INFORME ANUAL CIESOL

CIESOL ANNUAL REPORT

2021

CIESOL

Centro de Investigacion en Energia Solar

Solar Energy Research Center


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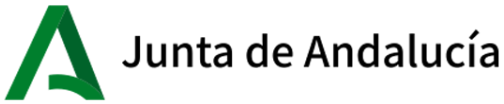
Junta de Andalucía


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HORIZON 2020
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ÍNDICE

1. EXECUTIVE SUMMARY

1.1 PRESENTATION AND WELCOME

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

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

We collaborate with companies and institutions in our desire to serve society. In the field of training, we are proud of the Official Master's Degree in Solar Energy, a clear example of the understanding between the two institutions that make up CIESOL (http://cms.ual.es/UAL/estudios/masteres/MASTER7106).

Welcome to CIESOL, we appreciate your interest in our work and we try to provide you, on the following pages, with relevant information, as well as the contact details of the groups that give life to the center.

1.2 CIESOL 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 CIESOL RESEARCH LINES

What is done at CIESOL?

Work is carried out in different areas, all of them focused on the knowledge of the solar resource and its various applications, which can be classified into two lines: one related to the energy use of solar radiation, and the other to the development of solar technologies for the treatment of waters

Convinced of the importance of preserving the environment, at CIESOL research is carried out in two essential areas 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 must know to use solar energy is its availability, which is why new methods are being investigated to evaluate and predict the solar resource and the optimization of sky cameras to monitor and predict cloudiness.

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

In addition, solar thermal energy allows to produce what is called "solar cold" through phase change, compression and decompression systems. Research is being carried out on "solar air conditioning", the building that houses the CIESOL being an example of this. Work is being done on the design and optimization of solar cooling and heating plants, both for domestic and industrial use, with the study of energy efficiency and comfort control in buildings being especially important here. The introduction of smart energy networks is also a very significant saving factor.

Research is also being carried out on the development of new substances with photochemical activity and that are soluble in water with the aim of opening the way to new, more environmentally sustainable photovoltaic cells.

How is CIESOL advancing in water treatment?

We must protect the water resource, as necessary as it is scarce, 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 has small amounts of persistent pollutants, which affect the aquatic environment.

Among the solar methods of wastewater purification, a new process based on microalgae is making its way that takes advantage of photosynthesis to decontaminate, with less energy consumption and producing useful biomass for other industrial sectors.

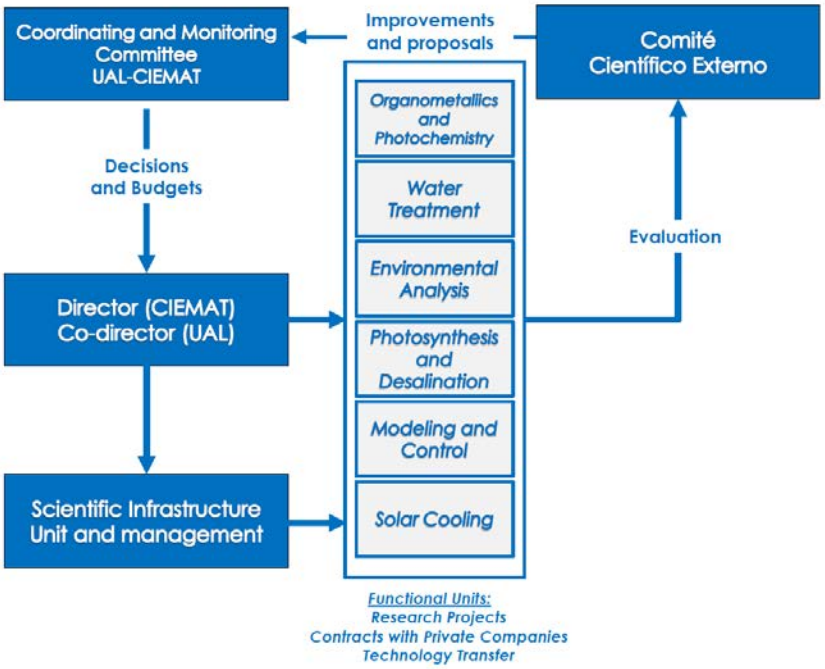
Once purified, the water can have a new use, especially for irrigation. For this it is necessary to inactivate the pathogenic microorganisms that still remain in the water. Disinfection by solar photocatalysis of treated water is especially efficient. In all these processes, the study of the influence of treatments on the quality of treated water and the evaluation of the impact derived from its use play a crucial role. The development of advanced chemical analysis methods is necessary to measure the presence of contaminants at very low concentrations, down to one billionth of a gram per liter (nanogram/liter). But when water shortages are pressing, it is necessary to desalinate to generate new fresh water. The desalination of seawater, or brackish water, using solar energy is a much-needed alternative. In this sense, the combination of membrane

distillation, which requires less heat input than other processes, and the use of solar energy to provide that heat is proposed as an alternative solution to conventional technologies.

1.4 CIESOL ORGANIZATION

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.



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 what does it do?

The Management Team consists of a director and a deputy director, belonging to UAL and PSA (and vice versa). Currently the director is José Antonio Sánchez Pérez from the UAL and Sixto Malato Rodríguez from the PSA is deputy director. They are in charge of assigning spaces and resources to the different projects and working groups, supervising the technical staff, maintaining CIESOL and, in general, everything that affects the ordinary functioning of the centre.

Who is the External Evaluation Committee (Scientific Committee) 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 resources and solar cooling research 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.

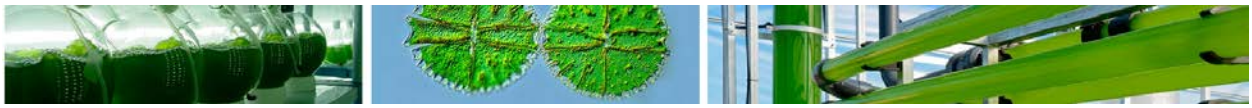
Modeling & automatic control" research group. Led by Manuel Berenguel Soria (UAL) and Lidia Roca Sobrino (PSA), the group works on the modeling and control of solar thermal plants, photoreactors and photobioreactors, while studying energy efficiency and comfort control in buildings, including smart energy networks .

Organometallics and photochemistry. Led by Antonio Manuel Romerosa Nievas (UAL) and Christoph Richter (DLR-PSA), it is working on the development of new water-soluble homo- and hetero-nuclear ruthenium

complexes with photocatalytic activity in high value-added molecule synthesis processes as well as as in new photovoltaic cells.

Advanced technologies for 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).



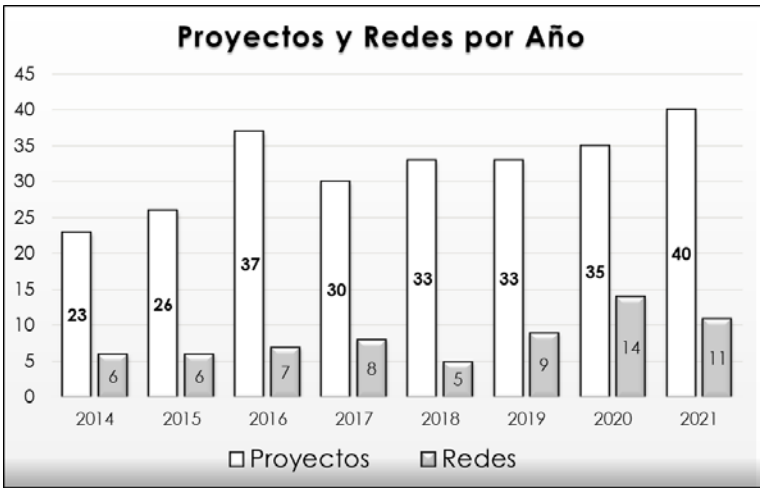
Desalination and phostosynthesis. The group develops two parallel lines of work, desalination and water treatment through membrane systems as well as the production of microalgae and products of interest. The main researchers are José M. Fernández Sevilla (UAL) and Guillermo Zaragoza del Águila (PSA).

1.5 ACTIVITIES OF CIESOL IN 2021

The year 2021 has been characterized by the difficulty in carrying out normal activity due to the expansion works of the center, which began in March and ended in September. In addition, the furniture and equipment of the laboratories have been renovated and expanded, which has had a great impact on the activity of the groups, especially those whose laboratories are located on the ground floor. Likewise, during 2021, the energy monitoring and control system in the center was renewed, through the execution of an infrastructure grant from the Junta de Andalucía. In this sense, 2021 has also been marked by the installation and commissioning of the infrastructures belonging to the Agroconnect project, in the facilities shared with IFAPA at its headquarters in La Cañada, adjacent to the University campus.

During this year 2021, 3 extracurricular internships have been offered for master's students with the intention of promoting initiation in research in the field of CIESOL, these internships are established with a duration of 6 months and with annual periodicity. We have received 3 students who have joined the Environmental Analysis, Water Regeneration and Solar Resources and Solar Cooling research groups. These internships cost €9,000 per year.

Ciesol has maintained its research activity during 2021 through the 40 research projects in execution. The figure shows the evolution of the number of projects in the last eight years, observing an average of 32 projects in execution per year. Regarding the networks, it has participated in 7 national and 4 international networks.



Regarding the scientific production corresponding to 2021, a total of 79 publications have been reached [36 in Q1 (46%), 27 in Q2 (34%), 12 in Q3 (15%) and 3 in Q4 (4%)] of them, 37 with international collaboration, which represents 47% of the total, as an indicator of the international character of the center. All the units have participated in national (10) and international (26) congresses and scientific meetings with a total of 58 contributions. The figure shows the evolution of the number of international scientific publications in JCR in the last eight years. An average of 101 articles per year is observed.

Regarding the doctoral theses, in the UAL-PSA collaboration during 2021, 9 doctoral theses have been defended.

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

2. . WHAT DOES CIESOL OFFER? - INFRASTRUCTURES AND SCIENTIFIC-TECHNOLOGICAL CAPACITIES

2.1 ACTIONS IN 2021

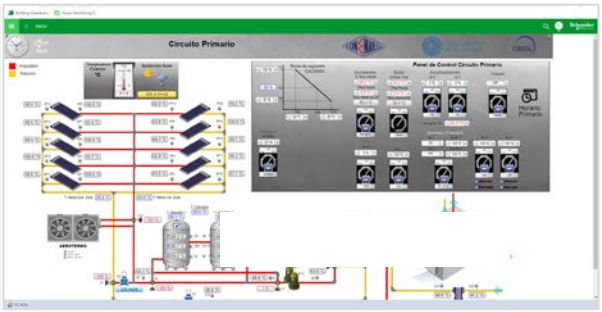
This year 2021, laboratories 1, 2, 3, 4, 6, 7 and 8 were expanded, absorbing the "patios" that were previously in them. Taking advantage of this reform, 4 ventilated booths were set up on the outside, the purpose of which is to house the gas cylinders and the N_2 generator, which can be used for various purposes.

In the extensions of laboratories 1 and 3, new air conditioning consoles were installed to be able to air-condition these two rooms independently of the building, since they house high-resolution chromatographic equipment that requires a certain and constant temperature.

The enclosure was also enlarged, extending the side courtyard until it was level with the rest of the building, thus achieving a larger area for research, and the charging area for electric vehicles was enabled.

On the other hand, new furniture has been acquired to equip these new areas and improve the existing ones. It is worth mentioning the acquisition of a laminar flow cabinet and an extraction arm for laboratory 2, several safety cabinets for chemical products and two extraction hoods (laboratories 3 and 4).

As for the building's climate control system, new open source software has been implemented, sensors, valves, controllers have been renewed and several webinars have been held to instruct the personnel involved.



Lastly, the CIESOL website has been completely renewed since the computer services of the University of Almería, where it was housed, recommended that the programming be changed due to security issues.

Taking advantage of this change, several improvements have been made:

- the contents have been updated,

- the interconnection between sections has been improved
- the information available on the projects has been increased
- includes a section where you can download the software that we have available
- We have included sections to expose the dissemination activities of the different research groups
- We have implemented an area to highlight those training activities that are of interest
- the responsiveness of the website has been reviewed and updated, and in parallel its visual appearance and programming has been modernized

2. FACILITIES AND INFRASTRUCTURES OF THE SOLAR ENERGY CHEMICAL USE AREA

XcelVap.

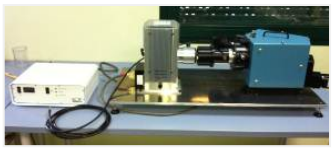
The XcelVap Automated Evaporation and Concentration System is a modern, compact nitrogen blow-down system that provides rapid, gentle evaporation of up to 54 sample extracts ranging in size up to 200-mL each. Evaporation is accomplished by combining consistent heat, controlled nitrogen flow, and active venting of the solvent vapors. With the XcelVap System, less time and attention are required to prepare reproducible extracts for chromatography analysis (GC/MS, LC/MS, GC, LC), improving laboratory productivity..

Micromolar photochemical system.

The micromolar photochemical reactor is a system that allows the controlled irradiation of small volumes containing photoactive species in both homogeneous and heterogeneous phases. Its irradiation source can be sunlight or an artificial halogen lamp and it is used to study photochemical reactions in real time, avoiding perturbations in the reaction medium and allowing external factors that might influence the reaction to be controlled.

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 photochemical reaction mechanisms, identification of reaction intermediates and kinetics.

Reaction carousels.

Each one can host up to 12 reaction tubes with Teflon caps to work in different kinds of atmospheric conditions and temperatures. Condensation of vapour is permitted by a chilling circuit in the upper part of the system. The working temperature ranges are from room temperature up to 300ºC.

They are mainly used to study catalytic reactions versus time and temperature along with varying the atmosphere

High sensitivity fluorimeter with temperature control.

The equipment makes it possible to determine the fluorescent characteristics of both a solution and a solid at different temperatures in the range from near IR to near UV. It allows to determine all the optical parameters of a sample as well as the lifetimes of excited states in the range of pico-seconds.

Cyclic volta-amperometry.

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

AB SCIEX QTRAP 5500 LC/MS/MS.

The QTRAP is designed to excel at metabolite identification, detection and confirmation of low-level pesticides, It also houses a high sensitive ion trap along with offering ultra-fast scan speeds and full MS3capabilities. Perform multiple reaction monitoring (MRM) scans for quantitation using this high-sensitivity triple quadrupole system. Identify, characterize, and quantitate metabolites more quickly and easily. Enable high-sensitivity, full-scan MS, MS/MS, and MS3with high-selectivity from true triple quadrupole precursor ion (PI) and neutral loss (NL) scans.

TripleTOF™ 5600+.

The TripleTOF 5600+ System is innovative in LC-MS/MS performance that uniquely integrates comprehensive, qualitative exploration, rapid profiling, and high-resolution quantification workflows on a single platform. It combines high-sensitivity detection, high resolution with fast acquisition speeds and stable mass accuracy over days of acquisition..

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

It allows analysis of volatile organic compounds of low/medium polarity, thus completing the range of compounds that can be analyzed in the Environmental Analysis laboratory. It is especially applied to the determination of trace levels of contaminants such as synthetic fragrances, pesticides, PAHs, THMs, etc.

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

This state-of-the-art mass spectrometer improves on the performance of the QTRAP 5500 LC/MS/MS, providing excellent sensitivity for ultra-trace analysis of organic contaminants, in many cases without the need for sample pretreatment. This improves the accuracy of the analysis, since losses in the extraction processes are avoided, in turn minimizing the cost and time of analysis.

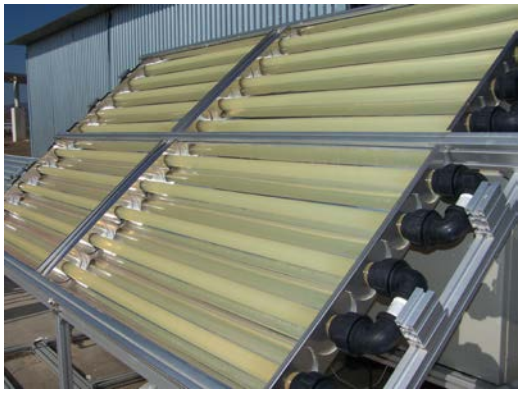
Autotrace.

Autotraces an automated solid-phase extraction (SPE) system for use with large samples (20 mL–20 L) to isolate trace organics in water or aqueous matrices. The compounds of interest are trapped on SPE adsorbents (cartridge or disk format), then eluted with strong solvents to generate an extract ready for analysis. AutoTrace instruments offer many advantages for sample preparation over traditional techniques including solid-phase extraction technology to save time, solvent, and labor.

Ion chromatograph (Metrohm 881 Compact IC Pro).
This equipment allows the accurate analysis of anions or cations in concentrations from µg/L to g/L, with detection limits of <1 µg/L. This system is essential for the characterization of the aqueous effluents used for experimentation, since the presence of certain cations as phosphates and chlorides affects various processes of water decontamination conducted at CIESOL (Fenton and solar photo-Fenton).

Total organic carbon analisers (TOC).
These analysers allow the dissolved carbon and nitrogen to be determined. In the laboratory they are used for the determination of inorganic and organic carbon and nitrogen dissolved in liquid samples of wastewater to evaluate their purification when oxidative treatments are applied.

Atlas Suntest cPS+ solar simulator.
This device simulates the solar spectrum, allowing laboratory scale experimentation. It is essential in pre initial scale pilot tests.

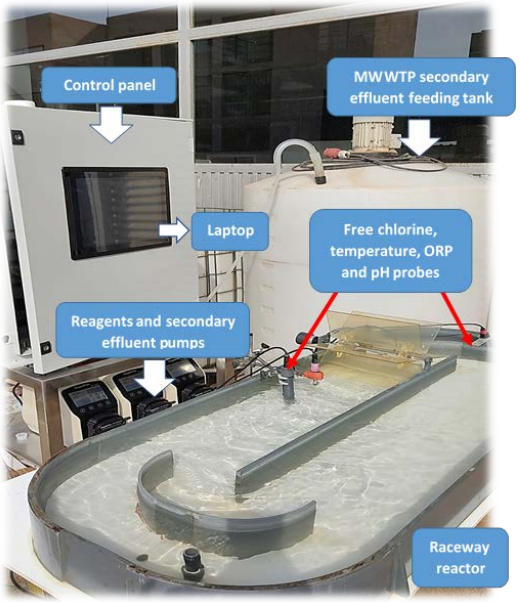


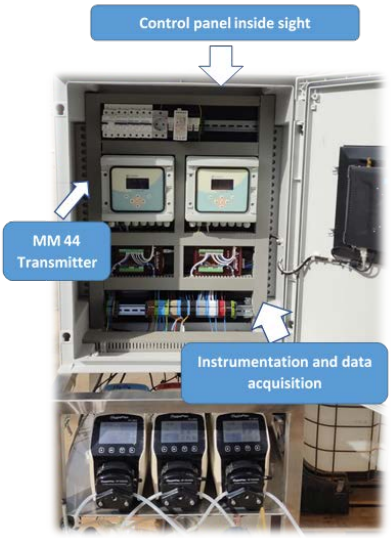
Pilot plants.
We have four pilot plants for contaminated water treatment by photo-Fenton (usually). They operate using solar irradiation and are equipped with radiometers to record the incident radiation. Pilot plant to evaluate the reuse of regenerated solar photocatalytic treatment water for irrigation. The plant is covered with an anti-pest 20x10 mm protector, and has twelve pots or containers with a mixture of coconut fibre and peat as substrate, where the tests are performed. It is equipped with two independent automated irrigation systems.

Bioreactors.
They are used to simulate different biological water purification processes

- Membrane bioreactor (MBR)
- Hollow fiber bioreactor (MBR)
- Batch bioreactor (SBR)
- SiClaro® 8PE Membrane bioreactor from Martin Systems AG

Membrane distillation using solar energy test plant facility, on the UAL central building rooftop.





Solar Photo-Fenton Experimental Automatic System. Solar photo-Fenton experiments are performed in pilot plant-scale raceway reactors. A SCADA system monitors and controls the entire operation of the process in real time.

2.3 FACILITIES AND INFRASTRUCTURES OF THE AREA OF ENERGY USE OF SOLAR ENERGY.

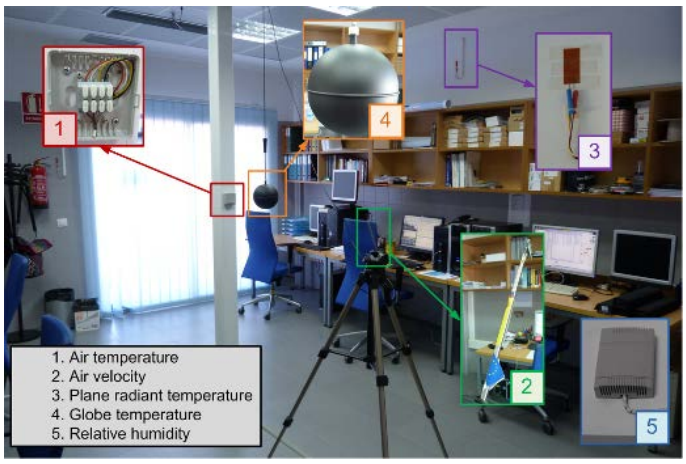
The installation has a **field of collectors** which is responsible for collecting the energy from solar radiation to heat water that is stored in tanks, later this water can be used in the cooling system or for phytosanitary purposes.

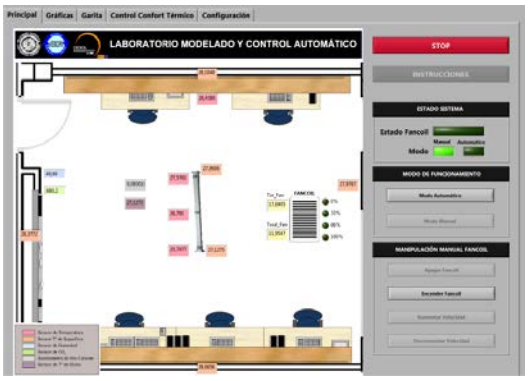
solar collectorS

Yazaki absorption machine and hot water storage tanks

Building monitoring system.

We have a system that monitors thermal comfort in our facilities





Comfort monitoring infrastructure in the CIESOL laboratories and screen of the SCADA monitoring system and examples of actuators

Load simulators.

The Modeling and Control functional unit also has a test bench in which the behavior 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. It is about replicating the elements that consume, store and produce electrical energy. There is also a test bench for the electric car that is currently, and for space reasons, located at CITE IV. This test bench is used to characterize the propulsion system of a light electric vehicle.

Inverters.

The Modeling and Control functional unit has two Victron inverters: one of them (Quattro model) manages the photovoltaic panel expansion row and supplies laboratory 6 and the electric vehicle recharging point, the other inverter (Multiplus model) manages two panels that are in the highest part of the roof, and simulate an isolated network.

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

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

Storage system.

A server for simulation and a storage service for the collected data. The monitoring and control system installed on the desktop PC consisting of a LENOVO tower, Hp monitor, NAS data server and CLOUD server infrastructure; and the aerial surveillance system (Mavic Air drone).

Stations for measuring climatic conditions.

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

Outdoor weather station (DeltaOhm Srl): formed by a base unit (HD35APW) to which the data collected by two recorders arrive: HD35EDM...TC and HD35EDW 1NB...F TCV.

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

Indoor weather station 1 (DeltaOhm Srl): formed by a base unit (HD35APW) to which data from 5 loggers arrive: 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.

Ejemplo registrador de datos

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.

Base Unit 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/m3, which is fed directly by seawater, and can generate 11 m3 of desalinated water per day. This water is stored in a 100 m3 tank. In addition, the RO unit generates 22 m3/h of brine which is stored in a 50 m3 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.

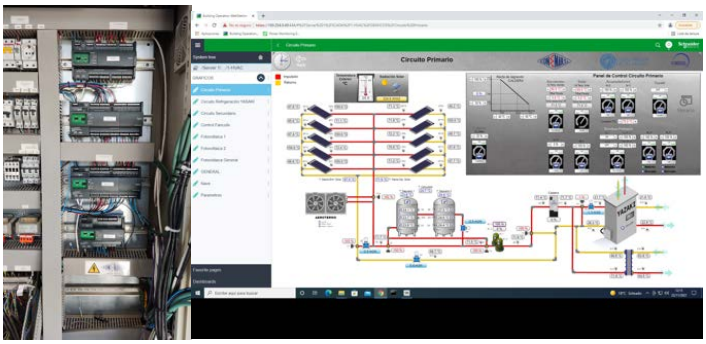
The centre of the installation is an experimental greenhouse of 1900 m^2 located in the IFAPA centre next to the University of Almeria (Almeria, Spain). The greenhouse is divided into two sectors of equal size and is equipped with a multitude of systems that allow a great deal of control over the growing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

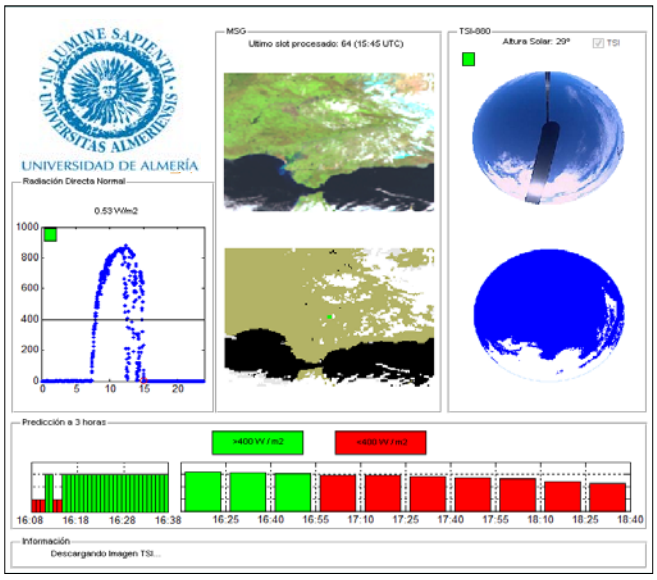
Direct, diffuse and normal radiation are measured with a frequency of 1 minute thanks to the two-axis solar tracker (2AP Sun Tracker - Kipp & Zonen) composed of a pyrheliometer (CH 1 Kipp & Zonen) and two pyranometers (CMP 11 Kipp & Zonen). In addition, 2 pyranometers (CMP 11 Kipp & Zonen) have been 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.



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.

3. ACTIVITIES OF CIESOL

3.1 ACTIVITIES OF "ORGANOMETALLICS AND PHOTOCHEMISTRY"

3.1.1 Functional unit description

In 2021 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 a postdoctoral research at the former ISSECC CNR, now ICCOM CNR, (Florence, Italy), before becoming Lecture Professor (1997) and finally Full Professor (2009) at the University of Almeria (Spain). His research interests range over 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, is the Secretary General of Solar PACES.

3.1.4 Summary of the functional unit's activities carried out in CIESOL during 2021

During 2021 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 main activities of the group were the student training, the publication of articles in the best journals in the area of chemistry, inorganic chemistry and materials, as well as the realization of invention patents.

3.1.5 Collaboration with other functional units of CIESOL during 2021

During 2021 the unit has collaborated with the Water Regeneration unit, and it is intended to collaborate with units of the solar platform for the design and use of suitable reactors to develop photochemical reactions under inert conditions.

3.1.6 Human resources

Visits and research stays in CIESOL:

- Dr. Nazanin Kordestani, Universidad de Isfahan (IRAN).
- 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	Number of papers in each Quartile				Number of papers with international collaborations
	Q_1	Q_2	Q_3	Q_4	
6	6				2

Papers

- Neutron Scattering Techniques for Studying Metal Complexes in Aqueous Solution. Franco Scalambra, Silvia Imberti, Nicole Holzmann, Leonardo Bernasconi, and Antonio Romerosa. ACS Main Cover: ACS Omega, volume 6, issue 3, January 26, 2021 1751−1757. https://doi.org/10.1021/acsomega.0c05030.
- Ru complexes containing Cp, mPTA and natural purine bases (mPTA = methyl-N-1,3,5-triaza-7-phosphaadamantane): Evaluation of their antiproliferative activity, solubility and redox properties. Lazhar Hajji, Cristobal Saraiba-Bello, Franco Scalambra, Gaspar Segovia-Torrente, Antonio Romerosa. Journal of Inorganic Biochemistry 218 (2021) 111404. https://doi.org/10.1016/j.jinorgbio.2021.111404
- Phosphorus Coordination Chemistry: A Special Issue in Honor of Maurizio Peruzzini.. Antonio Romerosa, Luca Gonsalvi. Coordination Chemistry Reviews 441 (2021) 213990. https://doi.org/10.1016/j.ccr.2021.213990
- New achievements on C-C bond formation in water catalyzed by metal complexes. Franco Scalambra, Pablo Lorenzo-Luis, Isaac de los Ríos, Antonio Romerosa. Coordination Chemistry Reviews 443 (2021) 213997-214028. https://doi.org/10.1016/j.ccr.2021.213997
- Maurizio Peruzzini: a protagonist in Transition Metal Chemistry. Maria Caporali, Andrea Ienco, Luca Gonsalvi, Antonio Manuel Romerosa Nievas, Francesco Vizza. Inorganica Chimica Acta 520 (2021) 120290. www.elsevier.com/locate/ica
- Monitoring spin-crossover phenomena via Re(I) luminescence in hybrid Fe(II) silica coated nanoparticles. Diaz-Ortega, IF; Fernandez-Barbosa, EL; (...); Herrera, JM. Dalton transation . Dalton Trans., 2021,50, 16176-16184. https://doi.org/10.1039/D1DT03334D

Congress assistance and contributions

- I congreso Anual de Estudiantes de Doctorado (CAED). Universidad Miguel Hernández. 2 de febrero de 2021.
- 1er GEQONOVEL (Simposio de Investigadores Jóvenes del Grupo Especializado de Química Organometálica) Evento virtual. 25 de marzo de 20221.
- OWPC1- 29-31 March 2021, Virtual versión of the EWPC-18 (Rostock, Germany) that was not held due to the COVIC-19.
- Metals and Water 202-MW2021 (virtual edition), Zaragoza, 24-25th June 2021.
- International Conference on Advance Research in Applied Sciences (ICARAS-2021) (virtual edition), Bhagwan Parshu Ram College, Kurukshetra 136118 Haryana, India. 25th September 2021.
- Materials Research Meeting 2021. Pacifico Yokohama, Japan. 13th – 16th December 2021.

Congress assistance and contributions

- New Ru(II) organometallic compounds generation with PTA ligand and its derivatives: antiproliferative properties. Andrés Alguacil Alarcón, Franco Scalambra and Antonio Manuel Romerosa Nievas. I congreso Anual de Estudiantes de Doctorado (CAED). Universidad Miguel Hernández. 2 de febrero de 2021. P96.
- Synthesis, characterization and study of new coordination compounds with water soluble phosphines and anticancer properties. Andrés Alguacil Alarcón, Franco Scalambra and Antonio Manuel Romerosa Nievas. 1er GEQONOVEL (Simposio de Investigadores Jóvenes del Grupo Especializado de Química Organometálica) Evento virtual. 25 de marzo de 20221. PA-03, pp 21.
- Significativo avance respecto al mecanismo de isomerización catalítica de alcoholes alílicos secundarios en agua. Belén López Sánchez, Franco Scalambra and Antonio Manuel Romerosa Nievas. 1er GEQONOVEL (Simposio de Investigadores Jóvenes del Grupo Especializado de Química Organometálica) Evento virtual. 25 de marzo de 2021.PA-06, pp 24.
- Bipyridyl-Ru(II) complexes containing 1,3,5-Triaza-7-phosphaadamantane (PTA) vs. plasmid DNA (pKSII). J. M. Veiga del Pino, A.Romerosa Nievas, F. Scalambra, F. García Maroto, A. Hernández

Zanoletty. OWPC1- 29-31 March 2021, Virtual versión of the EWPC-18 (Rostock, Germany) that was not held due to the COVIC-19. P15.

- Bipyridyl-Ru(II) complexes containing 1,3,5-Triaza-7-phosphaadamantane (PTA) vs. plasmid DNA (pKSII). J. M. Veiga del Pino, A.Romerosa Nievas, F. Scalambra, F. García Maroto, A. Hernández Zanoletty. OWPC1- 29-31 March 2021, Virtual versión of the EWPC-18 (Rostock, Germany) that was not held due to the COVIC-19. P19.
- Structures of half-sandwich Ru(II) complexes containing 1,3,5-triaza-7-phospaadamantane: behaviour of water in solution and in the solid state. F. Scalambra, B. López-Sánchez, A. M. Romerosa Nievas. Metals and Water 202-MW2021 (virtual edition), Zaragoza, 24-25th June 2021. Key Note KN04, pg. 11.
- Synthesis of new ruthenium - copper tetramer. A. Alguacil Alarcón,a Z. Mendoza,b P. Lorenzo-Luis,b F. Scalambra,a A. M. Romerosa Nievas.a*. Metals and Water 202-MW2021 (virtual edition), Zaragoza, 24-25th June 2021. Flash Presentation FP-03, pg. 18.
- New water-soluble bis-heterometallic complexes: synthesis, characterization and antiproliferative activity. N. Kordestani,a E. Abas,b L. Grasa,b,c A. Alguacil,a F. Scalambra,a A. Romerosa,a*. Metals and Water 202-MW2021 (virtual edition), Zaragoza, 24-25th June 2021. Flash Presentation FP-08, pg. 23.
- Water participation in the catalytic isomerization of linear allylic alcohols. N. B. López-Sánchez, F. Scalambra, and A. Romerosa. Metals and Water 202-MW2021 (virtual edition), Zaragoza, 24-25th June 2021. Flash Presentation FP-11, pg. 26.
- Metal complexes containing 1,3,5-triaza-7-phosphatricycle[3,3,1,13,7]decane (PTA) and parent ligands: a survey to their most interesting properties. A. Romerosa. International Conference on Advance Research in Applied Sciences (ICARAS-2021) (virtual edition), Bhagwan Parshu Ram College, Kurukshetra 136118 Haryana, India. 25th September 2021. Expert Talk. ICARAS-A-03.
- Photo-Oxidation in Water of Aldehydes to Carboxylic Acids. I.F. Diaz-Ortega, A. Romerosa, F. Scalambra. Materials Research Meeting 2021. Pacifico Yokohama, Japan. 13th – 16th December 2021. Oral Communication. F3-O2-12.
- Lanthanide luminescent bio-probes containing 1, 3, 5- Triaza-7-phosphaadamantane derivatives: A promising new family. I.F. Diaz-Ortega, J. M. Veiga, F. Scalambra, A. Romerosa. Materials Research Meeting 2021. Pacifico Yokohama, Japan. 13th – 16th December 2021. Oral Communication. G3G4-PV23-08.

Congress organization

- Metals and Water 2021: IV International Conference on Water Soluble Metal Complexes. (MW2021) (http://eventos.unizar.es/62789/section/29775/metals-and-water-2021-virtual-zaragoza.-iv-international-congress-in-water-soluble-metal-complexes-.html). Coorganizador. INTERNATIONAL. 24-25/06/2021. Virtual.

3.1.8 Functional Unit members

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Isaac de los Rios Hierro

Full Professor
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

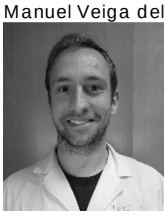
Belén López Sánchez

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 2021

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

Participants:
Functional Unit. "Coordination, Organometallic and Photochemical Chemistry". University of Almería (FQM-317)
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:
Functional Unit. "Coordination, Organometallic and Photochemical Chemistry". University of Almería (FQM-317)
Contacts:
A. Romerosa Nievas (romerosa@ual.es)
Funds:
Universidad de 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 2021

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: 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. Antonio Manuel Romerosa Nievas, Franco Scalambra, Nazanin Kordestani Mahani. P202030718 (2005009-ESP) (13/06/2020). PCT/ES2021/070509 (12/07/2021); 2005009-WOPP

3.1.12 Dissemination activities

Night of the researchers -2021. Universidad de Almería. Almería. 24-09-2021.

3.1.13 Others

Final degree and master projects

- Judit Cano Asensio. (Grado en Química). Isomerización del alcoholes alílicos usando el complejo [RuCp(OH2-κO)(PTA)2](CF3SO3)(Isomerization of allyl alcohols by using the complex [RuCp(OH2-κO)(PTA)2](CF3SO3)).
- Juan José Burgos Morata. (Grado en Química). Fotoisomerización catalítica de 1-hexen-3-ol en agua (Catalytic photoisomerization of 1-hexen-3-ol in wáter).

PhD Theses (under development)

- 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.

Awards during 2021

Best Publication JCR. Plan Propio de Investigación y Transferencia 2020.

Other scientific activities

Invited lecture: "Synthetic processes catalysed by water soluble metal complexes containing adamantanophosphine derivatives". Conferences in honor of Prof. Lumini□a Silaghi Dumitrescu at her 70th anniversary. Universitatea Babes-Bolyai. Cluj, Rumania. 12/03/2021.

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 29 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 24 national and international competitive R&D Projects. She is co-author of 2 patents and 167 scientific publications in indexed international journals (h-index = 61, January 2022). She has also co-authored more than 162 conference papers, 3 books and 14 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 148 publications in indexed scientific international journals and

more than 130 contributions to different International Congresses and Symposiums (until February 2021). She has also participated as teacher in some national and international curses and masters related with Advanced Treatment of Wastewater. H-index (February 2022): 43.

3.2.4 Summary of the functional unit's activities carried out in CIESOL during 2021

During 2021, the Research Group has worked on the execution of the 6 ongoing projects.

The analyses of the soil, foliar and tomato samples collected during the ANBAGENS project have continued. New work has been done to adapt the analytical methods to the new matrices. An extension of the execution period, until July 31, 2022 has been requested. The extension of the execution period of the LIFE PureAgroH2O project has also been requested and approved, until 12/31/2023. It is expected that the reactor will be received in 2022 and work can be done on its commissioning and operation. The activities carried out in the LIFE ULISES project have been linked to the activity developed by the Water Regeneration group, carrying out the analytical evaluation of the tests carried out in the pilot plant installed in the El Bobar WWTP, to verify their efficiency. For the PANI WATER project, work has been done to update and improve the available analytical methods, which currently exceed 200 contaminants of emerging concern. Likewise, the methods have been adapted to the new LC-QqQ-MS/MS equipment recently installed in the laboratory. This has improved the analytical capacity, as well as the efficiency of the methods, as this new equipment improves the performance of the previous one.

In the LIFE PHOENIX project (LIFE19 ENV/ES/000278), the characterization tasks of the WWTPs involved on it have been completed (Almonte WWTP, Huelva; El Toyo WWTP, Almería; Fonte Quente WWTP, Abrantes, Portugal; Talavera de la Reina, Toledo). Likewise, a method for the determination of hormones has been developed and validated, as required in the project. Finally, in the NAVIA project (PID2019-110441RB-C31), the degradation routes of sulfamethoxazole, a contaminant selected as a model, have been investigated, using TiO2-coated silica spheres synthesized by UPV as a catalyst. Up to 6 transformation products have been identified that show the main transformation routes of this compound.

3.2.5 Collaboration with other Functional Units of CIESOL during 2021

In 2021 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) y NAVIA (PID2019-110441RB-C31).

3.2.6 Human resources

Throughout 2021, the following members have left the Functional Unit due to the end of their contracts:

- Dennis Deemter
- Illaria Berruti
- Melina Rocamante
- Azahara Martínez García

New researchers have been incorporated;

- Ms. Flor Ximena Cadena Aponte. Research contract under the LIFE PureAgroH2O Project.
- Ms. Eva Jambrina Hernández. Research contract under the PaniWater Project.

- Ms. Alba Hernández Zanoletty (research contract charged to Project)
- Ms. Joyce Gloria Villachica Llamosas (research contract charged to Project)
- Ms. Kelly Johana Castañeda Retavizca (CIEMAT pre-doc researcher)

Postdoctoral contracts:

- Ana Ruiz Delgado. Postdoctoral research contract under the "Margarita Salas" Program.

Students in curricular internships

- Rosa Miranda Calvache. Chemistry Degree.
- Ana Anguís Morillas. Chemistry Degree.

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	9	3	1		4

Papers

- Solar processes and ozonation for fresh-cut wastewater reclamation and reuse: Assessment of chemical, microbiological and chlorosis risks of raw-eaten crops Nahim-Granados, S., Martínez-Piernas, A.B., Rivas-Ibáñez, G., Plaza-Bolaños, P., Oller, I., Malato, S., Pérez, J.A.S., Agüera, A., Polo-López, M.I. Water Research 2021, 203, art. no. 117532, https://doi.org/10.1016/j.watres.2021.117532
- Application of a fast and sensitive method for the determination of contaminants of emerging concern in wastewater using a quick, easy, cheap, effective, rugged and safe-based extraction and liquid chromatography coupled to mass spectrometry Martínez-Piernas, A.B., Plaza-Bolaños, P., Gilabert, A., Agüera, A. Journal of Chromatography A 2021, 1653, art. no. 462396. https://doi.org/ 10.1016/j.chroma.2021.462396
- Assessment of the presence of transformation products of pharmaceuticals in agricultural environments irrigated with reclaimed water by wide-scope LC-QTOF-MS suspect screening Martínez-Piernas, A.B., Plaza-Bolaños, P., Agüera, A. Journal of Hazardous Materials 2021, 412, art. no. 125080, https://doi.org/ 10.1016/j.jhazmat.2021.125080.
- Enhanced activated persulfate oxidation of ciprofloxacin using a low-grade titanium ore under sunlight: influence of the irradiation source on its transformation products Macías-Vargas, J.-A., Campos-Mañas, M.C., Agüera, A., Sánchez Pérez, J.A., Ramírez-Zamora, R.-M. Environmental Science and Pollution Research 2021, 28 (19), pp. 24008-24022. https://doi.org/ 10.1007/s11356-020-11564-8
- Aluminized surface to improve solar light absorption in open reactors: Application for micropollutants removal in effluents from municipal wastewater treatment plants Costa, E.P., Roccamante, M., Plaza-Bolaños, P., Oller, I., Agüera, A., Amorim, C.C., Malato, S. Science of the Total Environment 2021, 755, art. no. 142624, https://doi.org/ 10.1016/j.scitotenv.2020.142624
- Nanofiltration retentate treatment from urban wastewater secondary effluent by solar electrochemical oxidation processes. Salmerón, I., Rivas, G., Oller, I., Martínez-Piernas, A., Agüera, A., Malato, S. Separation and Purification Technology 2021, 254, art. no. 117614, https://doi.org/ 10.1016/j.seppur.2020.117614
- A rational analysis on key parameters ruling zerovalent iron-based treatment trains: Towards the separation of reductive from oxidative phases Sciscenko, I., Arques, A., Escudero-Oñate, C., Roccamante, M., Ruiz-Delgado, A., Miralles-Cuevas, S., Malato, S., Oller, I. Nanomaterials 2021, 11 (11), art. no. 2948, https://doi.org/ 10.3390/nano11112948
- Contribution of temperature and photon absorption on solar photo-Fenton mediated by Fe3+-NTA for CEC removal in municipal wastewater Soriano-Molina, P., Miralles-Cuevas, S., Oller, I.,

García Sánchez, J.L., Sánchez Pérez, J.A. Applied Catalysis B: Environmental 2021, 294, art. no. 120251, https://doi.org/ 10.1016/j.apcatb.2021.120251

- Direct oxidation of peroxymonosulfate under natural solar radiation: Accelerating the simultaneous removal of organic contaminants and pathogens from water Berruti, I., Oller, I., Polo-López, M.I. Chemosphere 2021, 279, art. no. 130555, https://doi.org/ 10.1016/j.chemosphere.2021.130555.
- Uv-c peroxymonosulfate activation for wastewater regeneration: Simultaneous inactivation of pathogens and degradation of contaminants of emerging concern Berruti, I., Nahim-Granados, S., Abeledo-Lameiro, M.J., Oller, I., Polo-López, M.I. Molecules 2021, 26 (16), art. no. 4890, https://doi.org/ 10.3390/molecules26164890
- Pilot-scale removal of microcontaminants by solar-driven photo-Fenton in treated municipal effluents: Selection of operating variables based on lab-scale experiments Kowalska, K., Roccamante, M., Reina, A.C., Plaza-Bolaños, P., Oller, I., Malato, S. Journal of Environmental Chemical Engineering 2021, 9 (1), art. no. 104788, https://doi.org/ 10.1016/j.jece.2020.104788.
- Two strategies of solar photo-Fenton at neutral pH for the simultaneous disinfection and removal of contaminants of emerging concern. Comparative assessment in raceway pond reactors Soriano-Molina, P., Miralles-Cuevas, S., Esteban García, B., Plaza-Bolaños, P., Sánchez Pérez, J.A. Catalysis Today 2021, 361, pp. 17-23. https://doi.org/ 10.1016/j.cattod.2019.11.028.
- Removal of pharmaceuticals in hospital wastewater by solar photo-Fenton with Fe^{3+}-EDDS using a pilot raceway pond reactor: Transformation products and in silico toxicity assessment. Cuervo Lumbaque, E., Cardoso, R.M., de Araújo Gomes,A., Malato, S. Microchemical Journal 2021,164 106014. https://doi.org/ 10.1016/j.microc.2021.106014

Congress contributions

- Investigation of pharmaceutical transformation products in real agricultural crops irrigated with reclaimed water: Current analytical tools and main difficulties. P. Plaza Bolaños, A.B. Martínez-Piernas, A. Agüera. ACS Fall 2021, Agosto 22 - 26, 2021.Comunicación oral.
- Wastewater reuse for agricultural irrigation in real crops: analytical tools and difficulties in the investigation of pharmaceutical transformation products. P. Plaza Bolaños, A.B. Martínez-Piernas, A. Agüera. XX Meeting of the Spanish Society of Chromatography and Related Techniques, SECyTA 2021. Virtual edition, 18-19 noviembre, 2021.
- Combined toxicity of micropollutants from a wastewater effluent and polystyrene nanoplastics towards three freshwater organisms. Irene Verdú, Georgiana Amariei, Patricia Plaza-Bolaños, Ana Agüera, Francisco Leganés, Roberto Rosal, Francisca Fernández-Piñas. SETAC Latin America 14th Biennial Meeting. 26-29 septiembre, 2021. Edición virtual.
- Evaluation of small doses of H_2O_2 for solar water disinfection enhancement. A. Martínez-García, I. Oller, M.I. Polo-López. CONGRESO INTERNACIONAL 4th SMALLWAT21v. On-line, Sevilla (España) 17-18 June 2021.
- Solar processes and ozone as alternative treatments for wastwater reuse in agro-food industires: water, crops and risk assessment. S. Nahim-Granados, A.B. Martínez-Piernas, G. Rivas-Ibáñez, P. Plaza-Bolaños, I. Oller, S. Malato, J.A. Sánchez Pérez, A. Agüera, M.I. Polo-López. CONGRESO INTERNACIONAL 4th SMALLWAT21V. Poster presentation. On-line, Sevilla (España) 17-18 June 2021.
- Comparison of UVC/H_2O_2 and UVC/$S_2O_8^{2-}$ processes for simultaneous removal of microcontaminants and bacteria in simulated municipal wastewater at pilot-scale. I. Sánchez-Montes, I. Salmerón, J.M. Aquino, M.I. Polo-López, S. Malato, I. Oller. CONGRESO INTERNACIONAL 4th SMALLWAT21V. Poster presentation. On-line, Sevilla (España) 17-18 June 2021.
- Fresh-cut wastewater reclamation by solar processes and reuse in agriculture: Assessment of chemical and microbial risks of raw-eaten crops. S. Nahim-Granados, M.I. Polo-López, P. Plaza-Bolaños, I. Oller, M. Malato, A. Aguera, J.A. Sánchez Pérez. 5th IWA Specialized International Conference on ecoSTP. Hibrid event. Mylan (Italy) 21-25 June 2021.
- Performance evaluation of CuO-TiO_2 catalyst for solar hydrogen production together with water detoxification and disinfection in pilot scale. Reunión Bienal de la Sociedad Española de Catálisis (SECAT 2021), Valencia (España) 18-20 de octubre 2021. Poster presentation P-041.

- Application of two different strategies for the simultaneous disinfection and decontamination of urban wastewater using solar photo-Fenton and solar/H2O2 processes. G. Maniakova, I. Salmeron, M.I. Polo-López, I. Oller, L. Rizzo, S. Malato. 17th International Conference on Environmental Science and Technology CEST2021. Oral presentation. Athens, Hibrid event (cest2021_00744). Greece. 1-4 September 2021.

Book Chapters

- Malato, S., Giménez, J., Oller, I., Agüera, A., Sánchez Pérez, J.A. Removal and Degradation of Pharmaceutically Active Compounds (PhACs) in Wastewaters by Solar Advanced Oxidation Processes (2021) Handbook of Environmental Chemistry, 108, pp. 299-326. https://doi.org/10.1007/698_2020_688

PhD Thesis

- Tertiary treatment of urban wastewater by advanced oxidation processes. Universidad. University of Salerno, April 2021. Director: Sixto Malato Rodríguez.

3.2.8 Functional Unit members

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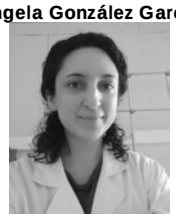

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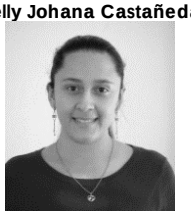

PhD Student
CIEMAT-PSA

3.2.9 Ongoing projects in 2021

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

Participants:

Functional Units: "Water Treatments" and "Environmental Analysis"

Contacts:

A. Agüera (aaguera@ual.es)

Funds:

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

Time Period:

July 2018 – December 2021

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:
01/10/2019-31/09/2021
Current Situation:
In progress
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.

Objetives:

- 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, LIFE18 ENV/ES/000165)

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 – July 2022

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 Unit: "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 Unit: "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:
Unidades funcionales de "Regeneración de aguas" y "Análisis Ambiental"

Contacts:
J.A. Sánchez Pérez (jsanchez@ual.es); A. Agüera (aaguera@ual.es); I. Oller (Isabel.oller@psa.es); 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:
"Water treatment" and "Environmental analysis" Functional Units

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 (1st Annual Payment)

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).

3.2.10 Network participation during 2021

Network: "Iberoamerican Solar Water Treatment Network (REDES180149)". Program to Support the Formation of International Networks between Research Centers, Call 2018. International Cooperation Program of CONICYT. Universidad de Tarapacá (Chile).

3.2.11 Dissemination activities

Isabel Oller has given the webinar "Water-Energy-Food nexus in industrial and urban wastewater recovery" at ODAKTR Seminar Series (26 February 2021).

3.2.12 Others

Final degree projects

- Ángel Bochs Cruz (Master in Advanced Chemistry Laboratory). “Determination of antibiotics in tomato irrigated with reclaimed water by liquid chromatography coupled to mass spectrometry”.
- Ester Mangas López (Degree in Chemistry). "Determination of three disinfection by-products in drinking water and waste water by LC-MS/MS in HILIC mode".

PhD Theses (under development)

- Melina Roccamante (Supervisors: Sixto Malato y Sara Miralles)
- Azahara Martínez (Supervisors: Inmaculada Polo e Isabel Oller)
- Dennis Deemter (Supervisors: Sixto Malato y Ana M. Amat)
- Illaria Berruti (Supervisors: Inmaculada Polo e Isabel Oller)
- Eva Jambrina (Supervisors: Patricia Plaza y Samira Nahim Granados).
- Alba Hernández Zanoletty (Supervisors: Inmaculada Polo López e Isabel Oller)
- Joyce Gloria Villachica Llamosas (Supervisors: Sixto Malato y Alba Ruiz)
- Kelly Joahana Castañeda (Supervisors: Sixto Malato e Inmaculada Polo López)

Attendance at Transfer and Dissemination Workshops

- Isabel Oller has participated in the XIII Conference on the European Union. Innovation and future challenges in wastewater treatment and regeneration in the European Union. 2nd Edition: “R+D+i in advanced oxidation technologies for the disinfection and elimination of emerging contaminants”. Online, November 25, 2021.

- Ana Agüera, Sixto Malato and Isabel Oller have participated in the Solar Water Treatment Online Seminar organized by SEC-CHILE, May 24-26, 2021 (Online format).
- Isabel Oller has participated in the National School of Electrochemistry in Environmental Processes with a paper entitled Advanced Solar Oxidation Processes. Online format, March 12, 2021.
- Isabel Oller has participated in the conference "The Almería model, a sustainable and efficient agri-food system to fight hunger in the world and to guarantee the universal right to food". Face-to-face format at the University of Almería, September 3 and 4, 2021.

Other scientific activities

Dissemination publications

- Regeneration of urban wastewater using new materials and advanced solar technologies. NAVIA project. M. I. Polo López, I. Oller, A. Agüera, J.A. Sanchez Perez, M.L. Marin, F. Bosca. Industria Química, January 2021.
- Impact of water reuse in agricultural irrigation: ANBAGENS project. Samira Nahim-Granados, Ángela González, María Jesús Abeledo-Lameiro, Inmaculada Polo-López, Isabel Oller, Sixto Malato, Patricia Plaza-Bolaños, Ana Agüera. IDIAGUA, magazine on R&D&I trends of the Spanish water technology platform. Edition Nº3 December 2021

3.3 ACTIVITIES OF "ADVANCED TECHNOLOGIES FOR WATER REGENERATION"

3.3.1 Functional unit description

The Functional Unit has been formed during 2021 by 14 researchers, with two full professors, one OPI principal researcher, one university professor, five doctors hired in charge of projects, two doctors hired Juan de la Cierva, and three predoctoral researchers. The group works on the decontamination of water contaminated with persistent toxics, removal of microcontaminants and disinfection of treated wastewater for reuse. It has basic analytical equipment located in the laboratories 1 and 2 of the center, as well as pilot plants for biological and photochemical water treatments, in the test yard.

3.3.2 Main research lines

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

- Use of solar photo-Fenton for decontamination of toxic water
- Use of solar photo-Fenton for micropolluant removal from treated wastewater
- Use of solar photo-Fenton for treated wastewater disinfection (regeneration)
- Combination of solar photo-Fenton and membrane bioreactor (pre-and post-treatment)
- Optimization of the operation and development of new technology for photo-Fenton
- Economics of water treatment processes

3.3.3 Main researchers

José Antonio Sánchez Pérez (ORCID ID: 0000-0001-5635-3137; Scopus Author ID 57195586656)
Full Professor. Department of Engineering. Degree in Chemical Engineering by Univ. of Granada (1988); PhD by the Univ. of Granada (1992). He has been involved in 26 national and international R&D projects and has leaded 13 of them, as well as in a 12 contracts with private companies. He has directed 19 PhD thesis in different fields such as biotechnology of microalgae, filamentous fungi fermentation 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 hired researcher. Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Almería Solar Platform. Graduated in biology from the University of Granada in 2006 and PhD in Chemical Engineering from the University of Almería (2012). He has carried out 20 national and international R&D projects, currently leading 4 of them. He has directed/co-directed two doctoral theses and is currently directing four other ongoing doctoral theses in the field of solar water treatment and reuse. Author and co-author of 75 publications in international journals with a high impact index, author of 1 book and co-author of 14 other book chapters.

3.3.4 Summary of the functional unit's activities carried out in CIESOL during 2021

The year 2021 has been characterized by the expansion works of the Ciesol laboratories, which have limited activity. Work has been done on the UAL-Feder AQUELOO, Life Ulises, Life Phoenix and NAVIA (Retos-AEI) projects, and the ANUKIS (Proof of concept-AEI) and Rayo (Junta de Andalucía) projects have begun. The construction and start-up of the solar photo-Fenton demonstration plant to treat up to 18 m^3/day of

secondary effluent from the "El Bobar" WWTP in the city of Almería stands out. It is a 100 m^2 RPR (Raceway Pond Reactor) type reactor operated in continuous flow mode for the disinfection and removal of emerging contaminants in secondary effluents for reuse in agriculture. The fluid dynamics of the reactor have been studied, as well as the treatment at acidic pH with acidification and neutralization online.

As for the work carried out in the center's facilities, a photoreactor with UVC LED lighting at 276 nm has been put into operation (the cost for 254 nm LEDs is still excessively high) and experimental studies with RPR have continued at pilot scale analyzing the effect of different variables of interest for the operation of the process such as different sources of iron and oxidants.

In terms of mobility, during 2021 we have welcomed Dr. Gianluca Li Puma from Loughborough University (United Kingdom) and Dr. Tamara Benzaquén Associate Researcher at CITEQ (UTN-CONICET, National Council for Scientific and Technical Research) (Argentina) between the months of September to December. Other planned stays have not been possible due to the state of the pandemic.

Figure 2.3.1. Raceway pond reactor for the operation of the solar photo-Fenton process in continuous flow mode for the treatment of secondary effluent, installed at the "El Bobar" WWTP in Almería.

3.3.5 Collaboration with other Functional Units of CIESOL during 2021

There is close collaboration with the group "Analytical evaluation of water treatment and environmental analysis", complementing and strengthening the main current lines of work, sharing the projects: NAVIA (PID2019-110441RB-C31 and PID2019-110441RB-C32), ANUKIS (PDC2021-121772-I00), Life PureAgroH2O (LIFE17 ENV/GR/000387), Life Ulises (LIFE18 ENV/ES/000165) y Life Phoenix (LIFE19 ENV/ES/000278). The collaboration with the "Modeling and Control Unit", has started for the implementation of control systems for the

disinfection and decontamination process using photo-Fenton solar operated in continuous mode in the framework of the projects ANUKIS (PDC2021-121772-I00) and Rayo (PY20_00786).

3.3.6 Human resources

During 2021, PhD student Solaima Belachqer El Attar and master's student Daniel Rodríguez García have joined the research team, as well as doctor Natalia Pichel Mira with a Juan de la Cierva training contract, and doctor Ana Belén Esteban García has left the group, who has joined the Technical Services of the UAL through a technical support staff contract, PTA.

Visits and research stays in CIESOL

- Dr. Gianluca Li Puma. Loughborough University (UK) (13/09/2021-09/10/2021)
- Dra. Tamara Benzaquén. CONICET (Argentina) (01/09/2021-31/12/2021)

Students in curricular internships

- José Daniel Sánchez López (16/11/2020 – 23/01/2021). Chemical Engineering.
- Daniel Rodríguez García (01/02/2021-16/04/2021). Chemical Engineering.
- Guillermo Cabrera Saldaña (01/03/2021-04/06/2021). Environmental Health training cycle.
- Estefanía Nadia Cano Lara (01/03/2021-04/06/2021). Environmental Health training cycle.

3.3.7 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	
16	10	5		1	10

Papers.

- Mechanistic modelling of wastewater disinfection by the photo-Fenton process at circumneutral pH. C. Casado, J. Moreno-SanSegundo, I. De la Obra, B. Esteban García, J. A. Sánchez Pérez, J. Marugán. Chemical Engineering Journal 403: 126335 (2021).
- https://doi.org/10.1016/j.cej.2020.126335
- Two strategies of solar photo-Fenton at neutral pH for the simultaneous disinfection and removal of contaminants of emerging concern. Comparative assessment in raceway pond reactors. P. Soriano Molina, S. Miralles, B. Esteban, P. Plaza-Bolaños, J. A. Sánchez Pérez. Catalysis Today 361: 17-23 (2021) https://doi.org/10.1016/j.cattod.2019.11.028
- Perspectives of the solar photo-Fenton process against the spreading of pathogens, antibiotic resistant bacteria and genes in the environment. M. I. Polo-López, J. A. Sánchez Pérez. Current Opinion in Green and Sustainable Chemistry 27: 100416 (2021) https://doi.org/10.1016/j.cogsc.2020.100416
- Enhanced activated persulfate oxidation of ciprofloxacin using a low-grade titanium ore under sunlight: Influence of the irradiation source on its transformation products. J. A. Macías-Vargas, M. C. Campos Mañas, A. Agüera, R. M. Ramírez-Zamora, J. A. Sánchez Pérez. Environmental Science and Pollution Research 28, 24008–24022 (2021) https://doi.org/10.1007/s11356-020-11564-8
- A critical evaluation of the use of accumulated energy as a parameter for the scale-up of solar photo-reactors during the treatment of simulated industrial wastewater by solar photo-Fenton. A. Cabrera-Reina, S. Miralles-Cuevas, P. Soriano Molina, J. A. Sánchez Pérez. Journal of Chemical Technology & Biotechnology 96(6): 1593-1602 (2021) https://doi.org/10.1002/jctb.6678

- Removal of pharmaceuticals in hospital wastewater by solar photo-Fenton with Fe3+-EDDS using a pilot raceway pond reactor: transformation products and in silico toxicity assessment. E. Cuervo Lumbaque, R. M. Cardoso, A. Araújo Gomes, S. Malato, J. A. Sánchez Pérez, C. Sirtori. Microchemical Journal 164: 106014 (2021) https://doi.org/10.1016/j.microc.2021.106014
- Contribution of temperature and photon absorption on solar photo-Fenton mediated by Fe3+-NTA for CEC removal in municipal wastewater. P. Soriano Molina, S. Miralles, I. Oller, J. L. García Sánchez, J. A. Sánchez Pérez. Applied Catalysis B: Environmental 294: 120251 (2021) https://doi.org/10.1016/j.apcatb.2021.120251
- Assessment of different iron sources for continuous flow solar photo-Fenton at neutral pH for sulfamethoxazole removal in actual MWWTP effluents. P. Soriano Molina, I. de la Obra, S. Miralles, E. Gualda-Alonso, J. L. Casas López, J. A. Sánchez Pérez. Journal of Water Process Engineering 41: 102109 (2021) https://doi.org/10.1016/j.jwpe.2021.102109
- Simultaneous disinfection and organic microcontaminant removal by UVC-LED driven advanced oxidation processes. S. Miralles, I. de la Obra, E. Gualda-Alonso, P. Soriano Molina, J. L. Casas López, J. A. Sánchez Pérez. Water 13: 1507 (2021) https://doi.org/10.3390/w13111507
- Solar processes and ozonation for fresh-cut wastewater reclamation and reuse: assessment of chemical, microbiological and chlorosis risks of raw-eaten crops. M. I. Polo-López, S. Nahim-Granados, A. Martínez-Piernas, G. Rivas-Ibáñez, P. Plaza-Bolaños, I. Oller, S. Malato, J. A. Sánchez Pérez, A. Agüera. Water Research 203: 117532 (2021) https://doi.org/10.1016/j.watres.2021.117532
- Application of solar photo-Fenton in raceway pond reactors: a review. A. Cabrera-Reina, S. Miralles-Cuevas, J. A. Sánchez Pérez, R. Salazar. Science of the Total Environment 800:149653 (2021) https://doi.org/10.1016/j.scitotenv.2021.149653
- Worldwide Research Trends on Solar-Driven Water Disinfection. M.M. Ballesteros, C. Brindley, J. A. Sánchez Pérez, P. Fernández-Ibáñez. International Journal of Environmental Research and Public Health 18(17): 9396 (2021) https://doi.org/10.3390/ijerph18179396
- Simultaneous bacterial inactivation and microcontaminant removal by solar photo-Fenton mediated by Fe3+-NTA in WWTP secondary effluents. S. Miralles, P. Soriano Molina, I. de la Obra, E. Gualda-Alonso, J. A. Sánchez Pérez. Water Research 205: 117686 (2021) https://doi.org/10.1016/j.watres.2021.117686
- UV-C Peroxymonosulfate Activation for Wastewater Regeneration: Simultaneous Inactivation of Pathogens and Degradation of Contaminants of Emerging Concern. I. Berruti, S. Nahim-Granados, M.J. Abeledo-Lameiro, I. Oller, M.I. Polo-López. Molecules 26: 4890 (2021) https://doi.org/10.3390/molecules26164890
- Direct oxidation of peroxymonosulfate under natural solar radiation: Accelerating the simultaneous removal of organic contaminants and pathogens from water. I. Berruti, I. Oller, M.I. Polo-López. Chemosphere 279: 130555 (2021) https://doi.org/10.1016/j.chemosphere.2021.130555

Science articles

- Regeneración de agua residual urbana mediante nuevos materiales y tecnologías solares avanzadas Proyecto Navia. M. I. Polo López, I. Oller, A. Agüera, J.A. Sánchez Pérez, M.L. Marín, F. Boscá. Industria Química Enero 2021

Congress assistance

- 7th Latin-American Congress of Photocatalysis, Photochemistry and Photobiology, México D.F., México, 2021
- Seminario Tratamiento Solar de Aguas, Proyecto ANID/REDES 180149, Santiago de Chile, Chile, 2021
- Webinar Tecnologías para la Remediación y Mitigación de Contaminantes de Preocupación Emergente en las Aguas Residuales Urbanas, proyecto NOR-WATER, Oporto, Portugal, 2021
- ODAKtr Seminar. H2020 Project SolarTwins, on-line 2021.
- International PhD School on Advanced Oxidation Processes (IPS-AOP) Webinars series 2020-2021. Online 16th March 2021.
- 5th IWA Specialized International Conference on ecoSTP. 21-25 June 2021. Hibrid event. Mylan, Italy

- 17th International Conference on Environmental Science and Technology CEST2021. Athens, Hibrid event. Greece, 1 to 4 September 2021.

Congress contributions

- Design and operation of raceway pond reactors for tertiary treatment of wastewater using solar photo-Fenton. J. A. Sánchez Pérez. 7th Latin-American Congress of Photocatalysis, Photochemistry and Photobiology, México D.F., México, 2021. (Conferencia plenaria)
- Eliminación de contaminantes de interés emergente en aguas residuales urbanas mediante foto-Fenton solar. De la fenomenología al escalado. J. A. Sánchez Pérez. Seminario Tratamiento Solar de Aguas, Proyecto ANID/REDES 180149, Santiago de Chile, Chile, 2021. (Oral)
- Desinfección de agua y aguas residuales por Procesos Avanzados de Oxidación. M.I. Polo-López. Seminario Tratamiento Solar de Aguas, Proyecto ANID/REDES 180149, Santiago de Chile, Chile, 2021. (Oral)
- Antibiotic Resistant Bacteria: occurrence and removal from urban wastewater. M.I. Polo-López. ODAKtr Seminar. H2020 Project SolarTwins .Online 5th February 2021 (oral)
- Eliminación de contaminantes de preocupación emergente en aguas residuales urbanas mediante foto-Fenton. J. A. Sánchez Pérez. Webinar Tecnologías para la Remediación y Mitigación de Contaminantes de Preocupación Emergente en las Aguas Residuales Urbanas, proyecto NOR-WATER, Oporto, Portugal, 2021. (Oral)
- Assessment of solar photo-Fenton mediated by Fe^{3+}-NTA for simultaneous disinfection and removal of contaminants of emerging concern in raceway pond reactors. E. Gualda-Alonso, S. Miralles-Cuevas, P. Soriano-Molina, J.L. Casas López, J.A. Sánchez Pérez. 7th Latin-American Congress of Photocatalysis, Photochemistry and Photobiology, México D.F., México, 2021. (Oral)
- Effect of iron source on continuous flow solar photo-Fenton for the removal of sulfamethoxazole as a surrogate of contaminant of emerging concern. P. Soriano-Molina, E. Gualda-Alonso, I. de la Obra, S. Miralles-Cuevas, J.L. Casas López, J.A. Sánchez Pérez. 7th Latin-American Congress of Photocatalysis, Photochemistry and Photobiology, México D.F., México, 2021. (Oral)
- Water and Wastewater disinfection by AOPs. M.I. Polo-López. International PhD School on Advanced Oxidation Processes (IPS-AOP) Webinars series 2020-2021. Online 16th March 2021. (oral)
- Novel Photocatalysts Based On Zinc Oxides For The Simultaneous Disinfection And Decontamination Of Water. I. Berruti, M.I. Polo-López, G. Nuno, I. Oller, P. Calza, M.C. Paganini. 5th IWA Specialized International Conference on ecoSTP. 21-25 June 2021. Hibrid event. Mylan, Italy. (Oral)
- Fresh-cut Wastewater Reclamation By Solar Processes And Reuse In Agriculture: Assessment Of Chemical And Microbial Risks Of Raw-eaten Crops. S. Nahim-Granados, M.I. Polo-López, P. Plaza-Bolaños, I. Oller, M. Malato, A. Aguera, J.A. Sánchez Pérez. 5th IWA Specialized International Conference on ecoSTP. 21-25 June 2021. Hibrid event. Mylan, Italy. (Oral)
- Application of two different strategies for the simultaneous disinfection and decontamination of urban wastewater using solar photo-Fenton and solar/H2O2 processes. G. Maniakova, I. Salmeron, M.I. Polo-López, I. Oller, L. Rizzo, S. Malato. 17th International Conference on Environmental Science and Technology CEST2021. Athens, Hibrid event (cest2021_00744). Greece, 1 to 4 September 2021 (oral)
- First demo-plant of solar photo-Fenton as a tertiary treatment for wastewater reclamation. E Gualda-Alonso, S. Belachqer El Attar, J.L. Casas López, J.A. Sánchez Pérez. X Simposio de Investigación en Ciencias Experimentales, Almería, España, 2021. (Oral)
- Assessment of solar photo-Fenton with Fe^{3+}-NTA for simultaneous disinfection and microcontaminant removal in raceway pond reactors. P. Soriano-Molina, E. Gualda-Alonso, J.L. Casas López, J.A. Sánchez Pérez. X Simposio de Investigación en Ciencias Experimentales, Almería, España, 2021. (Póster)
- Combination of oxidants for disinfection and decontamination in WWTP effluents by solar photo-Fenton for reuse in agricultural irrigation. S. Belachqer El Attar, P. Soriano-Molina, I. de la Obra, J.A. Sánchez Pérez. X Simposio de Investigación en Ciencias Experimentales, Almería, España, 2021. (Póster)

3.3.8 Functional unit members

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3.3.9 Ongoing projects in 2021

3.3.9.1 Toward a smart & integral treatment of natural radioactivity in water provision services (LIFE ALCHEMIA, LIFE16 ENV/ES/000437)

Participants:

CIESOL. Unidad funcional "Tecnologías avanzadas para la regeneración de aguas"
Fundación CARTIF (Coordinadores)
Diputación de Almería
Tallinn University of Technology
University of Tartu
Viimsi Vesi Ltd (Estonia)

Contacts:

J. L. Casas López (jlcasas@ual.es)

Funds:

Unión Europea. Programa LIFE (LIFE16 ENV/ES/000437)

Time Period:

October 2017 - September 2021

Current Situation:

In progress

Summary:

The Life Alchemia project tackle one of the current challenges in the treatment of water for human consumption, such as the presence of natural radioactivity. There is a notable lack of knowledge on the part of those involved in water management and despite current legislation (Directive 2013/51 / Euratom), radioactivity is not a parameter that is being systematically monitored at European level. In this regard, it should be noted that this project has the support of 43 of these actors, including the highest national authorities of the 2 member countries of the consortium: the Estonian Ministry of Environment and the Spanish Nuclear Safety Council. It is an environmental problem that cannot be solved at the source, since it is generated by the dilution in groundwater of minerals rich in radioactive isotopes, mainly uranium (U), radius (RA) and thorium (TH). Therefore, new systems capable of providing a sustainable elimination of radioactivity from the point of view of profitability and sustainability are needed. Reverse osmosis (RO) is the most used treatment for this application; However, the carbon footprint of this process is very high and generates large volumes of water rejection with radioactivity that needs additional treatment. The LIFE Alchemia project

offers a breakthrough to this problem from two angles. First, with the use of filter bed based treatment systems that will reduce the cost of water treatment up to five times. Second, considering the entire life cycle of radioactivity, including the management of generated waste.

Objectives:

- Demonstrate the technical and economic feasibility of filter beds that will be optimized to eliminate water radioactivity and minimize the generation of natural radioactive materials (NORM). Four pilot plants will be operated, three in Spain and one in Estonia, with different strategies to prevent the generation of NORM waste.
- Replicate Life Alchemia solutions in facilities in five other European countries (Italy, Poland and Finland, among others).
- Promote the transfer to other facilities and members of the EU.
- Encourage the active participation of interested parties in the implementation of Directive 2013/51 / Euratom to minimize the environmental impact of radionuclide treatment on water supply services.

During the execution of the project, the specific stakeholders of the target sectors (water suppliers, manufacturers, policy makers) will ensure compliance with the aforementioned objectives.

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

Participants:

Functional Units: "Water Treatments" and "Environmental Analysis"

Contacts:

A. Agüera (aaguera@ual.es)

Funds:

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

Time Period:

July 2018 – December 2022

Current Situation:

In progress

Summary:

The SFERA-II project (http://sfera2.sollab.eu), in which CIESOL is third party of CIEMAT-PSA, finances research stays of European groups in our facilities. During 2014, the functional units of "Analytical evaluation of water treatment and environmental analysis" and "Advanced Technologies for water regeneration" have welcomed the group of Prof. Nikos Xekoukoulotakis, Department of Environmental Engineering, Technical University of Crete (Greece). The approved project was related to the study of the photochemical degradation under solar radiation of two β-lactam antibiotics, meropenem of the subgroup of carbarenems and cefotaxime of the subgroup of cephalosporins, in aqueous solutions, in ultrapure water (UPW) and wastewater (WW).

Objectives:

- Develop analytical protocols for the determination of the two antibiotics in the matrices tested.
- Study the photolytic and photocatalytic degradation by photo-Fenton.
- Identification of the main degradation products generated in both processes.

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

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 – July 2022

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.

3.3.9. Water regeneration for irrigation using solar energy in low-cost reactors operated continuously (AQUELOO)

Participants:

Functional Unit: "Regeneración de aguas"

Contacts:

J. A. Sánchez (jsanchez@ual.es)

Funds:

Proyectos de I+D de la Universidad de Almería en el marco del programa operativo FEDER Andalucía 2014-2020, convocatoria 2018.

Time Period:

October 2019 – December 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 unconventional water resources. In this project, the photo-Fenton solar process is considered because its efficiency has been demonstrated to eliminate up to 80% of micro-contaminants and 6 log of CFU/mL of pathogenic microorganisms present in effluents from secondary WWTP treatments. On the other hand, the use of low-cost raceway type reactors (RPR) helps to drastically reduce both investment and operating costs. The disinfection of residual waters will be addressed by photo-Fenton solar in continuous mode at TRH of 30 to 60 min, with a liquid depth of between 5 and 15 cm (depending on local radiation) on a pilot scale as well as cost reduction of operation, minimizing the use of chemical reagents. The challenge will be to reduce up to 80% the microcontaminants present and achieve an inactivation of the E. coli bacteria below the detection limit (1 CFU/mL) according to the reuse requirements established for irrigation in Spain (RD 1620/2007). Likewise, the AQUELOO project will help to bridge the gap between validated treatments on a laboratory scale and their application in real conditions on a pilot scale and in continuous flow.

Objectives:

In this project, the continuous operation of solar photocatalysis reactors with residence times (30 - 60 min) shorter than those currently used with chlorination (90 min) is proposed. The general objectives of the project can be synthesized in:

- Optimize the continuous operation variables of the raceway reactors for the regeneration of wastewater on a pilot scale by photo-Fenton solar at neutral pH.
- Carry out the conceptual design of a commercial scale reactor and estimate costs.

3.3.9.5 Urban wastewater reclamation by Novel materials and advanced solar technologies: assessment of new treatment quality Indicators (NAVIA)

Participants:

Functional Unit: “Regeneración de aguas”
Functional Unit: “Análisis ambiental”

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 2019. Ministerio de Ciencia e Innovación.

Time Period:

June 2020 – May 2023.

Current Situation:

In progress

Summary:

Water stress is a growing worldwide problem, aggravated by the impacts of climate change. Spain is especially threatened by water scarcity and deterioration of the freshwater availability is envisaged in the near future. Among the solutions against hydric stress, urban wastewater (UWW) reclamation can play a key role as a non-conventional water source, destined for the biggest water consumer in Spain, the agricultural irrigation. To this end, modern tertiary treatment methods must meet the main challenges of water reuse: acceptable water quality, low cost and process sustainability.

The main objective of NAVIA project is the development of potent methods to treat UWW effluents, by the development of novel photocatalysts and technologies based on solar advanced oxidation processes, operated in continuous flow mode in low-cost reactors, destined for UWW reclamation. In order to ensure water quality and safety in reuse, the treatment goals of the developed processes will be the simultaneous removal of microbial pathogens, such as E. coli, total coliforms, coliphages (somatic coliphages & F-specific

RNA bacteriophages), antibiotic resistant bacteria and their genes (ARB&ARGs), and the elimination of organic microcontaminants (OMCs).
The final objective is to comply with the current legislation in Spain (Spanish RD 1620/2007) and future treatment regulations, as pointed out by the recent proposal of the European Parliament on 12 February 2019 (EC COM 337 final, 2018/0169).

Objectives:
Three research areas will be explored:

- Development of new heterogeneous photocatalysts with high efficiency for UWW decontamination and disinfection. The synthesis and characterization of new organic heterogeneous photocatalysts will be carried out, as well as new heterogeneous photocatalysts based on semiconductors. Their efficiency and stability will be evaluated against the simultaneous degradation of OMCs and microbial inactivation, with special focus on conducting mechanistic studies that will form the basis of the kinetic modeling of the processes.
- Development of new solar AOPs at pilot plant scale as tertiary treatments of actual UWW. The microbial disinfection and OMC removal will be evaluated through treatments such as the solar photo-Fenton at neutral pH, in both batch and continuous mode. New iron sources will be assayed alongside the utilization of chelating agents, as well as testing of the most efficient heterogeneous photo-catalyst previously developed in (i). Furthermore, solar irradiation employing low dosages of chemical oxidants (PDS/PMS, H2O2 and HClO/ClO-) will also be assessed towards simultaneous water disinfection and OMC removal.
- Development of effective and efficient solar-based solutions in continuous flow mode of operation: The effects of engineering parameters on the removal of the target contaminants (bacteria, ARB&ARGs, coliphages, OMCs) will be investigated, i.e. hydraulic residence time (30-60 min), and liquid depth (5-10 cm) in the processes developed in i) and ii). Finally, by pooling all the data obtained during the project (i, ii, iii) and the relevant literature, new physicochemical, energy and microbiological indicators will be selected as a set of key parameters for a simple, fast and reliable monitoring framework of UWW treatment performance; this conjuction will form an enduser decision-making tool, especially developed for agriculture irrigation.

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

Participants:
Functional Unit: “Regeneración de aguas”
Functional Unit: “Análisis ambiental”
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 purification and regeneration systems due to the recent adoption of the new European Parliament Regulation (EU) 2020/741 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, consists of 8 entities and includes international partners such as Aguas de Portugal and the Dutch company MicroLAN; other nationals such as CETIM or Newland EnTech;

and Spanish public entities such as the University of Almería, through the Solar Energy Research Center, the Provincial Council of Almería and the Guadalquivir Hydrographic Confederation (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 European Parliament Regulation (EU) 2020/741 on minimum requirements for water reuse. From the point of view of the technology provided by the University of Almería through CIESOL, Life Phoenix represents the leap of scale that Fenton photo process-based technology operated continuously in low-cost raceway reactors, needs to be able to study its definitive commercial implementation. Life Phoenix also represents the opportunity to bring Fenton UV LED photo technology from the lab to the pilot scale. The development of Fenton photo technology for the tertiary treatment of purified water can be a solution for many sites where the solar resource is not a limitation.

The University of Almería, through the CIESOL Solar Energy Research Center, participates in the Life Phoenix project being its main objective of the regeneration of purified water by applying the Fenton photo process continuously in both low-cost raceway reactors and intensive reactors illuminated with UV LED technology. In order to energy assess the different options, all systems are expected to be equipped with a constant supply of photovoltaic electrical power. The participation of members of the Environmental Analysis group allows to have their extensive experience in monitoring emerging contaminants and their processing products, because of this CIESOL assumes part of the analytical burden of the project.

Objectives:

The goals and challenges Life Phoenix faces are:

- Develop innovative urban wastewater regeneration solutions for small, medium and large treatment plants, adjusting solutions to each specific case, based on population size, water quality, as well as economic capacity. For each population size, tailor-made solutions will be developed, according to their needs, in order to achieve total sustainability, which translates into technical, economic and environmental feasibility.
- Quantify and remove emerging contaminants 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.
- Optimization of irrigation through intelligent management.
- Diagnose the tertiary systems existing in the province of Almería for optimization, in order to achieve the new quality requirements for agricultural use, feasibility of updating existing plants to achieve the new requirements.
- Finally, develop a diagnostic tool that will allow to select the best combination of technologies for each case, also mapping the tertiary treatments of existing treatment plants both nationally and internationally.

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

Participants:

Functional Unit: “Regeneración de aguas”
Functional Unit: “Análisis ambiental”

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. Ministerio de Ciencia e Innovación.
Time Period:
December 2021 – November 2023

Current Situation:
In progress
Summary:
Water scarcity is a growing problem in Spain, aggravated by the impacts of climate change, and Almería is particularly threatened by water stress. Among the solutions to this problem, the regeneration of urban wastewater can play a key role as a source of non-conventional water for agricultural irrigation. New advances in treatments based on solar radiation encourage their application for the regeneration of wastewater. Among them, the solar photo-Fenton process has demonstrated its effectiveness for the disinfection of wastewater and the elimination of micropollutants, due to the large amount of hydroxyl radicals ($HO^{\bullet}$) generated by the catalytic cycle of iron ions (Fe^{2+} and Fe^{3+}) activated by UV-vis radiation and its reaction with hydrogen peroxide. It is considered a treatment with great 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. Once 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 the disinfection of urban wastewater and the removal of micropollutants, a matter still pending to transfer the technology to the water industry.

A demonstration plant will be built that will operate in the WWTP of Uleila del Campo, Almería, a small rural town (750 inhabitants), which is operated by the company Calares Obras Servicios y Medioambiente S.L. who supports the project and is very interested in exploiting the results.

Regarding the socioeconomic impact of the ANUKIS project, the WWTP currently discharges into the public hydraulic domain and a tertiary treatment would allow the reuse of this water for the irrigation of olive groves or would improve the recharge of the overexploited aquifer. In addition, the replicability of the results in other populations with water stress 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 solution based on solar energy 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 demonstrative scale, of a continuous reactor for solar photo-Fenton to regenerate urban wastewater, as well as the protection of the knowledge acquired, 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 day). To this end, the following specific objectives will be addressed:

- Analysis of the technical and socioeconomic feasibility of wastewater regeneration 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.

3.3.9.8 Water regeneration using concentrated solar energy (RAYO)

Participants:

Functional Unit: "Regeneración de aguas"
Functional Unit: "Análisis ambiental"

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.

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

Participants:

Functional Unit: "Regeneración de aguas"
Functional Unit: "Análisis ambiental"

Contacts:

A. Agüera (aaguera@ual.es)
I. Oller (isabel.oller@psa.es)

Funds:

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

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..

Objective

About 2.1 Billion people live without access to safe water sources. Contaminants of Emerging Concerns (CECs) such as pharmaceuticals, personal care products, pesticides and nanoparticles are increasingly being detected in wastewater and in drinking water around the world, in addition to geogenic pollutants, pathogens, antibiotic resistant bacteria and antibiotic resistance genes. Water treatment systems that remove CECs and common contaminants from wastewater and drinking water are therefore urgently needed.

PANI WATER will develop, deploy and validate in the field six prototypes for the removal of contaminants, including CECs, from wastewater and drinking water. The prototypes for wastewater treatment will consist of (i) a 20,000 L/day multifunctional oxidation reactor, (ii) a 10 L/day photoelectrochemical system, and (iii) a 100 L/day solar photolytic plant. The prototypes for drinking water treatment will consist of (iv) a 300 L/hour filtration, adsorption, and UVC LED system (v) a 20 L transparent jerrycan for solar water disinfection, and (vi) a 2,000 L/day electrocoagulation, oxidation, and disinfection t system. These prototypes will be deployed in peri-urban and rural areas in India. The consortium will work closely with the communities at the fieldsites, and carry out water quality analyses, health and social impact assessments, and advocate for safe reuse of treated wastewater for irrigation, and preservation of drinking water sources. PANI technologies can find promising application among the agricultural sector, water-demanding businesses (e.g. textile, pharmaceutical), and the Indian water utilities.

3.3.10 Network participation during 2021

Participation in the "Iberoamerican Solar Water Treatment Network". Support Program for the Formation of International Networks between Research Centers, 2018 Call. CONICYT International Cooperation Program.

3.3.11 Dissemination activities

As in previous years, the functional unit has participated in the European Researchers' Night 2021, an activity carried out within the framework of the European OpenResearchers scientific dissemination project approved by the European Commission in the Marie Sklodowska-Curie call for actions. In addition, it has also participated in activities prior to the European Night of Researchers by disseminating the research in secondary schools.

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

Participation in the I Science Fair with the activity "Design of a WWTP", in collaboration with the IES GALILEO organized by the University of Almería, on April 22 and 23, 2021.

Organization of the Summer Course "Comprehensive water management in a hydric stress scenario". Almería, from July 6 to 8, 2021. The course dealt with various aspects of the integral water cycle, from urban supply, irrigation, circular economy and governance, as well as research and development in water technologies. To this end, there was the participation of speakers of the highest quality from both the industrial, academic and public management fields, with recognized national and international prestige.
Participation in the Science Week organized by the University of Almería, from November 8 to 11, 2021, with the aim of bringing scientific and technological knowledge closer to 4th ESO, Baccalaureate and Vocational

Training students in the province.

Organization of the XIII CONFERENCE ON THE EUROPEAN UNION. “Innovation in Wastewater Treatment and Regeneration in the European Union” Almería, from November 8 to 11, 2021. Several members of the functional unit have attended and carried out dissemination activities through scientific-technical presentations.

Organization of four workshops linked to the LIFE PureAgroH2O, Alchemia, Ulises and Phoenix projects.

3.3.12 Others

Final degree projects

- Nerea López Serrano. Grado en Ingeniería Química Industrial (Plan 2010). Desinfección y descontaminación simultánea de efluentes secundarios de EDAR mediante el proceso foto-Fenton solar con Fe^{3+}-NTA en reactores tipo raceway. Fecha de defensa: 03/06/2021. Directores: José Antonio Sánchez Pérez y Paula Soriano Molina.

- Elena Olivares Ligero. Grado en Ingeniería Química Industrial (Plan 2010). Primera planta demostrativa de foto-Fenton solar para la regeneración de efluentes secundarios de EDAR. Fecha de defensa: 03/06/2021. Directores: José Antonio Sánchez Pérez y Paula Soriano Molina.
- Daniel Rodríguez García. Grado en Ingeniería Química Industrial (Plan 2010). Estrategias de monitorización y control de un reactor de regeneración de aguas mediante foto-Fenton solar. Fecha de defensa: 27/07/2021. Directores: José Luis Casas López y Paula Soriano Molina.
- Solaima Belchqer El Attar. Máster en Ingeniería Química. Estudio reológico de lodos de microalgas cultivados en diferentes medios de cultivo.
- Alejandro Jamil Esteban Martínez Martínez. Diseño y evaluación de un planta solar fotovoltaica para el suministro energético de una planta piloto de regeneración de aguas mediante foto-Fenton solar-UVA.

PhD Theses (under development)

- Melina Roccamante (Supervisors: Sixto Malato y Sara Miralles)
- Azahara Martínez García (Supervisors: Inmaculada Polo e Isabel Oller)
- Ilaria Berruti (Supervisor: Inmaculada Polo)
- Elizabeth Gualda Alonso (Supervisors: José Luis Casas López y Paula Soriano Molina)
- Solaima Belachqer El Attar (Supervisors: José Antonio Sánchez Pérez y Paula Soriano Molina)
- Kelly Johana Castañeda Retavizca (Supervisors: Sixto Malato e Inmaculada Polo)
- Alba Hernández Zanoletty (Supervisors: Isabel Oller e Inmaculada Polo)

Prizes

- Irene of the Jiménez Work. Extraordinary Doctorate Award in the Engineering category from the University of Almería, Course 2018/2019. September 28, 2021.
- Paula Soriano Molina. Extraordinary Doctorate Award in the Engineering category from the University of Almería, Course 2018/2019. September 28, 2021.
- Leila Samira Nahim Granados. Extraordinary Doctorate Award in the Engineering category from the University of Almería, academic year 2019/2020. June 4, 2021
- Leila Samira Nahim Granados. “BEST PHD THESIS FOR 2020” award granted by International Ph.D. School on Advanced Oxidation Processes. April 23, 2021.
- Elizabeth Gualda Alonso. 1st Prize for poster and flash-type oral presentation in the area of Biotechnology and Industrial Bioprocesses Applied to Agrifood and the Environment, with the work entitled "First demo-plant of solar photo-Fenton as a tertiary treatment for wastewater reclamation". X Research Symposium in Experimental Sciences. Almeria, Spain. November 15, 2021

3.4 ACTIVITIES OF "MODELING & 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 (Profesor Titular de Universidad) 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 38 regular papers published in referred journals, 18 of them

ranked in Q1 and 15 in Q2, and more than 50 papers in international and national conferences. H-index: 19 (Google Scholar), 16 (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 41 papers in scientific journals with impact index, 43 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 17 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 2021

- 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.
- 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.

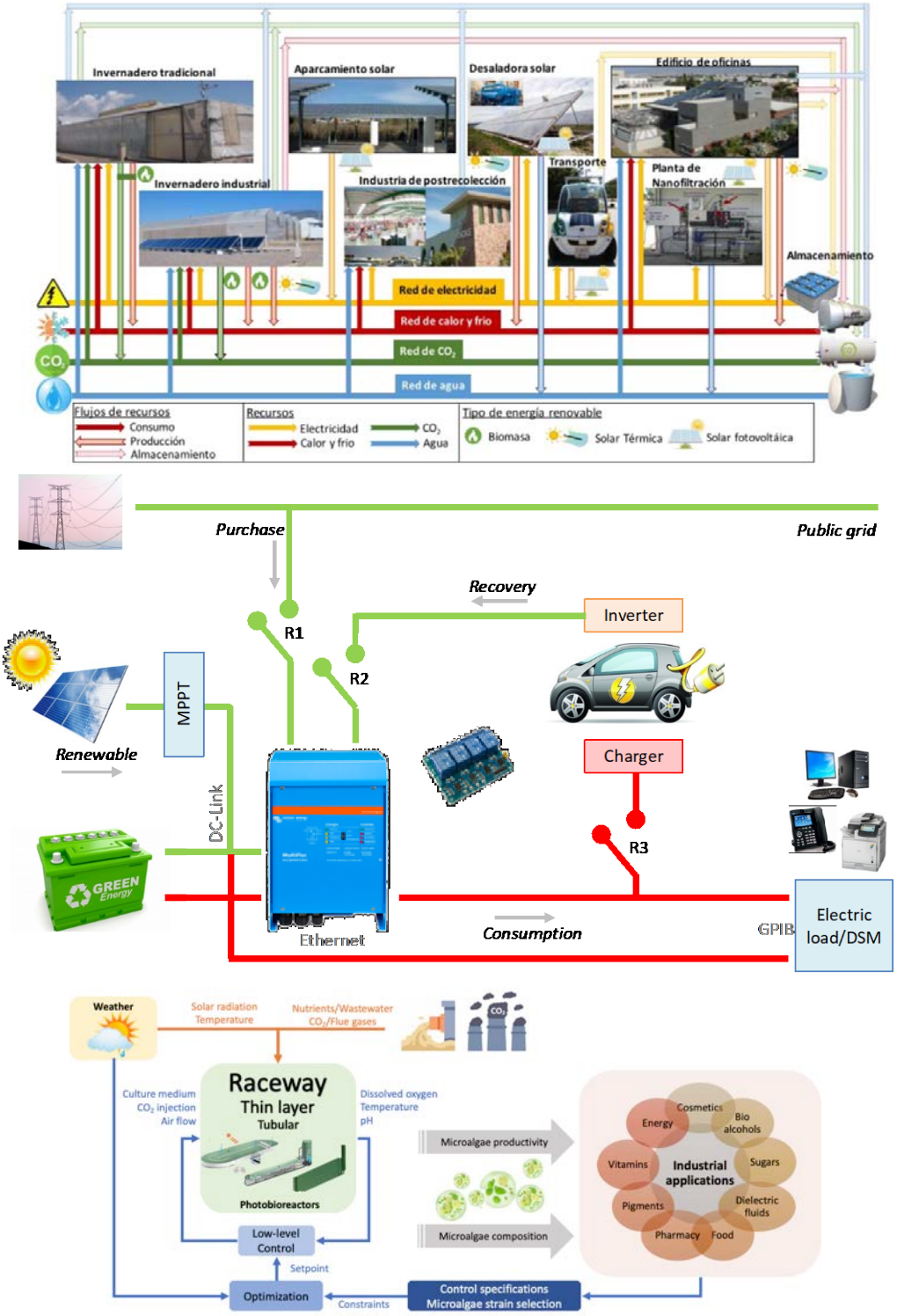

Fig. 2.X.1 Various examples of the activity of the modeling and control unit rol

3.4.5 Collaboration with other Functional Units of CIESOL during 2021

In 2021 the Modeling and Control Unit has maintained collaborations with the following CIESOL Research Groups:

- Desalination and Photosynthesis: European projects (SABANA, IndiaH2O), national plan projects (CALRESI, HYCO2BIO), 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. 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).
- Americano da Costa, Marcus V. Universidad Federal de Bahía, Brasil (02/11/2021-26/11/2021)

Students in curricular internships:

- Francesco Iaconis. Grado en Ingeniería Electrónica Industrial (09/02/2021-16/04/2021)
- Francisco José García Garcés. Grado en Ingeniería Eléctrica, mención en Energías Renovables (01/03/2021-31/05/2021)
- Javier Latorre Rodríguez. Grado en Ingeniería Electrónica Industrial (18/11/2020-05/02/2021).
- Jesús Pérez González. Grado en Ingeniería Informática (18/01/2021-01/04/2021).
- Jesús Ropero Moreno. Grado en Ingeniería Electrónica Industrial (11/11/2020-22/01/2021).
- Pablo Arias Moreno. Grado en Ingeniería Mecánica (8/2/2021-24/04/2021).
- José Jesús La Casa Nieto. Grado en Ingeniería Electrónica Industrial (16/11/2020-30/01/2021).
- José Ruiz Capel. Grado en Ingeniería Electrónica Industrial (08/11/2021-23/01/2022)
- Angel Salvador. Grado en Ingeniería Electrónica Industrial (09/11/2020-28/01/2021).
- David París Góngora. Grado en Ingeniería Electrónica Industrial (28/01/2021-08/05/2021).

3.4.7 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	
23	4	9	9	1	11

The publication history can be consulted at the following link:

https://arm.ual.es/arm-group/publications/

Papers

- Characterization of electricity demand in the auxiliary industry of the greenhouses agriculture in the province of Almería. M. Martínez-Molina, A. Vizcaíno-Pérez, M. Pérez, F. Rodríguez. DYNA Ingeniería e Industria, 96(4), 359-363, 2021. https://doi.org/10.6036/9879
- Optimal Water Management in Agro-Industrial Districts: An Energy Hub's Case Study in the Southeast of Spain. J. Ramos-Teodoro, J.D. Gil, L. Roca, F. Rodríguez, M. Berenguel. Processes, vol. 9, no. 2, 2021. https://doi.org/10.3390/pr9020333
- Experimental evaluation of feedforward tuning rules. F. García-Mañas, J.L. Guzmán, F. Rodríguez, M. Berenguel, T. Hagglund. Control Engineering Practice, vol. 114, 2021. https://doi.org/10.1016/j.conengprac.2021.104877
- A fast and practical one-dimensional transient model for greenhouse temperature and humidity. R. Liu, J.L. Guzmán, F. Rodríguez. Computers and Electronics in Agriculture, no. 186, 2021. https://doi.org/10.1016/j.compag.2021.106186
- Modelado y control de la producción de microalgas en fotobiorreactores industriales. J.L. Guzmán, F. G. Acién, M. Berenguel. Revista Iberoamericana de Automática e Informática industrial, v. 18, n. 1, p. 1-18, 2021. https://doi.org/10.4995/riai.2020.13604.
- Towards Optimal Management in Microgrids: An Overview. Á.O. Topa Gavilema, J.D. Álvarez, J.L. Torres Moreno, M.P. García. Energies 14, 5202, 2021. https://doi.org/10.3390/en14165202
- Optimal Management of a Microgrid with Radiation and Wind-Speed Forecasting: A Case Study Applied to a Bioclimatic Building. L.O.P. Vásquez, V.M. Ramírez, D. Langarica Córdova, J.L. Redondo, J.D. Álvarez, J.L. Torres-Moreno. Energies, 14, 2398, 2021. https://doi.org/10.3390/en14092398
- Control automático de la temperatura diurna en invernaderos mediante ventilación natural. F. García-Mañas, F. Rodríguez, J.L. Guzmán, M. Berenguel. Horticultura, 353, 64-68, 2021.
- The CHROMAE Project: resource management in agro-industrial district plants of the energy-water-food nexus. F. Rodríguez, J. Ramos-Teodoro. FuturEnergy, 84, 41-44, 2021.
- Demand-Side Optimal Sizing of a Solar Energy–Biomass Hybrid System for Isolated Greenhouse Environments: Methodology and Application Example. J.D. Gil, J. Ramos-Teodoro, J.A. Romero-Ramos, R. Escobar, J.M. Cardemil, C. Giagnocavo, M. Pérez. Energies, vol. 14, no. 13, 2021. https://doi.org/10.3390/en14133724
- Microalgae classification based on machine learning techniques. P. Otálora, J.L. Guzmán, F.G. Acién, M. Berenguel, A. Reul. Algal Research, 55, 2021. https://doi.org/10.1016/j.algal.2021.102256
- Real-time adaptation of a greenhouse microclimate model using an online parameter estimator based on a bat algorithm variant. M. Guesbaya, F. García-Mañas, H. Megherbi, F. Rodríguez. Computers and Electronics in Agriculture, 192, 2022. https://doi.org/ https://doi.org/10.1016/j.compag.2021.106627
- A nonlinear control approach for hybrid thermal solar plants based on operational conditions. I.M.L. Pataro, J.D. Gil, M.V. Americano da Costa, J.L. Guzmán, M. Renewable Energy, Volume 183, 2022, Pages 114-129, https://doi.org/10.1016/j.renene.2021.10.057.

- A computer-based tool to simulate raceway photobioreactors for design, operation and control purposes. Á. Hoyo, E. Rodríguez-Miranda, J.L. Guzmán, F.G. Acién, M. Berenguel, J.C. Moreno. Computers & Chemical Engineering, 156, 107572, 2022. https://doi.org/10.1016/j.compchemeng.2021.107572
- A general framework for modeling and dynamic simulation of multibody systems using factor graphs. J.L. Blanco-Claraco, A. Leanza, G. Reina. Nonlinear Dynamics, 105, 2031–2053, 2021, http://dx.doi.org/10.1007/s11071-021-06731-6
- Evaluation of an Interpolated Controller in an Industrial Photobioreactor. J.C. Moreno, P. Mercader, J.L. Guzmán, A. Baños, P. -O. Gutman. IEEE Access, 9, pp. 24406-24415, 2021. http://dx.doi.org/10.1109/ACCESS.2021.3057031
- A new model to analyze the temperature effect on the microalgae performance at large scale raceway reactors. E. Rodríguez-Miranda, J. L. Guzmán, F.G. Acién, M. Berenguel and A. Visioli. Biotechnology and Bioengineering, 877-889, 118(2), 2021. https://doi.org/10.1002/bit.27617
- Indirect regulation of temperature in raceway reactors by optimal management of culture depth. E. Rodríguez-Miranda, J. L. Guzmán, F.G. Acién, M. Berenguel and A. Visioli. Biotechnology and Bioengineering, 1186-1198, 118(3). https://doi.org/10.1002/bit.27642
- ABACO: A new model of microalgae-bacteria consortia for biological treatment of wastewaters. A. Sánchez-Zurano, E. Rodríguez-Miranda, J.L. Guzmán, F. G. Acién, J.M. Fernández-Sevilla and E. Molina. Applied Sciences, 11(3), 998, 2021. https://doi.org/10.3390/app11030998
- Modelling and pH control in raceway and thin-layer photobioreactors for wastewater treatment. M. Rodríguez-Torres, A. Morillas-España, J.L. Guzmán, F. G. Acién. Energies, 14(4), 1099, 2021. https://doi.org/10.3390/en14041099
- Web-based virtual lab for learning design, operation, control and optimization of an anaerobic digestion process. J.L. Guzmán and B. Joseph. Journal of Science Education and Technology , 30(3), 319-330, 2021. https://doi.org/10.1007/s10956-020-09860-6
- Tuning rules for feedforward control from measurable disturbances combined with PID control: A review. J. L. Guzmán and T. Hägglund. International Journal of Control, 2021. https://doi.org/10.1080/00207179.2021.1978537
- Boiler Combustion Optimization of Vegetal Crop Residues from Greenhouses. J.V. Moreno, M.G. Pinna, M.D. Fernández, J.A. Sánchez-Molina, J.C. López, F.G. Acién. Agronomy, 11, 626, 2021. https://doi.org/10.3390/agronomy11040626

Congress assistance

- XI Congreso Ibérico de Agroingeniería (Online), Valladolid, España, 2021
- 19th International Conference on Renewable Energies and Power Quality (ICREPQ'21), Almería, España, 2021
- IV Jornadas de Doctorado en Informática (JDI'2021), Almería, España, 2021.
- SFERA-III 2nd Doctoral Colloquium, Almería, España, 2021.
- 27th SolarPACES conference, conferencia online, 2021.
- XLII Jornadas de Automática, Castellón, España, 2021.
- Solar World Congress 2021, conferencia online, 2021.

Congress contributions

- Virtual sensor for ventilation flux estimation in greenhouses. M. Guesbaya, F. García-Mañas, F. Rodríguez, H. Megherbi, M.R. Ouamane. *XI Congreso Ibérico de Agroingeniería (online), Valladolid, España, 2021. (Oral, póster)*
- A comparative study of model fitting for estimating the overall efficiency of grid-connected photovoltaic inverters. J. Ramos-Teodoro, F. Rodríguez, M. Pérez, M. Berenguel. *19th International Conference on Renewable Energies and Power Quality, Almería, España. (Póster)*

- Technological developments for solar multi-effect distillation processes. J. M. Serrano, L. Roca, P. Palenzuela, D.Alarcón. M. Berenguel. *SFERA-III 2nd Doctoral Colloquium, Almería, España, 2021.(Oral)*
- Herramienta gráfica para la caracterización de cultivos de microalgas basada en redes neuronales artificiales. P. Otálora, J.L. Guzmán, F.G. Acién, M. Berenguel. *XLII Jornadas de Automática, Castellón, España, 2021. (Oral, póster)*
- Control automático y gestión de recursos en distritos agroindustriales. F. García-Mañas. *IV Jornadas de Doctorado en Informática (JDI'2021), Almería, España, 2021. (Póster)*
- Uso del paradigma Take-Home Labs para la enseñanza del control automático en estudios de ingeniería. Á. Hoyo, F. García-Mañas, J. Ramos-Teodoro, J.A. Sánchez-Molina, J.L. Guzmán, F. Rodríguez. *XLII Jornadas de Automática, Castellón, España, 2021. (Póster)*
- Contribuciones de control robusto para sistemas sometidos a perturbaciones. Á. Hoyo. *IV Jornadas de Doctorado en Informática (JDI'2021), Almería, España, 2021. (Póster)*
- El paradigma Take-Home Labs como entorno de experimentación en enseñanzas científico-técnicas. F. Rodríguez, J.A. Sánchez-Molina, J.L. Guzmán Sánchez, Á. Hoyo, F. García.Mañas, J. García-Donaire, J. Ramos-Teodoro.. *Jornadas de Innovación Docente, Almería, España, 2021. (Póster).*
- Integración de modelos como servicio (GMaaS) en iVeg, plataforma IoT para la agricultura intensiva protegida. M. Muñoz-Rodríguez. *IV Jornadas de Doctorado en Informática (JDI'2021), Almería, España, 2021. (Póster)*
- Towards the Optimal Design and Control of Solar–biomass Heating Networks for Greenhouse Applications: Methodology and Preliminary Results. J.D. Gil, J. Ramos-Teodoro, M. Martínez, J.A. Sánchez, M. Pérez. *ISES Solar World Congress 2021 (SWC'2021), Online, 2021. (Oral)*
- Techno-economic assessment of the use of Linear Fresnel Solar Collectors for the supply of heat in traditional fruits and vegetable processing industries in Almeria's province. J.D. Gil, J.A. Romero-Ramos, M. Pérez, M. Martínez-Molina, J. Ropero, A. Rodríguez. *19th International Conference on Renewable Energies and Power Quality, Almería, España, 2021. (Oral).*
- Desarrollo de un controlador predictivo con compensación por adelanto y garantía de estabilidad: Resultados preliminares. I. Pataro, J.D. Gil, M.V. Americano, J.L. Guzmán, M. Berenguel. *XLII Jornadas de Automática, Castellón, España, 2021. (Póster)*
- Optimización de temperatura en reactores raceway para la producción de microalgas mediante regulación de nivel. J. González, E. Rodríguez-Miranda, J.L. Guzmán, M. Berenguel, F.G. Acién. *XLII Jornadas de Automática, Castellón, España, 2021. (Póster)*
- Nexo CO2-agua-energía para una producción intensiva sostenible. R. Gónzales-Morales, M. Martínez-Molina, J.A. Sánchez-Molina, F. Rodríguez, M. Berenguel Soria, P. Fernández del Olmo. *XI Congreso Ibérico de Agroingeniería, Online, Online, 2021. (Oral)*

PhD Theses

- Energy management strategies in production environments with support of solar energy. Jerónimo Ramos Teodoro. Universidad de Almería, 22 de enero de 2021, Sobresaliente cum Laude.
- Aportaciones al modelado y control climático de invernaderos. Ana Paola Montoya Ríos. Universidad de Almería, 4 de mayo de 2021, Sobresaliente cum Laude
- Modeling and control of the microalgae biomass production process in raceway reactors. Enrique Rodríguez Miranda. Universidad de Almería, 15 de marzo de 2021, Sobresaliente cum Laude.
- Modelado y simulación de un nuevo concepto de vehículo urbano eléctrico ligero basado en la optimización del uso de energías renovables y la reducción de emisiones de CO_2. Francisco José Gómez Navarro. Universidad de Almería, 2 de julio de 2021, Sobresaliente cum Laude.

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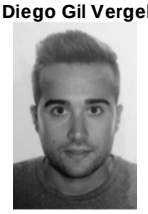

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3.4.9 Ongoing projects in 2021

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

Participants:

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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:

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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:

Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.
Centro de Tecnologías para Energía Solar CSET (Chile) centro mixto Fundación Fraunhofer
Inventive Power (México), empresa fabricante de captadores solares cilidroparabólicos para aplicaciones industriales

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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 Control y gestión óptima de recursos heterogéneos en distritos productivos agroindustriales integrando energías renovables (CHROMAE – Control and Optimal Management of Heterogeneous Resources in Agroindustrial production districts integrating renewable Energies)

Participants:

Research group "Automatic Control, Robotics & Mechatronics". Universidad de Almería (TEP 197)
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Sources of funding:

Ministry of Economy, Industry and Competitiveness (DPI2017-85007-R)

Duration:

January 2018 – December 2021

Status:

Finalised

Summary:

Currently there is a growing concern about the overexploitation of energy resources and non-renewable materials, associated with climate change and the need to maintain the modern economy and the quality of life. This proposal aims to contribute, from the discipline of automatic control, to the optimal management of these resources in a way that ensures equitable access, efficiency and sustainability in the fields of water, energy and others using renewable energy. Specifically, the project addresses the problem of optimal resource management in agroindustrial districts, consisting of agricultural holdings, processing companies and supply of inputs located in a specific territory. All these elements have different industrial objectives, therefore they present different needs of heterogeneous resources, both energy (electricity and heat / cold) and materials (water and CO_2). In this framework of collaboration, characterized by the heterogeneity in demand, it is necessary to conveniently manage the efficient use of resources in each of the systems, and to coordinate the flow among the elements of the district, especially if renewable energies are used. , establishing as a premise that the result of optimal management produces an environmental impact as small as possible. Taking into account these considerations, the main objectives of this proposal are:

- Characterization and modeling of the flows of resources and interrelations between the elements of the district that determine the productive activity, whether with the role of consumer, producer or warehouse thereof, based on the paradigm of distributed and multi-generation multi-generation systems. Energy. A simulation environment of consumption and production of heterogeneous resources for agri-food districts is proposed as a priority result of the project (although it can be easily extrapolated to any other) to analyze specific cases, test new management approaches and make decisions that optimize their use.
- Development of control strategies for the descriptive variables of operation of the elements of the district so that they can meet their objectives by meeting certain technical specifications, but also minimizing the use of the resources necessary for this, mainly using predictive control techniques.
- Development of control strategies and comprehensive and optimal management of heterogeneous resources necessary for the operation of the elements that make up an agro-industrial district using

control techniques (centralized and / or distributed predictive, optimal controllers or controllers based on rules, among others) that consider economic and environmental aspects as well as the efficient use thereof.

The fulfillment of these objectives represents a significant contribution with real impact in this kind of processes, as shown by the collaboration in the project of Institutions such as the Cajamar Foundation and the IFAPA and the interest that has awakened in different companies interested in the results. which are expected to be applicable in the medium term. The proposal is a natural continuation of previous project activities, in which considerable experience in the control of energy systems was acquired, with numerous articles published in prestigious journals and relations with international research groups.
Additional info: http://www2.ual.es/chromae/

3.4.9.5 Optimización de sistema integral de calefacción y enriquecimiento carbónico en invernaderos CARBON4GREEN

Participants:
Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.
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Sources of funding:
Proyectos de investigación orientados a los retos de la Sociedad Andaluza. Programa Operativo FEDER Andalucía 2014-2020. Convocatoria 2018 de Proyectos I+D+i en el Marco del Programa Operativo FEDER-Andalucía 2014-2020 (resolución de 23 de marzo de 2018, del Rector de la Universidad de Almería, BOJA nº 59 de 26 de marzo de 2018). Referencia UAL18-TEP-A055-B.
Duration:
October 2019 – September 2021
Status:
Finalised
Summary:
The project objective is the development, optimization, evaluation and demonstration under real conditions, of a previously patented process of heating and carbon enrichment in greenhouses. Using the plant residues produced in the production of vegetables in these greenhouses.
Additional info: http://www2.ual.es/carbon4green/

3.4.9.6 Sistema abierto y escalable de supervisión, gestión eficiente de la energía y control de confort del edificio singular estratégico CIESOL

Participants:
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Sources of funding:
Convocatoria de incentivos a los agentes del sistema andaluz de conocimiento, ayudas a infraestructuras y equipamientos de I+D+i (orden de 7 de abril de 2017, convocatoria 2017). Referencia proyecto: 5447-20 (153.320 €).
Duration:
January 2020 – December 2021
Status:
Finalised
Summary:
The aim of this infrastructure aid is to provide the CIESOL Joint Centre with a new monitoring and control system incorporating the latest technologies in data acquisition, IoT, monitoring, etc.

3.4.9.7 Sistema de Cultivo Intensivo Sostenible, Autonómo, Conectado y Abierto (AgroConnect).

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería (TEP 197)
IFAPA - Andalusian Institute for Research and Training in Agriculture, Fisheries, Food and Organic Production
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Sources of funding:

Ayudas para la adquisición de equipamiento científico-técnico del subprograma estatal de infraestructuras de investigación y equipamiento científico-técnico (Plan Estatal I+D+I 2017-2020), convocatoria 2019. Referencia proyecto: EQC2019-006658-P (308.850 €).

Duration:

January 2020 – December 2021

Status:

Finalised

Summary:

The aim of this infrastructure aid is to acquire infrastructure that will enable an agricultural production system to be set up with water and energy management under the paradigm of the circular economy. It incorporates two desalination plants supported by solar energy, a greenhouse and photobioreactors. It is a further step towards the creation of a centre of competence in water and energy.

3.4.9.8 Agricultural Collaborative Robot Inside IoT (AGRICOBIOT)

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería (TEP 197)
Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.

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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:

Under development

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.

3.4.9.9 Agricultural Collaborative Robot Inside IoT (AGRICOBIOT II)

Participants:

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

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Source of funding:

Plan Andaluz de Investigación, Desarrollo e Innovación (PAIDI 2020)

Duration:

January 2021 – December 2022

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.

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

Participants:

Grupo de Inv. "Automática, Robótica y Mecatrónica". Universidad de Almería (TEP 197)
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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 – December 2022

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.

3.4.9.11 CALRESI – Modeling and control of the combined process of microalgae production and wastewater treatment with industrial reactors

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería (TEP 197)
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Sources of funding:

Ministry of Economy, Industry and Competitiveness (DPI2017-84259-C2-1-R)

Duration:

January 2018 – December 2021

Status:

Finalised

Summary:

The project deals with the analysis, study and application of modeling and control strategies for the optimization of the wastewater treatment process and the production of microalgae biomass in large-scale industrial photobioreactors. The main objective is to achieve the optimal working conditions that allow an efficient synergy of the combined process of the optimal growth of microalgae and the treatment of wastewater, trying to reach an adequate balance between the energy required for said process, the injection of CO_2 for the maximization of microalgae production and the recovery of costs through the resulting derived products. Microalgae use nutrients derived from wastewater (carbon, nitrogen and phosphorus), thus avoiding the use of chemical fertilizers. The adequate combination of microalgae with wastewater will allow achieving an adequate energy balance for this type of process and in the same way contributing to mitigate the emission of gases into the environment. Note that the presence of microalgae, bacteria and organic matter makes this type of systems have highly complex dynamics and a strongly non-linear character.
Additional info: http://www2.ual.es/calresi/

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

Participants:

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

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.

3.4.9.13 SOLWARIS - Solving Water Issues for CSP Plants.

Participants:

Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.
Almeria Solar Platform
Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería (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:

Under development

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/

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

Participants:

University of Birmingham
Pandit Deendayal Petroleum University
CIEMAT
National Environmental Engineering Research Institute
Aquaporin AS
Institute for Water Education IHE-Delft
LEITAT
Govind Ballabh Pant Krishi Evam Prodyogik Vishwavidyalya
Modus research and innovation limited
Ben-Gurion University of the Negev
Davey products
Advanced Center for Water Resources Development & Management
Jadavpur University
Envirochem Services
CETIM
Aston University

Contact:

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

Contact in the CIESOL Modelling and Automatic Control Unit:

Lidia Roca (lidia.roca@psa.es)

Sources of funding:

European Commission (EC) Grant agreement ID: 820906 - H2020-EU.3.5.4. - Enabling the transition towards a green economy and society through eco-innovation (2.552.348 €)

Duration:

February 2019 – July 2023

Status:

Under development

Summary:

Already explained in the report of the Desalination and Photosynthesis Unit.

Additional info:

https://www.india-h2o.eu/
https://cordis.europa.eu/project/id/820906/es

3.4.10 Network participation during 2021

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.

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/

- Qualifying Tournament of the FIRST Lego League
- European Night of the Researchers, Almería
- Week of Science, Almería
- Robotics Club
- European Robotics Week
- Semana de la informática (Computer science week)
- Feria de la Ciencia 2021 (Science fair 2021)
- I Feria Aula Almería (I Almeria Classroom Fair)
- Event: SFERA-III Summer School “Solar Heat for Industrial Processes (SHIP)". Conference: "Advanced control of solar process heat applications". Year: 2021. Place: Almería.
- Webinar: “Recursos humanos, digitalización y robotización en la horticultura de Almería”. Year: 2021. Place: online
- Event organized by University of Almería for the International Year of Fruits and Vegetables and the Food Systems Summit convened by the United Nations Organization. Year: 2021. Place: Almería.
- Webinar: “I Jornada nuevas tecnologías en invernadero 2021”. Year: 2021. Place: online
- Webinar: “Sensores y TICs para fertirriego: una visión práctica”. Year: 2021. Place: online

- IV Programa Ciencia y Tecnología en Femenino. Year 2021. Place: Parque Científico - Tecnológico de Almería (PITA), Almería.

3.4.13 Others

Final degree projects:

- Alumno (supervisors)
- Masters's in Industrial Engineering. Supervisor:
- Ana Isabel Fernández Milán (Master's in Solar Energy). Design, implementation and study of an improved heliostat control system.
- Juan Miguel Serrano Rodríguez (Masters's in Industrial Engineering). Development of and open an modular architecture implemented in Python for the interaction between devices and industrial services with OPC.
- Pablo Otálora Berenguel (Masters's in Industrial Engineering). Deep learning techniques applied to microalgae processes.
- Normandi Rocío Tirado Ríos (Masters's in Technologies and Applications in Computer Engineery). Metabolic activity calculation using deep-learning and artificial vision techniques in Python.
- Francisco Martínez Castro (Masters's in Industrial Engineering). Modeling and control strategies for a solar furnace.
- Alejandro Fernández Mengibar (Industrial Electronics Engineering Degree). Fault detection system for a flat-plate collector solar field connected to a desalination unit.
- Ángel Salvador Criado (Industrial Electronics Engineering Degree). Teaching-Learning-Based Optimization inside a design methodology for heliostats solar fields 'HECTOR'.
- Jesús Ropero Moreno (Industrial Electronics Engineering Degree). Development of weather predicitions with machine learning techniques.
- Alberto Cruz González (Industrial Electronics Engineering Degree). Analysis and proposals to improve dynamic models and climate control tecniques in greenhouses.
- Manuel Francisco Cruz Caparrós (Industrial Electronics Engineering Degree). Development of indexes and controllers for thermal confort and air quality in bioclimatic buildings.
- Javier Latorre Rodríguez (Industrial Electronics Engineering Degree). Energy consumption models using machine learning techniques.
- Pablo Arias Moreno (Mechanical Engineering Degree). Characterization of the propulsion system of a light electrical vehicle.
- Cristina del Mar Jiménez Ibañez (Industrial Electronics Engineering Degree). Modelling and simulation of the production system of "Daniela" tomato in CorprohNijar Agriculture Cooperative.
- Georgiy Kalmutskyy Kalmutskyy (Industrial Electronics Engineering Degree). Simulation of robotic sortic system using deep-learning and artificial vision techniques in Python.
- Jesús Aporta Costela (Industrial Electronics Engineering Degree). Robot fleets control using CoppeliaSim software in Python.
- David Berbel Cabrerizo (Computer Engineering Degree). Augmented reality for teaching Engineery studies
- Andrés Fernández Marín (Industrial Electronics Engineering Degree). Control system development for SCORBOT-ER 4U robot using a visual interface and verbal commands.
- Sergio Fernández Mayor (Industrial Electronics Engineering Degree). Development of a low-cost visión station for SCORBOT ER V Plus robot.
- Mariachiara Mariotti (Industrial Electronics Engineering Degree – Brescia Double Degree). Design of a control strategy for guiding collaborative robots using wearable EMG and IMU sensors.

- Fernando Cañadas Aranega (Industrial Electronics Engineering Degree). Design and development of an automated multilevel platform for microalgae cultive measurements in Raceway reactors.
- Juan Jesús Berenguel Sánchez (Industrial Electronics Engineering Degree). Control strategies for solar furnaces.
- Adriana Morales Sierra (Industrial Electronics Engineering Degree). Control strategies for a hybrid cooling systems in CSP plants.

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).
- 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).
- González, Rubén (supervisores Francisco Rodríguez, Jerónimo Ramos)

Attendance at Transfer and Dissemination Workshops

- Solar Heat for Industrial Processes (SHIP), Almería, España, 2021
- Redes neuronales aplicada a problemas científico-técnicos (Neural networks applied to scientific problems), virtual, España, 2021.
- Divulgación de la ciencia y la tecnología (Dissemination of science and technology), virtual, España, 2021.
- Trajectory control in nonlinear systems, Almería, España, 2021
- Nuevos avances en estimadores de estado (New advances in state estimators), virtual, España, 2021
- Tecnologías habilitadoras para la Industria 4.0: hacia la fábrica del futuro (Technologies for Industry 4.0: towards the industry of the future), virtual, España, 2021

Awards during 2021

- Nombre. Premio. Evento o Entidad, Ciudad, Pais. Fecha
- Juan Diego Gil. Award to the best PhD Thesis in the area of control engineering by the Spanish Committee of Automatics in 2021.
- "Control and Optimal Management of Heterogeneous Resources in Agroindustrial production districts integrating renewable Energies (CHROMAE)". Finalist in the "Renewable Energy" category of the enerTIC Awards 2021.

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
- Sky cameras
- Optimization of sky cameras
- 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)

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), specifically in the Solar Energy research profile. 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). Member 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 50 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 a doctoral thesis and director of approximately

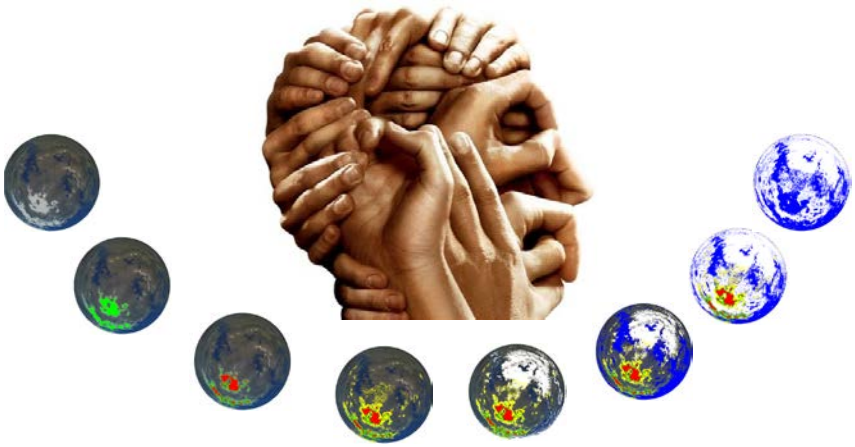
20 final projects (master's and bachelor's degree). Participant in the European Researchers' Night and reviewer in several high-impact scientific journals related to renewables, and guest editor of the journals: Remote Sensing and Journal of Energy and Power Technology.

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 2021

With regard to the strategic line of solar resources, a project has been obtained from the Ministry of Science and Innovation, in the 2020 call for Young Researchers for "R&D&I projects" within the framework of the state programmes for the generation of knowledge and scientific and technological strengthening of the R&D&I system and R&D&I oriented towards the challenges of society, whose Principal Investigator is Prof. Joaquín Alonso Montesinos. The project started on 1 November 2021, with a duration of 3 years. In addition, several end-of-degree projects have been carried out at the CIESOL facilities. Another project has also been obtained from the Andalusian Regional Government in the framework of building intelligence, with CIESOL being one of the scenarios to be addressed. This project was led by Prof. Luis Iribarne, from the TIC-211 Applied Computing group at the University of Almeria, with the collaboration of Profs. and researchers from CIESOL, Joaquín Alonso Montesinos and Manuel Pérez García. In addition, work continues on the optimisation of systems for the short-term prediction of cloud cover and solar radiation with low-cost systems.



In the solar air-conditioning line, we have continued to provide air-conditioning services.

It is also worth highlighting the achievement of a LIFE project (COOLSPACES 4 LIFE), whose Principal Investigator is Prof. Sabina Rosiek, from the Polytechnic University of Brevia (Poland). The project started on 1

September 2021 and during this year we are in the design phase of experiments and tests and acquisition of the necessary material.

3.5.5 Collaboration with other Functional Units of CIESOL during 2021

Within the framework of 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.

3.5.6 Human resources

Students in curricular internships:

- Andreea Castillo Cucura. Grado en Ingeniería Informática (inicio-fin de las prácitcas 08/11/2021-21/01/2022).
- David Camacho Jurado. Grado en Ingeniería Informática (inicio-fin de las prácticas (30/11/2011-11/02/2022).

3.5.7 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	
6	3	3			5

Papers

- The use of ANN and conventional solar-plant meteorological variables to estimate atmospheric horizontal extinction. J. Alonso-Montesinos, J. Ballestrín, G. López, E. Carra, J. Polo, A. Marzo, J. Barbero, F. J. Batlles. Journal of Cleaner Production 285, 2021. https://doi.org/10.1016/j.jclepro.2020.125395
- Development and comparison of PV production estimation models for mc-Si technologies in Chile and Spain. M. Trigo-Gonzalez, M. Cortés, J. Alonso-Montesinos, M. Martínez-Durbán, P. Ferrada, J. Rabanal, C. Portillo, G. López, F. J. Batlles. Journal of Cleaner Production, 281, 125360, 2021. http://dx.doi.org/10.1016/j.jclepro.2020.125360
- Estimation of soiling losses from an experimental photovoltaic plant using artificial intelligence techniques. N. Simal Pérez, J. Alonso-Montesinos, F. J. Batlles. Applied Sciences, 11(4), 1-18, 2021. http://doi.org/10.3390/app11041516
- Comparison and analysis of two measurement systems of horizontal atmospheric extinction of solar radiation. F.J. Barbero, G. López, J. Ballestrín, J.L. Bosch, J. Alonso-Montesinos, M.E. Carra, A. Marzo, J. Polo, J. Fernández-Reche, F.J. Batlles, R. Enrique. Atmospheric Environment 26, 118608, 2021. https://doi.org/10.1016/j.atmosenv.2021.118608
- Field Quality Control of Spectral Solar Irradiance Measurements by Comparison with Broadband Measurements. Aitor Marzo, Jesús Ballestrín, Joaquín Alonso-Montesinos, Pablo Ferrada, Jesús Polo, Gabriel López, Javier Barbero. Sustainability 13, 10585, 2021. https://doi.org/10.3390/su131910585
- Application of thermal storage in over-night refrigeration of an institutional building". FJ Batlles, AM Puertas, MS Romero-Cano, S Rosiek, B Gil, J Kasperski, A Nemś, M Nemś, M Grágeda, S Ushak, M Luján, D Maldonado. Solar Energy, 220, 450-461, 2021. https://doi.org/10.1016/j.solener.2021.01.070

Congress assistance

- Solar World Congress, Virtual, 2021.

Congress contributions

- Assessment of the Atmospheric Extinction for Solar Tower Power Plants along the Sun Belt: Preliminary Results. Aitor Marzo, Aloïs Salmon, Jesús Polo, Jesús Ballestrín, Joaquín Alonso-Montesinos and Diego Pulido. Solar World Congress, Virtual, 2021. (Póster).
- Increasing the Resolution and Spectral Range of Measured Direct Irradiance Spectra for PV Applications. Gabriel López, Christian A. Gueymard, Jesús Polo, Joaquín Alonso-Montesinos, Aitor Marzo, Nuria Martín-Chivelet, Pablo Ferrada, Francisco Javier Batlles and Martha Escalona-Llaguno. Solar World Congress, Virtual, 2021. (Póster).

Book chapters

- Heat flux and temperature measurement technologies. Jesús Ballestrín, Jeffrey Cumpston and Greg Burgess. Concentrating solar power technology**.** Principles, developments and applications. Woodhead Publishing Series in Energy-Elsevier. United Kingdom. 2021

PhD Theses

- Caracterización y predicción de la nubosidad a corto plazo, a partir de imágenes de cámara de cielo en la Ciudad de México. Román Damián Mondragón Rodríguez. Ciudad de México (virtual), 6 abril 2021, Mención Honorífica (maximun calification).
- Medida de Alta Irradiancia en Centrales Solares Termoeléctricas de Receptor Central. Marina Casanova Molina. Universidad de Almería, 11 octubre 2021, Sobresaliente Cum Laude.

3.5.8 Functional Unit members

Joaquín Alonso Montesinos

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Francisco Javier Batlles Garrido

Full professor
UAL

Francisco Javier Barbero Francisco

PhD researcher
UAL

Mercedes Martínez Durbán

Full professor
UAL

Antonio Manuel Puertas López

Full professor
UAL

Manuel Servando Romero Cano

Full professor
UAL

Sabina Rosiek-Pawlowska

PhD Researcher
Wroclaw University of Science and Technology

3.5.9 Ongoing projects in 2021

3.5.9.1 Short-term prediction of energy production in a photovoltaic plant and influence of panel fouling on energy production (PVCastSOIL)

Participants:

Universidad de Almería
Universidad de Huelva
CIEMAT

Contacts:

F.J. Batlles (fbatlles@ual.es).

Source of funding:

Ministerio de Economía y Competitividad.

Duration:

January 2018 – 30 September 2021

Status:

Finalised

Summary:

Photovoltaic solar energy (PV) is the technology for electric generation that shows the highest growth since 2002, experiencing an average annual increase of 48%. The prediction of the solar resource for a PV plant, connected to the grid, is absolutely necessary to ensure optimal capture and transformation of the available solar energy and reliable power production. The development of short-term forecasting methods for plant production is particularly important due to its growing incorporation into electricity grids and the variability of the solar resource, mainly due to the transitory phenomena caused by alternating clouds and clearings. The accumulation of dirt on the surface of photovoltaic modules has a significant impact on the production of a photovoltaic installation. This phenomenon, better known by the Anglo-Saxon term "soiling" is intimately related to the angle of inclination of the panel and weather conditions, such as the amount of aerosols present in the atmosphere, relative humidity, wind speed and direction and precipitation.

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

Participants:

Universidad de Almería.

Contacts:

Joaquín Alonso Montesinos (joaquin.alonso@ual.es) – PI project.

Source of funding:

Ministerio de Ciencia e Innovación.

Duration:

November 2021 – October 2024.

Status:

Ongoing

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.

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

Participants:

Wroclaw University of Science and Technology, WUST (Poland)
PROZON Fundacja Ochrony Klimatu (Poland)
Universidad de Almería
Hedera Helix Ingenieria y Biotecnologia S.L.

Contacts:

Sabina Rosiek (sabina.rosiek@pwr.edu.pl) – Overall PI of the project
Antonio Manuel Puertas López (apuertas@ual.es) – PI of the group from the UAL in the project

Source of funding:

LIFE20 action - LIFE CLIMATE CHANGE MITIGATION

Duration:

September 2021 – August 2026

Status:

Ongoing

Summary:

In this project we aim to develop a prototype of refrigeration device with low Global Warming Potential (low-GWP), running with photovoltaic solar energy and a system of thermal energy storage at low temperatures. The group in the UAL-CIESOL is responsible for the design and test of the storage system in the laboratory scale, including the selection of a phase change material for this purpose. In a 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.

3.5.9.4 AN OPEN IOT SERVICES REFERENCE MODEL FOR ENERGY EFFICIENCY STRATEGIES (UrbanITA)

Participants:

Universidad de Almería
Centro tecnológico CARTIF
Universidad de 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 – December 2022

Status:

Ongoing

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.

3.5.9.5 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 Sanchez (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 2022

Status:

Ongoing

Summary:

The overall objective of this project is to continue the work done over the last 8 years for the sustainability of the activities of the European advanced solar laboratories participating in SFERA and SFERA Phase 2, and to extend these activities to the new solar laboratories that will bring added value to this European Research Infrastructure for Concentrating Solar Power. The specific objective is to contribute to ensuring the long-term sustainability of these advanced European solar laboratories, supporting Europe as a world leader in solar research infrastructures. These activities will include (i) networking activities to further develop cooperation between research infrastructures, the scientific community, industries and other stakeholders; (ii) trans-national access activities aimed at facilitating access for all European researchers, both from academia and industry, to scientifically and technologically unique solar research infrastructures; and (iii) joint research activities with the sole objective of improving the integrated services provided by the infrastructure. This would contribute to the scientific excellence of these research infrastructures (RIs), to strengthen the interaction between the CSP industry and these RIs, to further enhance innovation, to develop new activities, and 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.

3.5.10 Transfer and Complementary Activities

Contracts with companies

Worldwide commercialisation of a solar extinction measurement system. Company BCB Computing and Control 2018. Acquisition of the system by NOOR ENERGY 1 (Dubai) in 2021.

3.5.11 Others

Final degree projects:

- Raúl José García Sánchez (Grado en Ingeniería Eléctrica). Predicción de la producción de una planta solar fotovoltaica, utilizando imágenes de una cámara de cielo. (Joaquín Alonso Montesinos)
- Joaquín Jesús Utrera Martínez (Grado en Ingeniería Eléctrica). Desarrollo de una interfaz de usuario, para el análisis y la visualización de datos procedentes de sistemas fotovoltaicos y meteorológicos. (Joaquín Alonso Montesinos)
- Jerónimo Ramos Teodoro (Máster en Profesorado de Educación Secundaria). Fundamentos de sistemas fotovoltaicos: una propuesta de enseñanza basada en el desarrollo de un laboratorio virtual. (Joaquín Alonso Montesinos)

PhD Theses under development

Mauricio Trigo González (Francisco Javier Batlles Garrido – Joaquín Alonso Montesinos).

Awards during 2021

- PREMIO DE INVESTIGACIÓN SAN ALBERTO 2021 los mejores artículos de investigación dentro del Q1 publicados en 2021. 250,00€. Facultad de Ciencias Experimentales de la Universidad de Almería, Almería, España. 27 septiembre 2021.

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 the water-energy-food nexus, beginning with the set up and operation of new installations and facilities dedicated to water desalination with solar energy by using hydrophobic membranes, 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 using membrane systems 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, rackish 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 Universidad de Almería. He obtaines a Degree in Industrias Chemistry (Químico Industrial) 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 85 papers in

peer-reviewed international journals, presented more than 125 papers on international conferences, authored 8 book chapters and co-authored 4 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 2021

During 2021, works related to project SOLWARIS have continued by developing the dynamic model of the multi-effect evaporation plant for water recovery purposes in a CSP plant, which has been implemented in Dymola software. All components of the plant have been modelled (bundle tube of each effect, steam ejector, desuperheater, cyclonic box of each effect, final condenser, plate heat exchangers, mixed tank). Likewise, the model has been validated with data given by the manufacturer (INDETEC), obtaining a good agreement between the results of the model and the design data. Finally, a sensitivity analysis has been carried out, in which the dynamic response of the system against disturbances in the main operating variables. This has been reflected in a paper that was sent to the SCI journal Desalination at the end of 2021. In project SOLTERMIN, we have continued working in the development of simplified models in Phyton of the components of the Brayton cycle (turbine, compressor, combustor, gas turbine and heat exchanger) in order to simulate the integration of a MED-TVC unit into a Brayton cycle. For the gas turbine, the characteristics of the receiver solar plant Aora Solar have been taken. Also, we have continued working on the code development to discharge data online from PVGis of solar radiation, temperature and wind velocity of a TMY, given the geographical parameters of a certain location. Regarding the EERES4WATER Project (Promoting Energy Water Nexus resource efficiency thourgh Renewable Energy and Energy Efficiency, INTERREG ATLANTIC AREA), during 2021, work has continued on the improvement of the simulation models aimed at the techno-economic evaluation of the combination of photovoltaic plants and central receiver solar thermal plants to feed reverse osmosis units. These improvements have focused on the management protocols of the thermal storage system as well as the operation of the reverse osmosis plant at partial load. During this year, work has also been carried out on the integration of forward osmosis technology as a pre-treatment for the MED process, obtaining theoretical results that show recovery ratio values of up to 55% while maintaining energy consumption values (GOR) above 13. With regard to the evaluation activity of the vacuum assisted membrane distillation technology, the evaluation has been carried out in batch configuration with the aim of increasing the recovery ratio and extending the application of the technology to other areas such as brine concentration and water mining.

In project WATERMINING we set up the demo plant at Plataforma Solar de Almería, consisting of a nanofiltration (NF) unit to pretreat seawater before a Multi-effect distillation (MED) plant powered by solar thermal energy. The NF eliminates the divalent salts from the seawater, allowing the MED plant to operate at higher temperatures and concentration, to reach higher thermal efficiency and salinity conditions near saturation. A further crystallizer should be able to obtain sodium chloride salts of greater purity from the MED brine in the absence of divalent ions. The reject from the NF, rich in divalent salts can be combined with the distillate produced by the MED plant for better value towards irrigation. The different systems have been implemented, including a large storage (300 m3) of real seawater with a chiller to dissipate the waste heat

so that real seawater can be used and circulated through the systems. We also formed a Community of Practice of our case study to discuss barriers, identify required policies, assess sustainability issues and elaborate a preliminary market mapping. We organized a first meeting to discuss these matters and how to incorporate criteria based on value sensitive design in the implementation of the system. In project INTELWATT we designed the solar membrane distillation pilot plant that will be implemented in CS2 and build a laboratory system to test the different membranes that will be evaluated in the first phase of the project, including hollow fibre membranes which have never been tested before in our group.

In the microalgae production line, different projects continue to be developed, such as those related to the production of microalgae for high-value applications, mainly food and feed, as well as the production of biostimulants and biopesticides, or those related to waste treatment, mainly wastewater, both urban and of animal origin, and combustion gases. These include ALQUABIOTIC with BIORIZON BIOTECH focused on the production of aquafeed for aquaculture, AL4BIO with UPC focused on the production of biostimulants from effluents after secondary treatment, ALGAE4CONTROL with BIORIZON BIOTECH focused on the production of biopesticides from microalgae, BLUECARE with BIORIZON BIOTECH focused on the production of microalgae cosmetic products, SETEC with SYTCOM focused on the production of bioplastics from combustion gases using microalgae. In this field, panbiñen has developed the SABANA project, which has concluded this year. The SABANA sabana project, funded by the EU Commission through the H2020 programme, has focused on the production of products related to agriculture and aquaculture from microalgae using waste. During this year, the PURASOL project has also ended, focused on the purification of manure with microalgae. The project has been completed ready for its justification during 2022. The successful execution of the PURASOL project has given rise to the request and concession of the "proof of concept" project called GREENFARM, which was requested and granted in 021 and has begun to be executed in 2022. The VALIMA and ALGA4FF projects have also been presented and awarded within the scope of the Andalusian Research, Development and Innovation Plan (PAIDI 2020). The VALIMA project is dedicated to the recovery of leachate from plant residues through microalgae, while ALGA4FF will study the formulation of food with microalgal biomass and its influence on nutritional and functional qualities. Two additional lines of research are also being developed in collaboration with other functional units of CIESOL, such as the recovery of heat and CO2 from combustion gases to be used in greenhouses through the CARBON4GREN project financed by the UAL-FEDER programme, and the removal of emerging pollutants through the ULISES project financed by the EU LIFE programme.

3.6.5 Collaboration with other Functional Units of CIESOL during 2021

During 2021 we have collaborated closely with the Functional Unit “Modelling and Control” in the framework of SOLWARIS project. We have worked jointly in the tasks related with modelling, optimization and control, accomplishing with all the items of the milestones so far.

3.6.6 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	
15	4	7	2	1	5

Papers

- Performance Modelling and Optimization of Three Vacuum–Enhanced Membrane Distillation Modules for Upscaled Solar Seawater Desalination. Andrés-Mañas, J.A., I. Requena, A. Ruiz-Aguirre, G. Zaragoza. Separation and Purification Technology in press. https://doi.org/ https://doi.org/10.1016/j.seppur.2021.120396.
- Characterization of the use of vacuum enhancement in commercial pilot-scale air gap membrane distillation modules with different designs. Andrés-Mañas, J.A., I. Requena, G. Zaragoza. Desalination in press. https://doi.org/10.1016/j.desal.2021.115490
- Removal of organic matter from wastewater coming from fruit juice production using solar photo-Fenton process. Poblete, R., Cortés, E., Pérez, N., Valdivia, M., Maldonado, M.I.International Journal of Chemical Reactor Engineering, 2021, 19(8), pp. 809–815. https://doi.org/10.1515/ijcre-2020-0228
- Annual assessment of the wastewater treatment capacity of the microalga Scenedesmus almeriensis and optimisation of operational conditions. Sánchez-Zurano A., Morillas-España A., Gómez-Serrano C., Ciardi M., Acién G., Lafarga T.. Scientific Reports. 11. 21651. 2021. https://doi.org/10.1038/s41598-021-01163-z
- Potential of the cyanobacteria Anabaena sp. and Dolichospermum sp. for being produced using wastewater or pig slurry: Validation using pilot-scale raceway reactors. Morillas-España A., Sánchez-Zurano A., Gómez-Serrano C., Ciardi M., Acién G., Clagnan E., Adani F., Lafarga T.. Algal Research. 60. 102517. 2021. https://doi.org/10.1016/j.algal.2021.102517
- Year-long evaluation of microalgae production in wastewater using pilot-scale raceway photobioreactors: Assessment of biomass productivity and nutrient recovery capacity. Morillas-España A., Lafarga T., Sánchez-Zurano A., Acién-Fernández F.G., Rodríguez-Miranda E., Gómez-Serrano C., González-López C.V.. Algal Research. 60. 2021 https://doi.org/10.1016/j.algal.2021.102500
- Microalgae derived astaxanthin: Research and consumer trends and industrial use as food. Villaró S., Ciardi M., Morillas-españa A., Sánchez-zurano A., Acién-fernández G., Lafarga T.. Foods. 10. 2303. 2021. https://doi.org/10.3390/foods10102303
- Microalgae classification based on machine learning techniques. Otálora P., Guzmán J.L., Acién F.G., Berenguel M., Reul A.. Algal Research. 55. 102256. 2021. https://doi.org/10.1016/j.algal.2021.102256
- Boiler combustion optimization of vegetal crop residues from greenhouses. Reinoso Moreno J.V., Pinna Hernández M.G., Fernández Fernández M.D., Sánchez Molina J.A., López Hernández J.C., Acién Fernández F.G.. Agronomy. 11. 626. 2021. https://doi.org/10.3390/agronomy11040626
- Indirect regulation of temperature in raceway reactors by optimal management of culture depth. Rodríguez-Miranda E., Guzmán J.L., Acién F.G., Berenguel M., Visioli A.. Biotechnology and Bioengineering. https://doi.org/10.1002/bit.27642
- Modelling and ph control in raceway and thin-layer photobioreactors for wastewater treatment. Rodríguez-Torres M.J., Morillas-España A., Guzmán J.L., Acién F.G.. Energies. 14. 1099. 2021. https://doi.org/10.3390/en14041099
- Abaco: A new model of microalgae-bacteria consortia for biological treatment of wastewaters. Sánchez-zurano A., Rodríguez-miranda E., Guzmán J.L., Acién-fernández F.G., Fernández-sevilla J.M., Grima E.M.. Applied Sciences (Switzerland). 11. 998. 2021. https://doi.org/10.3390/app11030998
- A new model to analyze the temperature effect on the microalgae performance at large scale raceway reactors. Rodríguez-Miranda E., Acién F.G., Guzmán J.L., Berenguel M., Visioli A.. Biotechnology and Bioengineering. 118. 877. 2021. https://doi.org/10.1002/bit.27617

- Modelling and control of microalgae production in industrial photobioreactors [Modelado y control de la producción de microalgas en fotobiorreactores industriales]. Guzmán J.L., Acién F.G., Berenguel M.. RIAI - Revista Iberoamericana de Automatica e Informatica Industrial. 18. 1. 2021. https://doi.org/10.4995/RIAI.2020.13604
- Dynamic model for the ph in a raceway reactor using deep learning techniques. Otálora P., Guzmán J.L., Berenguel M., Acién F.G.. Lecture Notes in Electrical Engineering. 695. 199. 2021. https://doi.org/10.1007/978-3-030-58653-9_18

Congress assistance

- International Conference on Polygeneration ICP 2021, 04-06 October, 2021. Online
- Conference on sustainable development of energy, water and environment systems. October 10-15, 2021. Online.
- 15th Sollab and 2nd SFERA III-Doctoral Colloquium. Almería, España, 2021.
- Secat 2021. Nuevos retos de la catálisis en Química, Medio Ambiente y Energía, Valencia, España, 2021.
- ICheap 15, The 15th international conference on chemical and process engineering, Napoles, Italia, 2021
- European algae biomass Association. 07/12/2021. Roma, Italia.
- 29th European Biomass Conference and Exhibition 26-29 April 2021. Online.
- The 7th Conference of the International Society For Applied Phycology. 14 May - 13 August 2021. Tsukuba, Japan. Online.

Congress contributions

- Evaluation of Operational Conditions on the Performance of Microalgae-Based Wastewater Treatment. Variation in the Bioremediation Capacity of Primary Urban Wastewater and Microalgae-Bacteria Consortia. Morillas-España A., Sánchez-Zurano, A., Lafarga, T., Morales, M., Gómez Serrano, C., Pinar, M., Acién-Fernández, F.G., Fernadez-Sevilla, J.M. 29th European Biomass Conference and Exhibition 2021. Type of presentation: Poster. Place: Online.
- Yearly assessment of a pilot scale thin-layer reactor for microalgae wastewater treatment. Variation of the microalgae-bacteria consortium and impact of the environmental conditions. Sánchez-Zurano, A., Garrido-Cárdenas, J.A., Gómez, C., Morales Amaral M., Acién-Fernández, F.G., Fernández Sevilla, J.M., Molina, E. 7th Congress of the International Society for Applied Phycology 2021. Type of presentation: Poster. Place: Online.
- Microalgae-based wastewater treatment: Understanding the effect of operational conditions on biomass productivity, nutrients removal, and composition of the microalgae-bacteria consortium. Sánchez-Zurano, A., Lafarga, T., Morales, M., Gómez-Serrano, C., Acién, G., Molina, E. 10th International Conference on Algal Biomass, Biofuels and Bioproducts 2021. Online.
- Recuperación de agua para el tratamiento de purines con microalgas. Ciardi, M., Sánchez-Zurano, A., Fernandez-Sevilla, J.M., Acién-Fernández, F.G. III Congreso de Jóvenes Investigadores del Mar 2021. Motril, España.
- Pilot-scale production of A.platensis as a source of functional and bioactive proteins. Ainoa Morillas España, Tomas Lafarga. European algae biomass Association. 07/12/2021. Roma, Italia.
- Production of high-Value microalgae using secondary wastewater. Cynthia Victoria González López; Lisa Maggioli; Cintia Gómez Serrano; Francisco Gabriel Acien Fernandez. 14/05/2021, The 7th Conference of the International Society For Applied Phycology. Tokyo, Japan (Virtual).
- Evaluation of Operational Conditions on the Performance of Microalgae-Based Wastewater Treatment. Variation in the Bioremediation Capacity of Primary Urban Wastewater and Microalgae-Bacteria Consortia. Ainoa Morillas España; Tomas Lafarga; Maria del Mar Morales Amaral; Cintia Gómez Serrano; Maria Guadalupe Pinna Hernandez; José María Fernández Sevilla; Francisco Gabriel Acien Fernandez. European Biomass converence.26/04/2021. Marsella, Francia

3.6.7 Functional Unit members

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Alba Ruiz Aguirre

Associate Researcher
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Patricia Palenzuela

Senior Researcher
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Juan Antonio Andrés Mañas

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Jose Peña Martín

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Tomás Lafarga Poyo

Juan de la Cierva Associate Researcher
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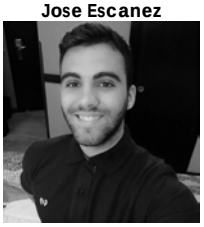
Jose Escanez



Associate Researcher
Ingeniería Química - UAL

M. Ignacio Maldonado

OPIs Researcher
CIEMAT-PSA

3.6.8 Ongoing projects in 2021

3.6.8.1 Optimization of the treatment of purines with microalge for the production of biofertilizers and feed for aquaculture. Study of the behavior of emerging pollutants (PURASOL)

Participants:

Universidad de Valladolid (ES).
Universidad de Almería

Contacts:

Silvia Bolado (UV) (Coordinated project)
Jose Maria Fernandez Sevilla (UAL) (Subproject 2)

Source of funding:

Ministerio de Economia, Industria y Competitividad

Time Period:

31/12/2017 – 31/12/2020. Extended until october 2021.

Current situation:

Completed

Summary:

The aim of PURASOL is to optimize manure valorization by the use of microalgae. In this way, a water stream (suitable for irrigation) and a nutrient recovery (as bioproducts and bioenergy) are obtained. The lack of natural resources coupled with the increasing need of importing basic compounds makes livestock industry of major importance in our country. Manure production is closely related to it and the challenge of turning a potential source of environmental problems, as manure, into a renewable resource with a high economic value is one of the issues in Europe nowadays. Previous studies confirmed that it is possible to use manure as nutrient source for microalgae growth. However, there are still some issues to be optimized, namely microalgae productivity and water quality. Moreover, it was proved that microalgae biomass can be successfully converted into biofertilizers, animal feed or biofuels, but these processes need to be further optimized and validated.

Objectives:

PURASOL project aims at finding a solution to all those issues. More specifically:

- Different pretreatments will be studied in order to reduce manure turbidity, maximizing the light use by the microalgae.

- In order to increase water recovery, evaporation will be reduced by covering the thin-layer photobioreactors.
- Microalgae-bacteria consortia will be studied to determine their optimal valorization way, since it has been demonstrated that their composition depends on the environmental and operation conditions.
- Study the presence of emerging pollutants and heavy metals in treated water and microalgae biomass, which besides represent a risk for the environment and public health, influence the microbial populations in the system, treatment capacity and valorization ways.

3.6.8.2 Sustainable algae biorefinery for agriculture and aquaculture (SABANA)

Participants:

MIKROBIOLOGICKY USTAV - AVCR, V.V.I., Czech Republic
GEA WESTFALIA SEPARATOR GROUP GMBH, Germany
UNIVERSITA DEGLI STUDI DI MILANO, Italy
UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA, Spain
SZECHENYI ISTVAN UNIVERSITY, Hungary
KARLSRUHER INSTITUT FUER TECHNOLOGIE, Germany
A.I.A. S.p.A., Italy
FCC AQUALIA SA, Spain
BIORIZON BIOTECH S.L., Spain
CIB-CONSORZIO ITALIANO BIOGAS E GASSIFICAZIONE
UNIVERSIDAD DE ALMERIA, Spain

Contacts:

F. Gabriel Acién (facien@ual.es)

Source of funding:

This project has received funding from the European Union's Horizon 2020 Research and Innovation program under the Grant Agreement No. 727874

Time Period:

December 2016 – November 2021

Current situation:

Completed.

Summary:

SABANA aims at developing a large-scale integrated microalgae-based biorefinery for the production of biostimulants, biopesticides and feed additives, in addition to biofertilizers and aquafeed, using only marine water and nutrients from wastewaters (sewage, centrate and pig manure). The objective is to achieve a zero-waste process at a demonstration scales up to 5 ha sustainable both environmentally and economically. A Demonstration Centre of this biorefinery will be operated to demonstrate the technology, assess the operating characteristics of the system, evaluate environment impacts and collaborate with potential customers for use.

Objectives:

The objective of SABANA is to develop and demonstrate an integrated microalgae-based sustainable biorefinery to produce a range of value-added products (biostimulants, biopesticides and aquafeed additives) and low-value products (biofertilizers, aquafeed) for agriculture and aquaculture, using marine water and recovering nutrients from wastewaters (sewage, centrate and pig manure), accomplishing market (quality, price, regulations) and social (acceptance, capacitation, skills) requirements. It provides a solution for three current key issues in the EU: (i) improvement of the safety and sustainability of food production in agriculture and aquaculture, (ii) contamination problems resulting from nutrients dissemination and scarcity (phosphorous), and (iii) minimization of greenhouse gas emissions from wastes (wastewater and flue gases).

3.6.8.3 Bioplastics production from carbon captured in household waste incineration fumes (SETEC)

Participants:
Universidad de Almería.
SETEC Environnement (France)
Contacts:
F. Gabriel Acién Fernández (UAL), facien@ual.es
Source of funding:
Private contract
Time Period:
May 2016– May 2021.
Current situation:
Extended
Summary:

Setec Environnement has concluded a research and development contract (hereinafter referred to as « MAIN CONTRACT ») with Syctom, the Paris Metropolitan Intercommunal household waste treatment and recycling Syndicate (hereinafter referred to as « Syctom »), the purpose of which is to provide within the framework of the project for bioplastics production from carbon captured in household waste incineration fumes (hereinafter referred to as « PROJECT »)

Setec Environnement requests that the UNIVERSIDAD DE ALMERIA, which agrees, provide its support as a subcontractor for the implementation of experimental missions to select microalgae strains.

3.6.8.4 Production of biopesticides from cyanobacteria for their use in agriculture (ALGAE4CONTROL)

Participants:
Universidad de Almería.
BIORIZON BIOTECH S.L.
Fundación Cajamar
Contacts:
F. Gabriel Acién Fernández (UAL), facien@ual.es
Source of funding:
RETOS COLABORACION 2017, Ministerio de Economía y Competitividad
Time Period:
October 2018– September 2021.
Current situation:
Completed
Summary:

The ALGAE4CONTROL project aims to develop biopesticide formulations based on the use ofAntimicrobial metabolites from Cyanobacteria (microalgae) for agricultural use as natural phytosanitaryof biological and sustainable origin compared to phytopathogenic microbial agents. This is a research projectImplemented by the biotechnology company Bioripple Biotech S.L., which also includes two organizations ofResearch such as the University of Almería and the Jamar Foundation. Biocurly Biotech S.L. specialises in theDevelopment and commercialization of new products of agricultural use that allow to improve the sustainability and profitability ofIntensive production under plastic, and other extensive crops, being the main European company in the development ofBiofertilizers and biostimulants from microalgae. In this line the company is interested in developingProducts based on inhibitory metabolites of the growth of phytopathogenic microbial agents for soils andPlants. This type of biopesticide compounds present in some microalgae have been reported in bibliography butAt this time there is not a single biopesticide product of these characteristics in the whole world market. This isBecause the source of raw material is difficult to access, and whose positive effect has not been sufficiently contrasted andshown in real conditions. That is why in the

project ALGAE4CONTROL is intended to resolve theseProblems by approaching all stages of characterization, production and application of this type of extractsof cyanobacteria, demonstrating finally the advantages of this type of bioproducts in both the profitability and theSustainability of agricultural production.

Objective:

The general objective of the project is to develop new biopesticides from microalgae as alternative to chemical pesticides for prevention of disease in plants and crops protection.

3.6.8.5 Biorefinería sostenible de microalgas para la producción de extractos fotoprotectores para la industria cosmética y formulados sustitutivos de harinas de pescado en piensos de acuicultura – Bluecare

Participants:

ALGAETECH INNOVATION
Universidad de Almeria

Contacts:

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

Source of funding:

NEOTEC-CDTI, EXP - 00104234/SNEO-20171045

Time period:

1 Enero 2019 – 31 Diciembre 2021

Current situation:

Completed

Abstract

The BLUECARE Project consists on the implementation of a new concept of Biorefinery for the complete use of algal biomass for the production of photoprotective formulations for the cosmetic industry from microalgae and the full use of biomass for the production of hydrolyzates as food formulations for aquaculture. This is a novelty in this sector that, according to previous tests, has been shown to improve the digestibility and quality of fish farmed in captivity. The technology to be developed is based on the identification of infection associated antigens that are differentially recognized in uninfected vaccinated animals.

Objetivos.

To develop new photobioreactors and biomass processing technologies to obtain products of cosmetic interest.

3.6.8.6 Microalgas para la Producción sostenible de bioproductos y agua regenerada (AL4BIO).

Participants:

Universidad Politecnica de Cataluña
Universidad de Almeria

Contacts:

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

Source of funding:

Proyectos de I+D+i RETOS INVESTIGACIÓN 2018
Ministerio de Ciencia, Innovacion y Universidades

Time period:

1 Enero 2019 – 31 Diciembre 2021

Current situation:

In progress.

Abstract

The AL4BIO project aims at producing high-value bioproducts and reclaimed water in microalgaebased systems for tertiary wastewater treatment. The bioproducts include biopolymers, biological pigments, biostimulants, biopesticides and biogas, along with reclaimed water. 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).

Objetives.

DIQUAL has a large experience on the design, construction and operation of microalgae-based bioprocesses both for high-value applications and wastewater treatment. This group has different pilot and demonstrative plants to study the production of microalgae and downstream processing, and obtain high-value products under real conditions. The group also has a fully equipped laboratory to characterize and evaluate the microalgae-based processes. DIQUAL will have the following external collaborators: an expert in energy engineering (Universidad Politécnica de Madrid), an expert on valuable compounds extraction from microalgae (University of Jaen), and an expert on the evaluation of bioproducts for the enhancement of crops production and protection (Cajamar Foundation).

3.6.8.7 Valorización de lixiviados de residuos vegetales para la producción de bioestimulantes y biopesticidas de interés agrícola mediante microalgas (VALIMA)

Participants:

Universidad de Almeria

Contacts:

José María Fernández Sevilla (IP).

Departamento de Ingeniería Química. Universidad de Almería. 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:

Enero 2021 – Julio 2023

Current situation:

Ongoing.

Abstract

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.

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

Participants:

Universidad de Almeria

Contacts:

Francisco Gabriel Acién Fernández (IP).
Departamento de Ingeniería Química. Universidad de Almería. 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:

Enero 2021 – Julio 2023

Current situation:

Ongoing.

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.

Objetives.

Formulación de alimentos con biomasa de microalgas. Estudiar el efecto en las propiedades físico-químicas, funcionales, nutricionales y en la aceptación del consumidor.

3.6.8.9 Water regeneration using concentrated solar energy (RAYO)

Participants:

Functional Unit: “Regeneración de aguas”
Functional Unit: “Análisis ambiental”

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.

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

Participants:

TECHNISCHE UNIVERSITEIT DELFT (NL)
SEALEAU BV (NL)
KWR WATER BV (NL)
FUNDACIO 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)
REVOLVE (ES)
EUROPEAN NETWORK OF LIVING LABS IVZW (BE)
WATER & ENERGY INTELLIGENCE BV (NL)
LENNTECH BV (NL)
TITAN SALT BV (NL)
ASSOCIATION EUROPEENNE DES EXPOSITIONS SCIENTIFIQUES TECHNIQUES ET INDUSTRIELLES (BE)
SOFINTER SPA (IT)
THE VASANTDADA SUGAR INSTITUTE (IN)
THERMOSOL ATMOLEVITES ANONIMI ETAIREIA (HE)
NOURYON INDUSTRIAL CHEMICALS B.V. (NL)
FLOATING FARM HOLDING BV (NL)
MADISI LTD (CY)

Contacts:

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

Funds:

European Commission, Horizon 2020 programme

Time Period:

Sep 2020 – Aug 2023

Current situation:

ongoing

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 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 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-Centro nacional de supercomputación
Brightsource industries Israel LTD
AMIRES s.r.o.

Contacts:

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

Funds:

European Commission, Horizon 2020 programme

Time Period:

May 2018-April 2021

Current situation:

Ongoing

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 m^3/MWhe. Fresh water production will save up to 0.45 m^3/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.

3.6.9 Network participation during 2021

RENUWAL action supported by the CYTED from 2020 to 2022.

3.6.10 Dissemination activities

- "Desalación solar y reutilización de salmuera para riego", por Guillermo Zaragoza en el webinar "Regando con agua cada vez más salina" organizado por COEXPHAL y Universidad de Almería, 10 junio 2021.
- "Decentralized solutions for solar-powered desalination", por Guillermo Zaragoza en la sesion "Decentralized solutions for securing safe water in the face of climate change" de la G-STIC Conference "Accelerating technological solutions for the SDGs", Dubai (Emiratos Árabes), 26 octubre 2021. (online)
- "Aplicación de sistemas de desalación solar a pequeña escala", por Guillermo Zaragoza en el Webinar "Desarrollo de tecnologías solares e integración multidisciplinaria de soluciones productivas a pequeña escala aplicadas a la macro zona Chile-Perú-Bolivia" organizado por Solar Energy Research Center Chile, 23 noviembre 2021.

- La noche europea de los investigadores. Almería, España, 2021
- X Simposio de Investigación en ciencias experimentales, Almería, España, 2021

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

- Characterization and modelling of batch membrane distillation systems to concentrate brines. I. Requena. PhD Thesis, supervisors: G. Zaragoza, J.A. Andrés-Mañas.
- Development of advance control techniques for their application in solar desalination processes. phD student: Juan Miguel Serrano Rodríguez, University of Almería, Programme: Computing. Supervisors: Lidia Roca, Patricia Palenzuela.
- Tesis de Joyce Gloria Villachica Llamosas, supervisores: 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

- Curso “Curso Básico de Igualdad de Género”. INAP, Madrid (España), 3, 8 y 10 de junio de 2021.
- Curso “Formación general para la promoción y acceso del personal a las plazas del CIEMAT”. CIEMAT, Madrid (España), 4 al 13 de mayo – 21 al 23 de junio de 2021
- Gestión integral del agua en un scenario de estrés hídrico, Almería, España, 2021.

4 COMMITTEES AND ACTIVITY RESPONSIBLES.

4.1 CIESOL MANAGEMENT

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
Technical team:	**Octavio Malato Rodríguez** omalato@ual.es

4.2 FUNCTIONAL UNIT RESPONSABLES

Activity	Universidad de Almería (UAL)	Plataforma Solar de Almería (PSA)
Organometallics and photochemistry	**Antonio Romerosa** Full Professor UAL romerosa@ual.es	**Christoph Richter** DLR Resedarcher PSA CIEMAT christoph.richter@dlr.de
Environmental analysis	**Ana Agüera** Full Professor UAL aaguera@ual.es	**Isabel Oller** Senior Researcher OPI - CIEMAT-PSA isabel.oller@psa.es
Advanced technologies for water regeneration	**José A. Sánchez** Full Professor UAL jsanchez@ual.es	**Inmaculada Polo López** Senior Researcher OPI - CIEMAT-PSA mpolo@psa.es
Modeling & automatic control	**José D. Álvarez Hervás** ProfessorUAL jhervas@ual.es	**Lidia Roca Sobrino** Senior Researcher OPI - CIEMAT-PSA lroca@psa.es
Desalination and phostosynthesis	**José M. Fernández** Full Professor UAL jfernand@ual.es	**Guillermo Zaragoza** Senior Researcher OPI - CIEMAT-PSA guillermo.zaragoza@psa.es
Solar resources and solar cooling research	**Joaquín Alonso Montesinos** Professor UAL joaquin.alonso@ual.es	**Jesús María Ballestrín Bolea** Senior Researcher OPI - CIEMAT-PSA jballestrin@psa.es

4.3 COORDINATION AND MONITORING COMMITTEE

Diego Valera - University of Almería Vice Chancellor	vinvest@ual.es
Manuel Berenguel -Full Professor UAL	beren@ual.es
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4.4 SCIENTIFIC COMMITTEE

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Ministerio de Ciencia, Innovación y Universidades, Spanish Goverment

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