECOALGA.
- Implememtation and evaluation of operation improvementas sugegsted for the microalgae plant.

3.6.8.14 Applications for zoosporic parasites in aquatic systems" (ParAqua)

Participants:
UNIVERSITY OF ALMERIA, Spain.
Contacts:
F. Gabriel Acién (facien@ual.es)
Source of funding:
EU Cost Action.
Time Period:
2022 –2024
Current Situation:
In progress.
Summary:

The main aim and objective of the Action is to organize and coordinate an innovative and dynamic Network, connecting academia, industries and water management authorities to advance and apply knowledge and expertise on zoosporic parasites (i.e. aquatic fungi and fungi-like microorganisms) and the relation with their hosts in natural ecosystems and industrial algal biotech production.

Objectives:

- Build a network to acquire knowledge on parasites that hinder the production of microalgae.
- Characterize such parasites.
- Implemeting strategies to minimize the impact of such parasites.

3.6.8.15 Development of novel and sustainable functional foods using microalgae-derived bioactive ingredients (ALGFOOD)

Participants:
UNIVESITY OF ALMERIA, Spain.
Contacts:
Tomás lafarga Poyo (tomas.lafarga@ual.es)
Cynthia López González (cyngl@ual.es)
Source of funding:
Convocatoria 2020 Proyectos de I+D en el marco del Programa Operativo FEDER Andalucía 2014-2020.
Time Period:
2020 –2022
Current Situation:
Completed.
Summary:

The starting hypothesis of the ALGFOOD project is that it is possible to produce safe, high-quality functional foods that are well accepted by consumers using microalgae produced in a sustainable, efficient manner and at a competitive price using photobioreactors that operate with artificial light and using combustion gases that normally end up in the atmosphere.

Objectives:

- Evaluate the production of S. platensis with combustion gases for human-related uses..
- Evaluation of the final consumer acceptance of such products.

3.6.8.16 Producción sostenible de bioestimulantes y biopesticidas agrícolas a partir de residuos agroindustriales (GREENFARM)

Participants:
University of Almeria

University of Valladolid

Contacts:

José María Fernández Sevilla (jfernand@ual.es)
Silvia Bolado Rodríguez (silvia.bolado@uva.es)

Source of funding:

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:

Noviembre 2022 – Diciembre 2023

Current Situation:

In progress.

Summary:

The GREENFARM project aims to develop a sustainable biorefinery based on microalgae that allows recovering 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 proven extensive experience of the partners in the production of microalgae, in the use of pig manure as a source of nutrients, the capacity of microalgae to produce biostimulants and biopesticides, and the market demand for this type of services and products. The GREENFARM project is supported by farmers' associations and biotech companies, and will be carried out in collaboration with the IFAPA research center with extensive experience in agriculture.

The microalgae will be used to recover nutrients (carbon, nitrogen and phosphorus) from agro-industrial waste, avoiding the need to use chemical fertilizers that exert a high pressure of sustainability on the environment, and at the same time obtain a benefit from the treatment of these waters. residuals. using less energy than that associated with conventional treatment processes.

Objectives:

Scaling-up of the results of the PURASOL project to photobioreactors on a pilot scale, evaluation of the process, techno-economic study and the sustainability of the process.

3.6.8.17 Nuevos materiales aglomerados avanzados libres de sílice (Silestone® Silica Free Advanced) (FREE ADVANCED-COSENTINO)

Participants:

UNIVERSITY OF ALMERIA, Spain.

Contacts:

F. Gabriel Acién (facien@ual.es)

Source of funding:

CREACIÓN UNIDADES DE INNOVACIÓN CONJUNTA (UIC).

Time Period:

2022 –2023

Current situation:

In progress.

Summary:

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

Objectives:

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

3.6.8.18 Impulso a las capacidades andaluzas para la bioeconomía en el sector del olivar, la horticultura y la biomasa algal (ATRESBIO)

Participants:
UNIVERSITY OF ALMERIA, Spain.
Contacts:
F. Gabriel Acién (facien@ual.es)
Source of funding:
CTA-JUNTA DE ANDALUCIA.
Time Period:
2021–2022
Current situation:
Completed.
Summary:

ATRESBIO is a project led by CTA with the aim of promoting value chains to obtain bioproducts derived from biomass from olive groves, horticulture and algae in Andalusia. ATRESBIO analyzes Andalusian capacities in research and in 10 key innovation services, with the aim of identifying areas for improvement. In addition, the project will draw up an action plan for the deployment of the bioeconomy in Andalusia and a medium-term technological surveillance system. In this way, ATRESBIO aims to maximize the competitiveness and sustainability of the Andalusian industrial fabric in the area of the bioeconomy, facilitating economic growth and the generation of jobs associated with sectors with high added value for the region.

Objectives:

- To promote value chains in Andalucia to boost economy and sustanaibility.
- Improve Andalusian competitivity.
- Strengthen the Andalusian industrial fabric.

3.6.8.19 Evaluación del potencial de captura de CO_2 de procesos basados en plantas acuáticas y algas.

Participants:
UNIVERSITY OF ALMERIA, Spain.
Contacts:
F. Gabriel Acién (facien@ual.es)
Source of funding:
Private contract.
Time Period:
2022–2023
Current situation:
In progress.
Summary:

This project proposes the development of a theoretical model of CO_2 capture systems using aquatic plants and algae: This task consists of defining a theoretical model that will be later verified. The theoretical model aims to define the capacity of processes based on algae and aquatic plants to capture CO_2 based on the most relevant design and operation variables. Then, the model developed will be evaluatedin a small scale, through laboratory tests and later tests in small-scale reactors that confirm the CO_2 production and capture values predicted by the model.

Objectives:

- Study and model the CO_2 uptake potential of hybrid systems microalgae/seaweeds.
- Evaluate the model and scaleup to pilot scale.

3.6.8.20 Solving water issues for csp plants (SOLWARIS)

Participants:

TSK
CEA
DLR
CIEMAT
Cranfield University
Fundación Tekniker
Rioglass Solar S.A
Archimede Solar Energy S.r.l.
Ingeniería para el desarrollo tecnológico S.l.
FENIKS Cleaning and Safety S.l.
Barcelona Supercomputing Center-
Brightsource industries Israel LTD
AMIRES s.r.o.

Main research:

Luis Millán (TSK)

Contacts:

Dra. Patricia Palenzuela (patricia.palenzuela@psa.es)

Source of funding:

European Commission, Horizon 2020 programme

Time Period:

May 2018-April 2022

Current Situation:

Completed.

Summary:

The overall purpose of the SOLWARIS project is to upscale, implement and demonstrate cost-effective technologies and strategies that bring about a significant reduction of water of CSP plants while ensuring excellent performance of electrical power production. The overall purpose of the SOLWARIS project is to upscale, implement and demonstrate cost-effective technologies and strategies that bring about a significant reduction of water of CSP plants while ensuring excellent performance of electrical power production. The SOLWARIS approach proposed will tackle all segments of water consumption in a CSP plant by:

- 90 % for reduction of cleaning operations;
- 15 to 28 % for cooling of turbine condenser;
- 90 % for recovery and recycling of water;
- Then, a total reduction of water consumption by:
- 35 % for a wet cooled CSP plant
- 90 % for a dry cooled CSP plant

Objectives:

- Reduction of water cleaning operations. SOLWARIS targets a reduction of water consumption by 90%, i.e. savings nearly 0.25m3/MWhe depending on the soiling rate and the location of the solar field.
- Delayed cooling of turbine condenser. To keep a low temperature at the turbine condenser, i.e. a high efficiency while reducing the water consumption, SOLWARIS will demonstrate the efficiency of a cold storage reservoir, regenerated by the lower temperatures that occur at night.
- Water recovery technologies. SOLWARIS will demonstrate the efficiency of using a Multiple Effect Evaporation (MEE) system to recycle and re-use 90% of these waste water streams (0.5 m3/MWhe) using thermal energy otherwise dumped by defocussing parts of the solar field, achieving a water consumption reduced to 0.05 m3/MWhe. Fresh water production will save up to 0.45 m3/MWhe.

- Plant operation optimizer including soiling rate forecast. The probabilistic treatment of forecasts for the following days is essential for optimisation of CSP plant operations. SOLWARIS will demonstrate the efficiency of the optimized global control of the plant thanks to a dedicated application.
- Socio-economic and environmental studies. Social, economic and environmental impacts on local communities close to CSP plants are a point of concern.
- Demonstration and validation of SOLWARIS technologies. All technologies will be installed, demonstrated and validated under real conditions at "La Africana" CSP plant in Spain and "Ashalim" solar thermal power station in Israel.

3.6.8.21 Desarrollo y transferencia de conocimiento en procesos sostenibles de tratamiento de aguas residuales y mejora de la producción de alimentos empleando microalgas (RITAL).

Participants:

UNIVERSITY OF ALMERIA, Spain.
UNIVERSITY OF ANTOFAGASTA, Chile.
UNIVERSITY OF BUENOS AIRES, Argentina.

Contact:

Cintia Gómez Serrano (cgs1818@ual.es)

Source of funding:

This project has received funding from EU under FORCYT programme.

Time Period:

October 2021 – April 2023

Current Situation:

Completed.

Summary:

The RITAL project is made up of three entities with extensive experience in the development of biotechnological processes based on microalgae, and aims to respond to technological and training/transfer needs for the development of sustainable microalgae production processes that integrate water treatment. residuals and obtaining products of agricultural and aquaculture interest. Therefore, the objective of the project is to improve existing knowledge in processes based on microalgae for the treatment of wastewater and obtaining 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. The general objective of the project is to apply the current knowledge available in the requesting groups to the development of sustainable wastewater treatment processes and improvement of food production using microalgae.

Objectives:

The general objective is achieved through the following specific objectives:

- Knowledge transfer in wastewater treatment processes using microalgae.
- Development of joint pilot experiences to validate existing prior knowledge.
- Enhancement of the biomass generated for its application in various fields, related to both agriculture and aquaculture.
- Dissemination of knowledge in the scientific field, especially the incorporation of women into it.
- Transfer to the productive sector and preparation of new development proposals

3.6.8.22 Economía circular para la producción de extractos bioestimulantes de microalgas mediante recuperación de nitrógeno y fósforo residual (ALCERES)

Participants:

Biorizon Biotech (Representante del consorcio).

University of Almeria (F. Gabriel Acién Fernández, Coordinador Técnico).

Fundation Cajamar.

Contac:

F. Gabriel Acién (facien@ual.es)

Source of funding:

Ayudas a proyectos de colaboración público-privada, del programa estatal para impulsar la investigación científico-técnica y su transferencia, del plan estatal de investigación científica, técnica y de innovación 2021-2023, en el marco del plan de recuperación, transformación y resiliencia.

Time Period:

October 2022 – Octubre 2025

Current Situation:

Started.

Summary:

The ALCERES project aims to develop a new and innovative 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 nitrogen and phosphorus. chemical. In addition, the development of a production process for a Trichoderma fungus, typical of Biorizon Biotech, non-commercial to date and with powerful antifungal activity that would be the basis of a new biopesticide that contributes to reducing the use of of chemical synthesis phytosanitary products.

Objectives:

- Development of a microalgae biomass production process in residual currents for the recovery of N and P.
- Modeling of the cultivation process in waste streams.
- Production of strains with biostimulant activity.
- Maximization of the biostimulant profile based on the medium and culture conditions.
- Large-scale cultivation of selected microalgae on an industrial scale.
- Crop optimization in pilot raceway system (80 m2, parameters and management).
- Modeling of cultivation in an industrial system.
- Development of harvesting methodologies and
- biomass stabilization.
- Cultivation without use of fresh water.
- Open production without contamination.

3.6.9 Network participation during 2022

- Participation on 8th expert meeting of IEA SHC Task 62. Solar Energy in Industrial Water&Wastewater Management, Graz (Austria), 5 April 2022.
- Participation on final expert meeting of IEA SHC Task 62. Solar Energy in Industrial Water&Wastewater Management, Kassel (Germany), 29-30 September 2022.
- Red Iberoamericana para el tratamiento de efluentes con microalgas (RENUWAL)

- RED CYTED 2019 RENUWAL 320RT0005: Develop dissemination and training activities as well as collaborations with companies in the field of microalgae biotechnology, applied to wastewater treatment.
- Red Internacional de Investigación y Transferencia en Procesos Sostenibles Basados en Microalgas (RITAL) ORGANIZACIÓN DE ESTADOS IBEROAMERICANOS PARA LA EDUCACIÓN, LA CIENCIA Y LA CULTURA (OEI) The RITAL network aims to improve the existing knowledge in processes based on microalgae for the treatment of wastewater and obtaining 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.

3.6.10 Dissemination activities

- "Recursos en línea y modelos de simulación para instalaciones de energía solar térmica", by Diego Alarcón in the Master en Energías Renovables of Universidad Internacional de Valencia, 17 february 2022.
- "Solar water desalination and treatment technologies" by Diego Alarcón in the summer school held at the campus of the Middle East Technical University (METU) in Ankara (Turkey) within the framework of H2020 SolarTWINS (Solar Twining to Create Solar Research Twins) project, 30 august – 1 september 2022.
- "Integrating Renewables" by Guillermo Zaragoza in the Future of Desalination International Conference, organized by Saline Water Conversion Corporation and Global Water Intelligence in Riyadh (Saudi Arabia), 12 september 2022.
- "Desalination with solar energy" by Guillermo Zaragoza at the ETEIA Workshop on Energy Transition organized by University of Tás-os-Montes and Alto Douro in Vila Real (Portugal), 22 september 2022.
- "Solar Desalination for Sustainable Brackish Water Management in Jordan for Agriculture and Drinking Water" by Diego Alarcón and Guillermo Zaragoza, course held at PSA in the context of project "Solar Desalination for Sustainable Brackish Water Management in Jordan for Agriculture and Drinking Water" coordinated by IHE Delft Foundation, 3-7 october 2022.
- "The European night of researchers. Almeria, Spain, 2022"

3.6.11 Others

Final degree projects:

- Silvia Villaro Cos (Master in Industrial and agro-food biotechnology). Optimization of the production of Haematococcus pluvialis as a sustainable source of astaxanthin.
- Francisco Javier Delgado Puerto (Master in Industrial and Agrifood Biotechnology). Comparative analysis of microalgae production using fertilizers or wastewater.
- Rubén López Pastor (Master in Solar Energy). Solar Thermal Energy Applied to the Drying of Microalgae.

PhD Theses under development

- Bueso Sánchez, Alejandro (supervisors: G. Zaragoza, J.D. Gil)
- Requena Requena, Isabel (supervisors: G. Zaragoza, J.A. Andrés-Mañas)
- Serrano Rodríguez, Juan Miguel (supervisors: Lidia Roca, Patricia Palenzuela).
- Villachica Llamosas, Joyce Gloria (supervisors: Sixto Malato, Alba Ruiz-Aguirre).
- Modeling and control of consortiums of microalgae and bacteria for wastewater treatment. Rebecca North. Doctorate Program in Biotechnology and Industrial Bioprocesses Applied to Agrifood and the Environment. Director: Francisco Gabriel Acien Fernandez
- Design and optimization of raceway photobioreactors using computational fluid dynamics (CFD). Cristian Inostroza Gonzalez. Doctorate Program in Biotechnology and Industrial Bioprocesses Applied to Agrifood and the Environment. Director: Jose Maria Fernandez Seville
- Characterization by means of numerical simulations (CFD) of the fluid dynamic behavior and the light regime in photobioreactors destined to the cultivation of microalgae. Application to improve productivity. Pablo Fernandez del Olmo. Doctorate Program in Biotechnology and Industrial Bioprocesses Applied to Agrifood and the Environment. Director: José María Fernández Seville.

- Use of greenhouse plant residues for heating and carbon enrichment. Jose Vicente Reinoso Moreno. Doctorate Program in Biotechnology and Industrial Bioprocesses Applied to Agrifood and the Environment. Director: Francisco Gabriel Acien Fernandez.
- Obtaining, evaluating and yielding biostimulants by cultivating microalgae in wastewater and analyzing the quality of irrigation water for its use in desert agriculture. Loreto Cavieres Seine. Doctorate Program in Biotechnology and Industrial Bioprocesses Applied to Agrifood and the Environment. Director: Francisco Gabriel Acien Fernandez.

Attendance at Transfer and Dissemination Workshops

- Sistemas de cromatografía iónica de doble canal con automatización, Metrohm Hispania S.L.U, 16 November 2022, Almería.

4. COMMITTEES AND ACTIVITY MANAGERS.

4.1 MANAGEMENT OF THE CENTER

Director	**José Antonio Sánchez Pérez** Full Professor, University of Almería jsanchez@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
Energy area	**Enrique Garcia Campos** ecampos@ual.es Youth Guarantee Contract, Investigo programme (01/10/2022-30/09/2023)

4.3 ACTIVITY MANAGERS

Activity	University of Almería (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 Full Professor of UAL aaguera@ual.es	Isabel Oller 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 Photosynthesis	José M. Fernández Professor of UAL jfernand@ual.es	Dr. 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

4.4 COORDINATION AND MONITORING COMMITTEE

Diego Valera Martínez University of Almería Vice Chancellor	vinvest@ual.es
Manuel Berenguel Full Profesor University of Almeria	beren@ual.es
Julián Blanco Plataforma Solar de Almería Director, CIEMAT	julian.blanco@psa.es
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4.5 SCIENTIFIC COMMITTEE

Ángela Fernández Curto Subdirectora General Adjunta de Grandes Infraestructuras Científico Técnicas Ministerio de Ciencia, Innovación y Universidades, Spanish Goverment	af.curto@ciencia.gob.es
Carlos Bordons Alba Full Professor of University of Sevilla	bordons@us.es
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David Serrano Full Professor of Chemical Engineering and IMDEA-Energy Director	david.serrano@imdea.org

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