INFORME ANUAL CIESOL

CIESOL ANNUAL REPORT

2020

INVESTIGACIÓN

SOLAR ENERGY

RESEARCH

ENERGÍA SOLAR

CIESOL

Centro de Investigacion en Energia Solar

Solar Energy Research Center


GOBIERNO
DE ESPAÑA
MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES
FEDER
Fondo Europeo de
Desarrollo Regional
UNIÓN EUROPEA
"Una manera de hacer Europa"


Life


THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION
HORIZON 2020
European
Commission
Horizon 2020
European Union funding
for Research & Innovation


IEEE
Control Systems
Society


ERA
LEARN


JUNTA DE ANDALUCIA


switchasia


CDTI
Centro para el Desarrollo
Tecnológico Industrial

Empresas


NOVAGRIC
NOVEDADES AGRÍCOLAS


setec
énergie environnement


aqualia

INDEX

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION AND WELCOME

The Solar Energy Research Center, CIESOL, is a joint institute of the University of Almería (UAL)and the Almería Solar Platform (PSA), which designs and develops new applications in solar energy. At CIESOL, researchers from the Solar Platform and from the University are working together to get the most out of solar radiation, encompassing energy use, water treatment and the study of air conditioning and thermal comfort in buildings.

Edificio CIESOL

At the center, we carry out international research, transfer, dissemination and training on various aspects of solar energy.

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

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

1.2 CIESOL DESCRIPTION

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

It comprises a total area of about 1700 m^2, with a warehouse of 200 m^2 and a courtyard of 300 m^2. There is also 1 workshop, an external laboratory, 3 cold storage rooms, 1 meteorological station, 7 laboratories, 5 offices, 1 dining room, 1 study room , 1 work room, a classroom/meeting room. The solar heating and cooling system covers most of the center's demand as 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 talk about the facilities in detail.

During 2020, 93 researchers participated in projects and contracts assigned to CIESOL (61 men and 32 women), 22 of them (10 men and 12 women) with their permanent base at its laboratories and offices during this period. The activities carried out by these researchers form part of 18 projects from official competitive calls (National Research Plan and the Program for Incentives to Agents of the Andalusian Knowledge System), 2 contracts with companies and institutions, 17 European projects and 13 networks (8 Spanish, 1 Ibero-American and 4 European).

In addition , the center's units have hosted 36 international research stays from 12 different countries, most notably from Mexico, Brazil, France and Italy.

1.3 RESEARCH LINES IN CIESOL

What is done in CIESOL?

Our work is carried out in different areas, all of them focused on knowledge of solar resources and various applications, which we can classify into two lines: one related to the energy use of solar radiation, and the other to the development of solar technologies for treatment of water.

Comimitted to preserving the environment, CIESOL research centres on two essential areas for life, water and energy, both linked by the use of solar radiation.

How is CIESOL progressing in the use of energy?

The first thing we need to know about using solar energy is its availability, which is why new methods are being investigated to evaluate and predict solar resources and the optimization of sky cameras to track and predict cloudiness.

Monitoring, modeling and automatic control of solar installations are also important, at very different scales, from large solar thermal plants to generate electricity, to electric vehicles powered by solar energy using the photoelectric effect, better known as photovoltaic energy.

Solar cooling instalation

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

Research is also underway on the development of new water-soluble substances with photochemical activity, with the aim of paving the way towards new, more environmentally sustainable photovoltaic cells.

How is CIESOL making advances in water treatment?

We must protect water resources, as vital as they are scarce, whose value for life increases in line with with quality. For this purpose, CIESOL is developing new clean technologies for decontamination based on solar irradiance, both for toxic waters that cannot be treated by conventional biological methods, and treated wastewater, which still has small amounts of persistent pollutants, which affect the aquatic environment.

Among the solar wastewater treatment methods, a new process based on microalgae is emerging , taking advantage of photosynthesis for decontamination, with lower energy consumption and generating useful biomass for other industrial sectors.

Triple TOF 5600

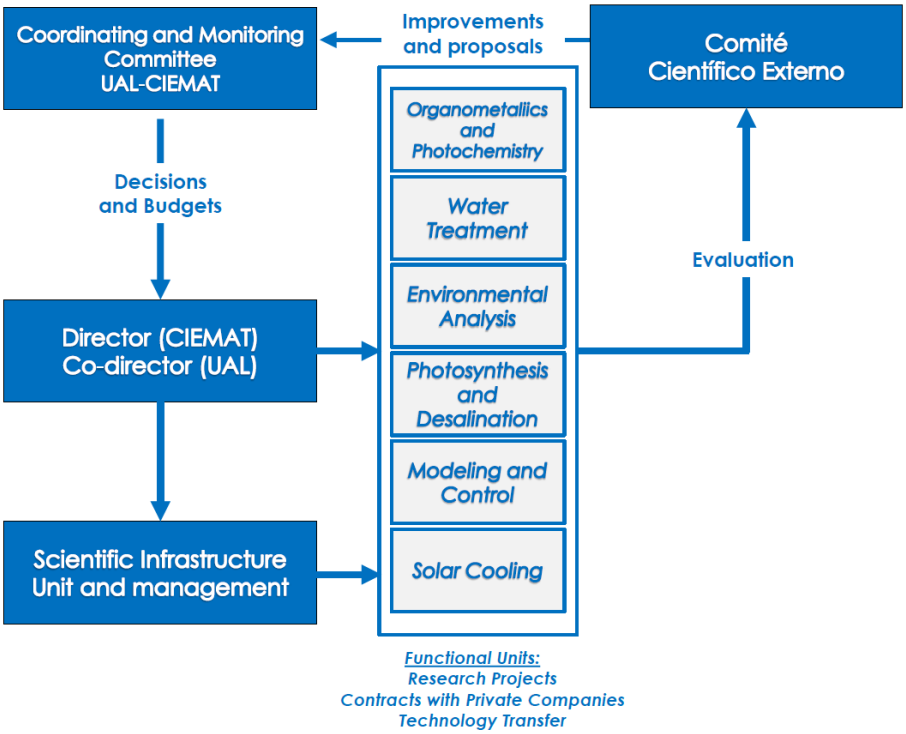
Once purified, water can have a new use, especially for irrigation. As such , it is necessary to inactivate the pathogenic microorganisms that still remain in the water. Disinfection by solar photocatalysis of treated wastewaterwater is especially efficient. In all these processes, studying the influence of the treatments on the quality of the purified waters and the evaluation of the impact derived from their use plays a crucial role. The development of advanced chemical analysis methods is vital for measuring the presence of contaminants at a very low concentration, up to one billionth of a gram per liter (nanogram/liter). However, when the water shortage is pressing, desalination is required to generate new fresh water. Desalination of seawater, or brackish water, using solar energy is a much-needed alternative. In this regard , the combination of membrane distillation, which requires less heat input than other processes, and the use of solar energy to provide that heat, is proposed as an alternative solution to conventional technologies.

1.4 CIESOL ORGANISATION

How does CIESOL work?

CIESOL's functional structure is made up of a Coordination and Monitoring Committee, CCS, its highest decision-making and management body; a Management Team and a set of 6 Functional Units that group researchers from institutions by different specific subject areas. It should be noted that CIESOL also has an External Evaluation Committee, CEE, with four members of recognized prestige as well as both national and

international impact. This annually assesses and supervises the scientific output 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 responsible for the maintenance and operation of the center's equipment.



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

The Coordination and Monitoring Committee, CCS, is made up of two researchers from the UAL, one of whom must be the Vice-rector for Research, Development and Innovation at the university and two researchers from the PSA, one of whom must be the Director of the Almería Solar Platform. Currently, the CCS is made up of Diego Valera (Vice-Rector for Research), Manuel Berenguel from the UAL, Julián Blanco (Director of the Almería Solar Platform) and Eduardo Zarza from the PSA.

The Coordination and Monitoring Committee is in charge of 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 suitability for the planned objectives.

Who comprises the Management Team and what does it do?

The Management Team consists of a director and an assistant director, belonging to the UAL and PSA (and vice versa). Currently, the director is Sixto Malato Rodríguez from the PSA and the assitant director is José Antonio Sánchez Pérez from the UAL. They are responsible for the allocation of spaces and resources for the different projects and work groups, the supervision of technical personnel, the maintenance of CIESOL and, in general, everything that affects the day to day operations of the center.

Who comprises the External Evaluation 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, Angela Fernández Curto, Deputy Assistant Director General for Large Scientific Technical Infrastructures (Ministry of Science, Innovation and Universities, Government of Spain), David Serrano, Director of IMDEA ENERGÍA in Madrid and Professor at the King Juan Carlos University and finally Carlos Bordons Alba, Full Professor of Systems Engineering and Automatics at the University of Seville..

The CEE is in charge of evaluating the scientific quality of CIESOL and proposing improvements. Among its duties are 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 its facilities and issues a report on its activity.

What are CIESOL's Functional Units?

Solar Resources and Solar Cooling. Its main activity is the evaluation and prediction of the solar resources, and its main researcher is Francisco Javier Batlles Garrido (UAL). It also works on remote sensing and optimization of sky cameras, as well as in the design and optimization of solar heating and cooling plants. Trigeneration.

Modeling and Control. 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 intelligent energy networks.

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

Water Treatment. It focuses its activity on the study of solar photocatalysis for the decontamination of toxic waters and the elimination of micro-contaminants and disinfection of teated wastewaterurified 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 micro-contaminants 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).

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

1.5 CENTER ACTIVITIES IN 2020

The year 2020 was marked by the impact of the COVID-19 pandemic. The research centre was closed from mid-March until the beginning of June, when it gradually returned to activity, following the guidelines of the University of Almeria in terms of prevention measures and social distancing.

With regard to the management of the centre, after a lengthy process, the agreement between CIEMAT and the UAL for the consolidation of CIESOL was signed in 2020 and published in the Official State Gazette on 28 October 2020.

BOLETÍN OFICIAL DEL ESTADO
Núm. 285 Miércoles 28 de octubre de 2020 Sec. III. Pág. 92691

III. OTRAS DISPOSICIONES

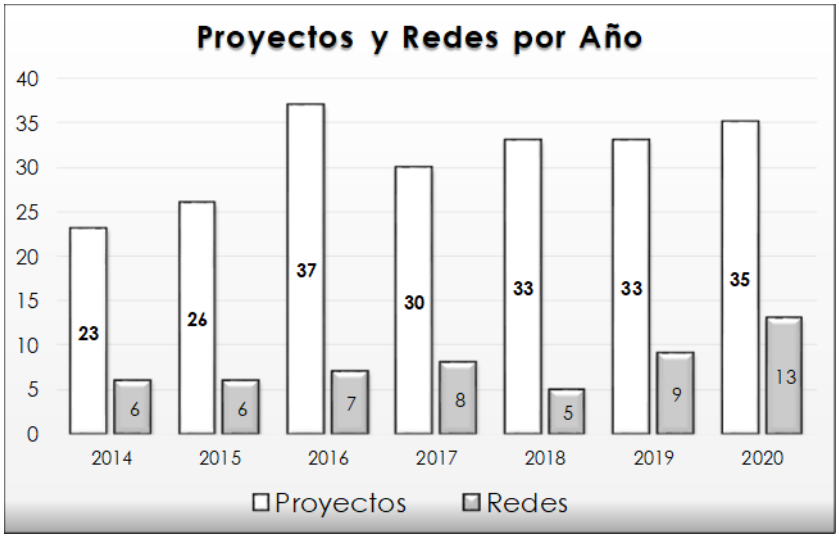
MINISTERIO DE CIENCIA E INNOVACIÓN

13071 *Resolución de 16 de octubre de 2020, de la Dirección General del Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, O.A., M.P., por la que se publica el Convenio con la Universidad de Almería, para la consolidación de un centro mixto de investigación y aplicaciones de la energía solar.*

With regard to the centre's facilities, through an agreement with the Management of the UAL, the extension of the laboratories has been planned, incorporating the courtyards, as requested by the CIESOL researchers. The works project has been drawn up and the tender has been issued, with work scheduled to be carried out in December and January. As a result, in November 2020, experimental activity at the centre was halted in order to clear the laboratories and facilitate the masonry work. However, the concessionary company did not meet the deadlines and, after the change of company, the work began in March 2021.

In the area of collaborations with companies and other institutions, in 2020 the university chair "Aqualia Chair of the integral water cycle" was created with the participation of four of the six functional units of the centre, its director and secretary being José Antonio Sánchez Pérez and Ana Agüera López, respectively. An agreement has been signed with the Andalusian Institute for Agricultural, Fisheries, Food and Ecological Production Research and Training (IFAPA) for the installation of the infrastructures of the Agroconnect project, whose main researcher is Manuel Berenguel Soria, at the IFAPA centre in La Cañada, Almeria, next to the university campus.

Ciesol maintained its research activity during 2020 through 35 research projects in progress. In addition, 41 new projects have been requested this year. The figure shows the evolution of the number of projects over the last seven years, with an average of 31 projects being carried out per year. In terms of networks, we have participated in 8 national and 5 international networks. The funding obtained through the aforementioned projects amounted to 3,950,431€ in 2020.



In terms of scientific production corresponding to 2020, a total of 123 publications have been achieved [76 in Q1 (62%), 26 in Q2 (21%), 7 in Q3 (6%) and 14 in Q4 (11%)], 65 of them with international collaboration, which represents 53% of the total, as an indicator of the international nature of the centre. All units have participated in national (7) and international (12) congresses and scientific meetings, with a total of 52 contributions. The figure shows the evolution of the number of international scientific publications in JCR over the last seven years. An average of 104 articles per year can be observed.

With regard to doctoral theses, 7 doctoral theses were defended in the UAL-PSA collaboration during 2020.

Recognitions and awards received during 2020:

CIESOL stood out in the 2020 Awards of the University of Almeria's Own Research Plan. These awards, promoted by the UAL, highlight the quality of the research carried out at the centre, with three of its groups, led by José Antonio Sánchez, Ana Agüera and Antonio Romerosa, winning the award for the best publication, and another of them, BIO263, the award for the most publications in number one journals in the JCR ranking.

The Faculty of Experimental Sciences of the University of Almeria announced the San Alberto 2020 Research Awards to the ten researchers with the best publications in their category in the JCR. Four CIESOL researchers were awarded, Ana Agüera López, Patricia Plaza Bolaños, José Luis Casas López and José Antonio Sánchez Pérez.

The TEP197 'Automation, Robotics and Mechatronics' research group, led by Manuel Berenguel, continues to reap success. In July 2020 it was chosen as a 'success story' by Mathworks, a renowned US scientific software company, which selected its work GreenhouseModels as a Service - GmaaS, which allows farmers to estimate the future climate of their greenhouse and the state of the crop based on weather forecasts, and before the end of the year it received a new international award for its contribution to teaching. The International Federation of Automatic Control, an association of Control Engineering that brings together and coordinates all the tasks, both research and teaching, in this field of knowledge worldwide, has awarded him the IFAC Teaching Innovation Award. Specifically, its proposal for the creation of an online platform to support education in control engineering, under the name 'An online benchmark for control engineering education'. The project aims to develop an open, international platform that allows students, teachers and researchers to carry out self-assessment activities using industrial process simulators.

Research dissemination and transfer activities:

Members of the Environmental Analysis unit have participated as lecturers in the series of Webinars 2020-2021 organised by the International PhD School on Advanced Oxidation Processes (IPS-AOP), with the talk on "Advances and challenges in the measurement of contaminants of emerging concern (and transformation products) in environmental matrices". As speakers at the XII Conference on the European Union: Innovation and future challenges in wastewater treatment and reclamation in the European Union, with talks on "New European regulation on water reuse". They gave a talk on "Advanced oxidation technologies for disinfection and removal of pollutants of emerging concern". Innovation and future challenges in wastewater treatment and reclamation in the European Union. Almeria Provincial Council and CIESOL. 16-20 Nov. 2020. Isabel Oller has participated as a speaker in "Polluters of growing concerns: pharmaceuticals in ground and drinking water" (2 October 2020). SME CONNECT SDG6. And the first (online) seminar of the LIFE PureAgroH2O project on "Sustainable Water Management in the Agri-Food Industry: Issues and Future Challenges" has been organised.

As in previous years, the members of the Water Regeneration unit participated in the European Researchers' Night 2020, an activity carried out within the framework of the European scientific dissemination project OpenResearchers approved by the European Commission in the call for Marie Sklodowska-Curie actions. In addition, it has also participated in activities prior to the European Researchers' Night by disseminating research in secondary schools. It also participated in the 'Café con Ciencia' activity, which promotes meetings between scientists and small groups of secondary and high school students and their respective teachers in Andalusia, with the aim of sharing experiences and bringing young people closer to research. Members of the functional unit have collaborated in this activity which, given the health emergency situation, has been carried out via an online platform. Name of the round table: Is there water for everything, held on 5 November 2020. Organised the XIIth CONFERENCE ON THE EUROPEAN UNION. "Innovation in Wastewater Treatment and Regeneration in the European Union" Almeria, 16-20 November 2020. At the final conference associated with the ALICE (H2020) project, held on-line on 4 December 2020, Dr. Inmaculada Polo presented the paper entitled: "Reuse of reclaimed wastewater: assessment of chemical and biological cross-contamination and phytotoxicity on crops". And finally, an ORAL presentation entitled "ALCHEMIA preliminary Spanish results" was given at the seminar of the LIFE ALCHEMIA project "Purification of Drinking Water from Natural Radionuclides and Management Options for NORM" held on 3 and 4 March 2020, in Viimsi (Estonia).

The Modelling and Control unit participated in the following events:

- Advanced Course Technological Innovation for intensive greenhouse production. Conference title: Digitalizing the greenhouse agriculture. Organising Society/Institution: Mediterranean Agronomic Institute. Researchers: Francisco Rodríguez Díaz. Year: 2020. Venue: Cajamar Foundation Experimental Station "Las Palmerillas".
- Agro-Athenaeum. Title of the conference: IoT: the big brother tech. Organising Society/Institution: La Voz de Almería, Ser Agricultor, Agricultura 2000. Researchers: Francisco Rodríguez Díaz. Year: 2020. Place: Fundación Tecnova
- Conference. Title of the conference: Big Data and Artificial Intelligence, Improve the profitability of your crops. Organising Company/Institution: Junta de Andalucía, Grupo Operativo RENTIA and COEXPHAL. Year: 2020. Place: Coexphal
- TAIDA Seminar. Title of the conference: Modelling and control of irrigation and fertilisers in greenhouses. Organising Society/Institution: UPCT. Year: 2020. Place: Cartagena
- Agora Agronomists. Title of the conference: Agriculture 4.0. Organising Society/Institution: Colegio Oficial de Ingenieros Agrónomos de Andalucía. Year: 2020. Place: Colegio Oficial de Ingenieros Agrónomos de Andalucía.
- Exhibition "The UAL shows its face for Science".
- Qualifying Tournament of the FIRST Lego League
- III Conference on Automatics, Robotics and Mechatronics
- Robotics Club Challenge of the University of Almeria
- European Researchers' Night, Almeria
- Science Week, Almeria
- Robotics Club
- Science Window

- European Robotics Week
- Girls Technology Campus
- Computer Science Week
- Visit your University
- La Salle 2020 Business Classroom Fair
- Science News in Almeria

The Desalination and Photosynthesis unit collaborated in the following events:

- "Renewable energy desalination in the WEF Nexus", Webinar "Technology options for the Water-Energy-Food nexus" organised by EU-GCC Clean Energy Technology Network ("Addressing the Water-Energy- Food (WEF) Nexus in the context of Climate Change and Sustainable Development"), 14 October 2020.
- Performance tests of commercial systems", in the Webinar Panel Discussion on Thermal Desalination by Membrane Distillation ("International Colloquia on Thermal Innovations") organised by MIT, 10 November 2020.
- MOOC course entitled "Microalgae Biotechnology" of the University of Almeria, which was taught in its second and third edition through the Miriada X platform (www.miriadax.net).

2. ACTIVITIES OF CIESOL

2.1 ACTIVITIES OF "ORGANOMETALLICS AND PHOTOCHEMISTRY"

2.1.1 Functional unit description

In 2020 the unit was constituted by 9 members (3 university professors, 3 researchers, 1 predoctoral contract and 3 postdoctoral cntract) 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 (> 230 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.

2.1.2 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.

2.1.3 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 150 international refereed papers, 15 Spanish and international patents and made more than 250 presentations at national and international meetings. He has been responsible for more than 20 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.

2.1.4 Summary of the functional unit's activities carried out in CIESOL during 2020

During 2020 the group has continued its renewal with the incorporation of new members thanks to youth employment contracts, pre-doctoral students, several undergraduate and master students and a foreign student on a pre-doctoral stay. During 2020, the training of PhDs and the publication of articles in the best journals in the field of chemistry, inorganic chemistry and materials continued. It has also extended the effort in the AACI project achieved in 2017 for the development of Latin American countries, which together with contracts with companies, will allow it to continue its research activity in the coming years.

2.1.5 Collaboration with other functional units of CIESOL during 2020

In 2020 started a collaboration with the Water Treatment Unit. Results are being evaluated.

2.1.6 Human resources of the Functional Unit

Visits and research stays in CIESOL:

- Due to the pandemic, none of the events planned for 2020 could take place..

Research stays of CIESOL researchers in other institutions:

- Due to the pandemic, none of the events planned for 2020 could take place.

Students in curricular internships

- Belen Lopez Sanchez, PhD Thesis in Chemistry
- Jose Veiga del Pino, PhD Thesis in Chemistry
- Andrés Alguacil Alarcón, PhD Thesis in Chemistry
- Juan Alfredo Cayuela Castillo, Final Degree Project in Chemistry
- Alverto Barros Pardo, Final Degree Project in Chemistry
- Cristina Campoy Muñoz, Final Master's Thesis in Advanced Laboratory Chemistry

2.1.7 Scientific production

Number of papers	Number of papers in each Quartile				Number of papers with international collaboration
	Q_1	Q_2	Q_3	Q_4	
2	2				1

Papers

- First exfoliated Ru–Ru–Au organometallic polymer with layered structure. Franco Scalambra, Benjamin Sierra-Martin, Manuel Serrano-Ruiz, Antonio Fernandez-Barbero, Antonio Romerosa,* Chemical Communication, 2020, 56, 9441-9444. DOI: 10.1039/d0cc04325g.
- BACK COVER de Chemical Communication, 25 August 2020, Issue 66, F. Scalambra, A. Romerosa. DOI: https://doi.org/10.1039/D0CC90356F
- Steps ahead in understanding the catalytic isomerization mechanism of linear allylic alcohols in water: dynamics, bonding analysis and crystal structure of a □2-allyl-intermediate. Franco Scalambra, Belen Lopez-Sanchez, Nicole Holzmann, Leonardo Bernasconi, Antonio Romerosa,* Organometallics 2020, 39, 24, 4491–4499. DOI: 1https://0.1021/acs.organomet.0c00585

Congress assistance

- Synthesis and characterization of the hydrosoluble luminiscent ruthenium complex cis-[Ru(dcBpyH)2(PTAH)2]Cl2: a possible new agent for the selective Cd2+ sensors. José Manuel Veiga del Pino, Franco Scalambra and Antonio Manuel Romerosa Nievas. EWPC17-February 26-28, 2020, Rennes, France. P26.
- Due to the pandemic it was not possible to participate in more during 2020.

Congress contributions

- Due to the pandemic it was not possible to participate in more during 2020.

Congress organization

- Due to the pandemic it was not possible to participate in more during 2020.

2.1.8 Staff members

Antonio Manuel Romerosa Nievas

Main Researcher
UAL
romerosa@ual.es
(+34) 950 015 305

Christoph Richter

Main Researcher
DLR-PSA CIEMAT
christoph.richter@dlr.de
+(34) 950 271486

Pablo Antonio Lorenzo Luis

Full Professor
Univ. La Laguna

Isaac de los Rios Hierro

Full Professor
Univ. Cádiz

Cristóbal Saraiba Bello

PhD Researcher
UAL

Franco Scalambra

PhD Researcher
UAL

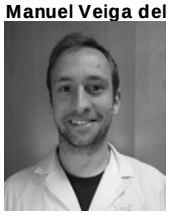
Belén López Sánchez

PhD Student
UAL

Sonia Mañas Carpio

PhD Researcher
UAL

José Manuel Veiga del Pino



PhD Student
UAL

Lourdes Sánchez

PhD Researcher
UAL-CTAP

2.1.9 Ongoing projects in 2020

2.1.9.1 Water soluble fluorescent heterometallic polymers.

Participants:

Grupo de Inv. "Química de Coordinación, Organometálica y Fotoquímica". Universidad de Almería (FQM-317)

Contacts:

A. Romerosa Nievas (romerosa@ual.es)

Funds:

Grupo FQM-317

Time Period:

No planned completion time.

Current situation:

In progress.

Summary

The project is targeted to the design of new heterometallic polymers with gel and fluorescent properties in water, which can be confined in a matrix that increase their respond to environment variations.

Objectives.

The ultimate goal is to obtain sensors that are able to tune their optical response against common explosives both in dissolution and vapours.

2.1.10 Participation in networks during 2020

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

2.1.11 Transfer and Complementary Activities

Due to the pandemic it was not possible to participate in more during 2020.

2.1.12 Dissemination activities

Especial I+D+i number published in Actualidad Económica, El Mundo, 22-28/3/2020 (https://www.elmundo.es/elmundo/hemeroteca/2020/03/22/m/index.html).

2.1.13 Project's applications in 2020

PID2020-115492GB-I00, title: Procesos Photoactivados En Agua Catalizados Por Complejos De Rutenio Con Fosfinas Acuosolubles.

2.1.14 Others

Final degree and master projects

- Alberto Barros Pardo (Degree in Chemistry). Complejos de Ru(II) fotoactivables con propiedades antiproliferativas/ Photoactivable Ru(II) complexes with antiproliferative activity.
- Juan Alfreso Cayuela Castillo (Degree in Chemistry). Fotoisomerización catalítica de propenol en agua: una novesosa estrategia respetuosa con el medio ambiente / catalytic photoisomerization of propenol in water: a novel environmentally friendly strategy.
- Cristina Campoy Muñoz (Master's Degree in Advanced Chemistry Laboratory). Complejos de rutenio citotóxicos fotoactivables.
- Maria Belen Lopez Sanchez (Master's Degree in Advanced Chemistry Laboratory). Síntesis y caracterización de los complejos acuosolubles $[RUCp(PTA)_2(\eta^2\text{-}CH_2{=}CH\text{-}CHOH\text{-}(CH_2)_4\text{-}CH_3)](CF_3SO_3)$ Y $[RUCp(PTA)_2(\eta^2\text{-exo-}CH_2{=}CH\text{-}CHOH\text{-}(CH_2)_4\text{-}CH_3)](CF_3SO_3)$.

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.

2.2 ACTIVITIES OF " ENVIRONMENTAL ANALYSIS"

2.2.1 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).

2.2.2 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.

2.2.3 Main researchers

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 more than 28 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 research projects, in 10 of them as principal investigator. She is co-author of 2 patents and 162 scientific publications in international indexed journals (h-index=57, February, 2021). She has co-directed 10 doctoral theses and participated in more than 150 conference papers. She is the author of 3 books and 12 book chapters and has participated in the organisation of 8 international conferences.

Isabel Oller Alberola (ORCID ID: 0000-0002-9893-6207; Scopus Author 8415190600)

Researcher 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 (5^{th}, 6^{th} & 7^{th} EU FP, H2020). 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 129 publications in indexed scientific international journals and more than 130 contributions to different International Congresses and Symposiums (until February 2020). She has also

participated as teacher in some national and international curses and masters related with Advanced Treatment of Wastewater. H-index (February 2020): 41.

2.2.4 Summary of the functional unit's activities carried out in CIESOL during 2020

In general, it should be noted that the government's declaration of a state of alarm in March, triggered by the COVID-19 pandemic, has led, to a greater or lesser extent, to delays in some programmed activities of ongoing projects.

In the ANBAGENS project, the development of an analytical method for the determination of 30 target antibiotics by LC-QqLIT-MS/MS in water and tomato has been completed. The samples are also being analysed by high-resolution mass spectrometry (LC-QqTOF-MS), which will make it possible to process them in search of new compounds not included in the target method, as well as to identify possible transformation products generated during treatment. Microbiological analyses have also been fine-tuned, including E. coli, total coliforms, Pseudomonas aeruginosa, E. coli resistant to carbapenem antibiotics and 3rd generation cephalosporins and Pseudomonas aeruginosa resistant to carbapenem antibiotics.

The sampling plan has been initiated on 4 farms with intensive cultivation of tomatoes of different varieties under plastic, and which are irrigated with reclaimed water from the Las 4 Vegas irrigation community. Sampling is being carried out in the water storage ponds of the farms, and directly in the irrigation drippers. Samples of fruit and leaves of tomato plants are also being collected. At the same time, analyses are being carried out at different points of the reclamation plant, including: incoming raw water (secondary effluent from the El Bobar WWTP), water leaving the sand filters, water leaving the chlorination treatment and water at the point of distribution to the farmers, after passing through the storage pond, in order to determine whether the water supplied suffers any deterioration in quality during transport and storage (plant pond and farm ponds) after treatment. In addition to the chemical and microbiological analyses, the characterisation of the water is being completed with physical-chemical analyses (pH, turbidity, conductivity, TC, IC, DOC, F^-, Cl^-, NO_2, Br^-, NO^{3-}, PO_4^{3-}, $SO_4^=$, Na^+, K^+, NH_4^+, Mg^{2+}, Ca^{2+}, free chlorine and total chlorine).

Regarding the activities derived from the LIFE PureAgroH2O project, the Mid-Term report of the project was finalised in July, which was positively evaluated by EASME. The exceptional situation caused by the pandemic has, however, caused delays in the construction by the Demokritos group of the pilot plant that is expected to be installed in the company Cítricos del Andarax (Almeria). This was completed in December 2020 and after the necessary adjustments for correct operation, which are being carried out by the Greek group, it is expected to be received at the end of February 2021. Work has continued on the dissemination activities, organising the 1st workshop of the project in Spain, which has been carried out in an on-line format, with great success in terms of attendance and participation.

The activities carried out in the LIFE ULISES project are described in greater detail in the report of the Water Regeneration Unit. The Environmental Analysis Unit has proceeded to update and improve the method of analysis of emerging pollutants available in the laboratory. The acquisition of a new UHPLC system and the renewal of the control and processing software of the LC-QqLIT-MS/MS equipment, financed by the FEDER 2018 scientific-technical infrastructure and equipment plan, has enabled the development of a more efficient method, with high resolution and shorter analysis times, as well as increasing the number of compounds to be analysed. This method has been applied to the analysis of the project samples.

The PANI WATER project, funded by the European Union's H2020 Programme, started in February 2019 under the leadership of Dr Isabel Oller, with CIESOL's Environmental Analysis Unit joining as a third party in 2020. The

project aims to treat wastewater and drinking water from peri-urban and rural areas in India that are highly contaminated with contaminants of emerging concern (CECs), such as pesticides, pharmaceutical and personal care materials or antibiotics, as well as pathogenic microorganisms. The project will test the application of six prototypes for this purpose, which will be implemented in-situ. Throughout the first year of implementation of this project, the PSA has evaluated the efficiency of different advanced oxidation processes based on UV/H2O2, UV/persulphate and solar/chlorination to find the most suitable CEC and pathogen removal strategy to scale up in a DEMO in India. CIESOL will evaluate the effectiveness of the applied treatments by analysing CEC and disinfection by-products before and after the treatments studied in PSA and in the DEMO to be installed in India.

Two new projects have started during 2020, LIFE PHOENIX (LIFE19 ENV/ES/000278), with a start date of 01/09/2020 and the NAVIA project (PID2019-110441RB-C31) of the State Programme for R&D&I Oriented to the Challenges of Society, which started in July. In both projects, work is being carried out on the selection of pollutants to be analysed and fine-tuning of the necessary methods.

2.2.5 Collaboration with other Functional Units of CIESOL during 2020

In 2020 the collaboration with the Water Regeneration unit has been maintained, with which joint projects are being carried out:

- LIFE PureAgroH2O (LIFE17 ENV/GR/000387)
- LIFE ULISES (LIFE18 ENV/ES/000165)
- LIFE PHOENIX (LIFE19 ENV/ES/000278)
- NAVIA (PID2019-110441RB-C31)

2.2.6 Human resources of the Functional Unit

During 2020 they left the Functional Unit due to the end of their contracts:

- Ms Marina Celia Campos Mañas (30/06/2020), who after the defence of her doctoral thesis obtained a Juan de la Cierva training contract at the University Jaume I of Castellón.
- Ana Belén Martínez Piernas (31/12/2020), who has obtained a doctoral research staff contract awarded by the Andalusian Regional Government at the University of Jaén.
- Ms. Carmen María Morales Álvarez, due to the end of her one-year contract funded by the Youth Employment Operational Programme 2014 - 2020.
- Mr Leónidas Armando Pérez Estrada (07/2020), due to the end of his Ramón y Cajal contract.
- Ms Ángela González García has joined, with a research contract under the ANBAGENS project.

Postdoctoral contracts:

- Ana Ruiz Delgado. October, 2020. Research contract corresponding to the postdoctoral phase of the PIF 2012 (Research project with reference P-12-RNM-1739).
- Irene Salmerón. November, 2020. Research contract under the PANI WATER project.

Visits and research stays in CIESOL

- Massimo Dell'Ederda. Università di Bari, Italia (02/03/2020-13/03/2020; 08/09/2020-27/11/2020).

Students in curricular internships

- Esther Mangas. Degree in Chemistry.

2.2.7 Scientific production

Number of papers	Number of papers in each Quartile				Number of papers with international collaboration
	Q_1	Q_2	Q_3	Q_4	
17	14	2		1	8

Papers

- A global multinational survey of cefotaxime-resistant coliforms in urban wastewater treatment plants. Marano, R.B.M., Fernandes, T., Manaia, C.M., Nunes, O., Morrison, D., Berendonk, T.U., Kreuzinger, N., Telson, T., Corno, G., Fatta-Kassinos, D., Merlin, C., Topp, E., Jurkevitch, E., Henn, L., Scott, A., Heß, S., Slipko, K., Laht, M., Kisand, V., Di Cesare, A., Karaolia, P., Michael, S.G., Petre, A.L., Rosal, R., Pruden, A., Riquelme, V., Agüera, A. et al. Environment International, 144, art. no. 106035, 2020. DOI: 10.1016/j.envint.2020.106035
- Olive mill wastewater reuse to enable solar photo-Fenton-like processes for the elimination of priority substances in municipal wastewater treatment plant effluents. Ruíz-Delgado, A., Roccamante, M.A., Malato, S., Agüera, A., Oller, I. Environmental Science and Pollution Research, 27 (30), pp. 38148-38154, 2020. DOI: 10.1007/s11356-020-09721-0
- Determination of dextromethorphan and dextrorphan solar photo-transformation products by LC/Q-TOF-MS: Laboratory scale experiments and real water samples analysis. Campos-Mañas, M.C., Cuevas, S.M., Ferrer, I., Thurman, E.M., Sánchez-Pérez, J.A., Agüera, A. Environmental Pollution, 265, art. no. 114722. DOI: 10.1016/j.envpol.2020.114722.
- Investigating the impact of UV-C/H2O2 and sunlight/H2O2 on the removal of antibiotics, antibiotic resistance determinants and toxicity present in urban wastewater. Michael, S.G., Michael-Kordatou, I., Nahim-Granados, S., Polo-López, M.I., Rocha, J., Martínez-Piernas, A.B., Fernández-Ibáñez, P., Agüera, A., Manaia, C.M., Fatta-Kassinos, D. Chemical Engineering Journal, 388, art. no. 124383, 2020. DOI: 10.1016/j.cej.2020.124383.
- Removal of contaminants of emerging concern by continuous flow solar photo-Fenton process at neutral pH in open reactors. Arzate, S., Campos-Mañas, M.C., Miralles-Cuevas, S., Agüera, A., García Sánchez, J.L., Sánchez Pérez, J.A. Journal of Environmental Management, 261, art. no. 110265, 2020. DOI: 10.1016/j.jenvman.2020.110265.
- Advanced evaluation of landfill leachate treatments by low and high-resolution mass spectrometry focusing on microcontaminant removal. Ruiz-Delgado, A., Plaza-Bolaños, P., Oller, I., Malato, S., Agüera, A. Journal of Hazardous Materials, 384, art. no. 121372, 2020. DOI: 10.1016/j.jhazmat.2019.121372.
- Advanced treatment of urban wastewater by UV-C/free chlorine process: Micro-pollutants removal and effect of UV-C radiation on trihalomethanes formation. Cerreta, G., Roccamante, M.A., Plaza-Bolaños, P., Oller, I., Aguera, A., Malato, S., Rizzo, L. Water Research, 169, art. no. 115220, 2020. DOI: 10.1016/j.watres.2019.115220.
- Wastewater treatment by advanced oxidation process and their worldwide research trends. Garrido-Cardenas, J.A., Esteban-García, B., Agüera, A., Sánchez-Pérez, J.A., Manzano-Agugliaro, F. International Journal of Environmental Research and Public Health, 17 (1), art. no. 170, 2020. DOI: 10.3390/ijerph17010170.
- Fresh-cut wastewater reclamation:Techno-Economical assessment of solar driven processes at pilot plant scale. Nahim-Granados, S., Rivas-Ibáñez, G., Sánchez-Pérez, J.A., Oller, I., Malato, S., Polo-López, M.I. Applied Catalysis B: Environmental, 278 (2020) 119334.

https://doi.org/10.1016/j.apcatb.2020.119334.

- New approaches to solar Advanced Oxidation Processes for elimination of priority substances based on electrooxidation and ozonation at pilot plant scale. Roccamante, M., Salmerón, I., Ruiz, A., Oller, I., Malato, S. Catalysis Today, 355 (2020) 844–850. https://doi.org/10.1016/j.cattod.2019.04.014.
- New trend on open solar photoreactors to treat micropollutants by photo-Fenton at circumneutral pH: Increasing optical pathway. Costa, E.P., Roccamante, M., Amorim, C.C., Oller, I., Sánchez-Pérez, J.A., Malato, S. Chemical Engineering Journal, 385 (2020) 123982. https://doi.org/10.1016/j.cej.2019.123982.

- Modelling persulfate activation by iron and heat for the removal of contaminants of emerging concern using carbamazepine as model pollutant. Cabrera-Reina, A., Miralles-Cuevas, S., Oller, I., Sánchez-Pérez, J.A., Malato, S. Chemical Engineering Journal, 389 (2020) 124445. https://doi.org/10.1016/j.cej.2020.124445.
- The influence of location on solar photo-Fenton: Process performance photoreactor scaling-up and treatment cost. Cabrera Reina, A., Miralles-Cuevas, S., Cornejo, L., Pomares, L., Polo, J., Oller, I., Malato, S. Renewable Energy, 145 (2020) 1890-1900. https://doi.org/10.1016/j.renene.2019.07.113.
- Electro-oxidation process assisted by solar energy for the treatment of wastewater with high salinity. Salmerón, I., Oller, I., Malato, S. Science of the Total Environment, 705 (2020) 135831. https://doi.org/10.1016/j.scitotenv.2019.135831.
- Best available technologies and treatment trains to address current challenges in urban wastewater reuse for irrigation of crops in EU countries. L. Rizzo, W. Gernjak, P. Krzeminski, S. Malato, C. S. McArdell, J. A. Sanchez-Perez, H. Schaar, D. Fatta-Kassinos. Science of the Total Environment, 710 (2020) 136312. https://doi.org/10.1016/j.scitotenv.2019.136312.
- Synthetic fresh-cut wastewater disinfection and decontamination by ozonation at pilot scale. Nahim-Granados, S., Rivas-Ibañez, G., Sánchez-Perez, J.A., Oller, I., Malato, S., Polo-Lopez, M.I. Water Research, 170 (2020) 115304. https://doi.org/10.1016/j.watres.2019.115304.
- Samira Nahim Granados, Ana Agüera López, Isabel Oller Alberola, Sixto Malato Rodríguez, José Antonio Sánchez Pérez, Inmaculada Polo López. Agua residual y economía circular en la industria de IV gama: aplicación de procesos solares y ozono para la regeneración y reutilización agrícola a escala piloto. Revista sobre tendencias en la I+D+i de la PTA, 2, 38-41. 2020.

Congress assistance

- 16th Annual Workshop on emerging high-resolution mass spectrometry (HRMS) and LC-MS/MS applications in environmental analysis and food safety. Online, 15-16 octubre 2020.

Congress contributions

- Identification of transformation products of pharmaceuticals in real-field agricultural environments irrigated with reclaimed water by retrospective analysis by LC-QTOF-MS/MS. A.B. Martínez-Piernas, P. Plaza Bolaños, A. Agüera. 16th Annual Workshop on emerging high-resolution mass spectrometry (HRMS) and LC-MS/MS applications in environmental analysis and food safety. Online, 15-16 octubre 2020.. Comunicación oral.

Book Chapters

- Removal and Degradation of Pharmaceutically Active Compounds (PhACs) in Wastewaters by Solar Advanced Oxidation Processes. Sixto Malato, Jaime Giménez, Isabel Oller, Ana Agüera, José Antonio Sánchez Pérez. In: Removal and Degradation of Pharmaceutically Active Compounds in Wastewater Treatment. Sara Rodriguez-Mozaz, Paqui Blánquez Cano, and Montserrat Sarrà Adroguer (eds.). Springer Nature Switzerland AG 2020. 2020.
- Removal of contaminants of emerging concern by microalgae-based wastewater treatments and related analytical techniques. A. Agüera, P. Plaza-Bolaños, F.G. Acién Fernández. In: Current Developments in Biotechnology and Bioengineering. Emerging Organic Micro-Pollutants. Elsevier. 2020

PhD Thesis

- Evaluation of electrochemical treatments assisted by solar energy for water depuration. Irene Salmerón. Universidad de Almería, 25/09/2020, Sobresaliente CUM LAUDE.

2.2.8 Staff members

Ana Agüera López

Main Researcher
Professor UAL
aaguera@ual.es
(+34) 950 215 531
www.ciesol.com

Isabel Oller Alberola

Main Researcher
Senior Researcher OPI - CIEMAT-PSA
isabel.oller@psa.es
(+34) 950 387 993
www.psa.es

Sixto Malato Rodríguez

Senior Researcher OPI.
CIEMAT-PSA

Patricia Plaza Bolaños

Post-doc Researcher
UAL

Ana Ruiz Delgado

PhD Student
PSA

Ricardo Sánchez

Senior Researcher OPI
CIEMAT-PSA

Leónidas Pérez Estrada

Ramón y Cajal Post-doc
CIEMAT

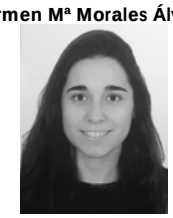
Azahara Martínez García

PhD Student
CIEMAT-PSA

Ana Belén Martínez Piernas

Post-doc Researcher
UAL

Carmen Mª Morales Álvarez



National Youth Guarantee Grant
UAL

Ilaria Berruti

PhD Student
CIEMAT-PSA

Marina Celia Campos Mañas

PhD Student
UAL

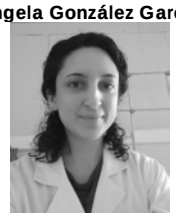
Melina Roccamante

PhD Student
CIEMAT-PSA

Dennis Deemter

PhD Student
CIEMAT-PSA

Ángela González García



Contratada proyecto
UAL

2.2.9 Ongoing projects in 2020

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

Participants:

Functional Unit of "Environmental Analysis"

Contacts:

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

Funds:

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

Time Period:

July 2018 – December 2021

Current Situation:

In progress (3rd annuity)

Summary:

LIFE PureAgroH2O is a demonstration project aimed at developing a photocatalytic nanofiltration reactor (PNFR) using a previously developed and patented water purification device based on the use of advanced photocatalytic monoliths and visible light activated photocatalysts (VLA) stabilised with porous polymeric fibre, which has been designed to effectively remove organic substances from wastewater. The innovation of the reactor lies in the synergy between two of the most efficient processes for the removal of pesticides from agricultural wastewater: nanofiltration (NF) and photocatalysis. This synergy provides a significant intensification of the process which, in turn, allows for a reduction in reactor size (investment costs) and a decrease in operational cost (running costs). The consortium aims to guarantee the autonomous operation of the process by providing a stable efficiency that will not depend on seasonal conditions (solar irradiation) and the composition of the agricultural wastewater. Additionally, the possibility of achieving a 60% reduction

in the required transmembrane pressure allows for a significant extension of the lifetime of the process (2 times) and a higher efficiency in the removal of organic and inorganic pollutants (>99.5%).

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

Participants:
Functional Units "Environmental Analysis"
Contacts:
A. Agüera (aaguera@ual.es)
Funds:
Programa Operativo FEDER-Andalucía 2014-2020
Time Period:
October 2019 – September 2021.
Current Situation:
In progress (1 annuity)
Summary:

The deficit of water resources is especially notable in arid and semi-arid areas such as the south of Spain and Andalusia, and is accentuated in periods of drought, which are becoming more frequent, and in a context of climate change. In the search for alternative resources, non-conventional resources such as reclaimed urban wastewater (RWW) are an effective alternative that can be used in various activities. However, it has been shown that reclaimed UWW can contain relevant concentrations of antibiotics and their transformation products (TP), while also acting as a propagator of antibiotic resistant bacteria and genes (ARB and ARG). A proper assessment of reuse practices is therefore necessary, especially in such sensitive applications as irrigation of crops for consumption, to ensure protection of both the environment and the consumer. From a socio-economic point of view, this information will help to increase public confidence in fruit and vegetable products produced under these conditions and to reduce the generalised suspicion that this causes. From a scientific point of view, it is essential to deepen the knowledge of the presence and behaviour of these chemical and microbiological contaminants in the Water-Soil-Plant nexus, providing information about their accumulation, distribution, persistence and assimilation/translocation by the plant. This information will be essential for an assessment of the emerging risk associated with these practices, and will serve as a basis for the establishment, where appropriate, of quality criteria necessary for the protection of the environment and human health. The ANBAGENS project will comprehensively 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 Almeria, irrigated with real reclaimed WUA.

El proyecto engloba el desarrollo de métodos de análisis para la determinación de antibióticos y sus PT, ARB y ARG en los que se considerarán (i) antibióticos de amplio uso en España y antibióticos ampliamente reportados en ARU tratadas; y (ii) la Lista de Patógenos Prioritarios de la OMS para bacterias y antibióticos que presentan Prioridad Crítica o Alta, tales como Acinetobacter baumannii (resistente a carbapenémicos), Pseudomonas aeruginosa (resistente a carbapenémicos), Enterobacteriaceae (resistente a carbapenémicos y a cefalosporinas de 3ª generación). Los resultados obtenidos contribuirán a cubrir el vacío de información actual en aspectos como la eficacia de los tratamientos de regeneración en la eliminación de ARB y ARG y el posible recrecimiento a lo largo del sistema de riego (almacenamiento y transporte), el efecto de la exposición a largo plazo a mezclas de antibióticos o a sus potencialmente tóxicos PT o el comportamiento de los contaminantes condiciones reales de cultivo.

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

Participants:

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

Contacts:

J. L. Casas López (jlcasas@ual.es)

Funds:

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

Time Period:

July 2019 – June 2022

Current Situation:

In progress

Summary:

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

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

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

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

Participants:

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

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:

February 2019 – Junuary 2023

Current Situation:

In progress

Summary:

Wastewater and drinking water in peri-urban and rural areas of India are contaminated by contaminants of emerging concerns (CECs), such as pesticides, pharmaceutical and personal care materials or antibiotics. The EU-funded PANI WATER project aims to scale up and confirm six prototypes that remove CECs and other pollutants from wastewater. The project will be implemented on site and in liaison with local stakeholders. Indeed, PANI WATER places particular emphasis on understanding the social context in which the technologies will potentially be deployed and will review potential health and social impacts to provide quality analysis. It will also support wastewater treatment for safe water reuse in agriculture, related industries and public water structures. CIESOL's activity focuses on the development, optimisation and analytical assessment of advanced wastewater treatment processes applied to complex effluents in order to achieve their regeneration and enable their possible reuse.

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

Participants:

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

Contact:

J. L. Casas López (jlcasas@ual.es)

Funds:

European Union. LIFE Environment and Resource Efficiency (LIFE19 ENV/ES/000278)

Time Period:

September 2020 – February 2024

Current Situation:

In progress

Summary:

Water scarcity in Europe is increasing due to climate change, especially in water-stressed areas, particularly in southern countries (ES, PT, CY, GR, IT). Agriculture is the most important water use in the EU, accounting for about 40% of annual EU water use, but increases to 80% of water use in the Mediterranean areas during summer. Wastewater reuse in the EU is still limited and is mainly implemented in countries with water scarcity problems. Most reuse is for irrigation purposes and some countries already irrigate mainly using reclaimed water. The publication of the European Parliament and Council Regulation on minimum requirements for water reuse introduces further restrictions on certain maximum permitted values (suspended solids, turbidity, BOD5 and E. coli, coliphages and bacterial spore-forming pathogens).

These requirements will oblige WWTPs to upgrade their treatment systems or incorporate new ones. In addition, water reuse must take into account scientific progress regarding contaminants of emerging concern: pharmaceuticals and personal care products, pesticides, disinfection by-products, microplastics and other pollutants, the potential effects of which can be very serious. In this context, LIFE PHOENIX will demonstrate a novel modular and flexible solution for the sustainable and safe production of reclaimed water for agricultural irrigation.

2.2.9.6 Urban wastewater reclamation using new materials and advanced solar technologies operated in continuous operation: analysis of new treatment quality indicators (NAVIA)

Participants:

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

Contact:

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:

Ministerio de Ciencia e Innovación (PID2019-110441RB-C31)

Time Period:

June 2020 – May 2023

Current Situation:

In progress

Summary:

The main objective of the NAVIA project is the development of new methods of urban wastewater reclamation through the development of new photocatalysts and technologies based on solar advanced oxidation processes (AOP), operated in continuous flow in low-cost reactors. To ensure the quality and safety of reused water, the objectives of the processes will be the simultaneous removal of microbial pathogens, such as E. coli, total coliforms, coliphages (somatic and RNA-specific bacteriophages), antibiotic resistant bacteria and their genes (ARB and ARG), and the removal of organic micropollutants (OMC). The ultimate goal is to comply with Spanish legislation (RD 1620/2007) and future regulations, such as the recent European Parliament proposal of February 2019 (EC COM 337 final, 2018/0169).

To achieve these objectives, three distinct but interspersed 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 pilot-scale solar AOPs as tertiary treatments of real WWTP effluents.
- The development of effective and efficient solutions based on solar energy in continuous flow operation.

2.2.10 Participation in networks during 2020

Participation in the "Iberoamerican Solar Water Treatment Network (REDES180149)". Programme to Support the Formation of International Networks between Research Centres, Call 2018. CONICYT International Cooperation Programme. University of Tarapacá (Chile).

2.2.11 Transfer and Complementary Activities

Stefanos Giannakis, Sami Rtimi, Ricardo A. Torres-Palma, Sixto Malato. “Light-Assisted Catalysis for Water and Wastewater Treatment”. Appl. Catal. B: Environ., Article collections, 2020. 31 artículos.

2.2.12 Dissemination activities

Members of the group have participated as lecturers in the series of Webinars 2020-2021 organised by the International PhD School on Advanced Oxidation Processes (IPS-AOP), with the talk on "Advances and challenges in the measurement of contaminants of emerging concern (and transformation products) in environmental matrices".

Members of the group participated as speakers at the XII Conference on the European Union: Innovation and future challenges in wastewater treatment and reclamation in the European Union, with talks on "New European regulation on water reuse".

Talk on "Advanced oxidation technologies for the disinfection and elimination of pollutants of emerging concern". Innovation and future challenges in wastewater treatment and reclamation in the European Union. Almeria Provincial Council and CIESOL. 16-20 Nov. 2020.

Isabel Oller has participated as a speaker in "Polluters of growing concerns: pharmaceuticals in ground and drinking water" (2 October 2020). SME CONNECT SDG6.
The first seminar (online) of the LIFE PureAgroH2O project has been organised on "Sustainable Water Management in the Agri-Food Industry: Issues and Future Challenges".

2.2.13 Project's applications in 2020

- "Valorization of wastewater as raw material for solar-driven hydrogen production: comprehensive chemical characterization of the produced gas and treated water effluents". Research Talent Recruitment Programme EMERGIA. Patricia Plaza. Pendiente de resolución.
- Mejora en la resiliencia del ciclo urbano del agua: diagnóstico de los sistemas de depuración y potabilización existentes y propuesta de tratamientos alternativos a la cloración (RECIVIR). Convocatoria de subvenciones a «proyectos de I+D+i» universidades y entidades públicas de investigación, Junta de Andalucía. Ana Agüera. Pendiente de resolución.
- Valorización del agua residual como materia prima para la producción solar de hidrógeno desde una perspectiva química verde (RAHDOS). Programa Estatal de I+D+i Orientada a los Retos de la Sociedad. Modalidad de proyectos de I+D+I para jóvenes investigadores sin vinculación o con vinculación temporal. Patricia Plaza Bolaños. Pendiente de resolución.
- No-Toxic Environment - Framework for the Detection, Assessment, and Remediation of PFAS Chemicals. Programa H2020 EU, TOPIC ID: LC-GD-8-1-2020 / RIA Research and Innovation action. Patricia Plaza Bolaños. Pendiente de resolución.

2.2.14 Others

Final degree projects

- Celia Sánchez Vallejo (Master's Degree in Advanced Chemistry Laboratory). "Tendencias y aplicaciones actuales del modo de adquisición SWATH en la determinación de contaminantes orgánicos en muestras medioambientales, alimentarias y biológicas".
- José Francisco Ramón Torres (Degree in Chemistry). "Búsqueda de productos de transformación de ciprofloxacino y levofloxacino en aguas residuales mediante la estrategia de *Suspect Screening* ".
- Sandra Escánez Capel (Degree in Chemistry). "Determinación de antibióticos en aguas residuales mediante extracción QuEChERS y análisis por cromatografía de líquidos acoplada a espectrometría de masas".

PhD Theses (under development)

- Melina Roccamante (Supervisors: Sixto Malato y Sara Miralles)
- Azahara Martínez (Superisors: Inmaculada Polo e Isabel Oller)
- Dennis Deemter (Supervisors: Sixto Malato y Ana M. Amat)
- Illaria Berruti (Supervisors: Inmaculada Polo e Isabel Oller)

Attendance at Transfer and Dissemination Courses and Conferences

- Isabel Oller ha participado en PHOTOPUR Online-Symposium, France, 9-10 Diciembre 2020.

Awards won during 2020 (https://arm.ual.es/arm-group/awards/)

- A. Agüera. Research Award San Alberto 2020. Faculty of Experimental Sciences, University of Almería. 16/11/2020.

- Research group FQM-374. Award to the research group with the most publications in number 1 journals in its JCR category. University of Almeria.
- Research Group FQM-374. Prize for the best JCR publication in journal number 1 in its category. University of Almeria.

Other scientific activities

- Agüera. Delivering the Inaugural Lecture of the 2020-2021 academic year with a talk on: “La calidad del agua: una mirada desde la Ciencia”.
- Agüera. Member of the Technical Committee for Evaluation and Accreditation of the Andalusian Knowledge Agency.
- Agüera. Coordination of the PhD programme "Advanced Chemistry" at the University of Almeria.
- Oller. Co-leader del Working Group on Emerging Contaminants in the Platform “Water Europe”.

2.3 ACTIVITIES OF "ADVANCED TECHNOLOGIES FOR WATER REGENERATION"

2.3.1 Functional unit description

The Functional Unit has been formed during 2020 by 12 researchers, with a Full professor, an OPI principal researcher, a researcher hired from OPI, two university professors, five doctors hired in charge of projects, one doctor hired Juan de la Cierva, one doctor hired in the Technical Services of the university and one predoctoral researcher. 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.

2.3.2 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

2.3.3 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 24 national and international R&D projects and has leaded 12 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 170 scientific publications in international journals.

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 15 national and international R&D projects, currently leading 2 of them. He has directed/co-directed two doctoral theses and is currently directing two other ongoing doctoral theses in the field of solar water treatment and reuse. Author and co-author of 65 publications in international journals with a high impact index, author of 1 book and co-author of 14 other book chapters.

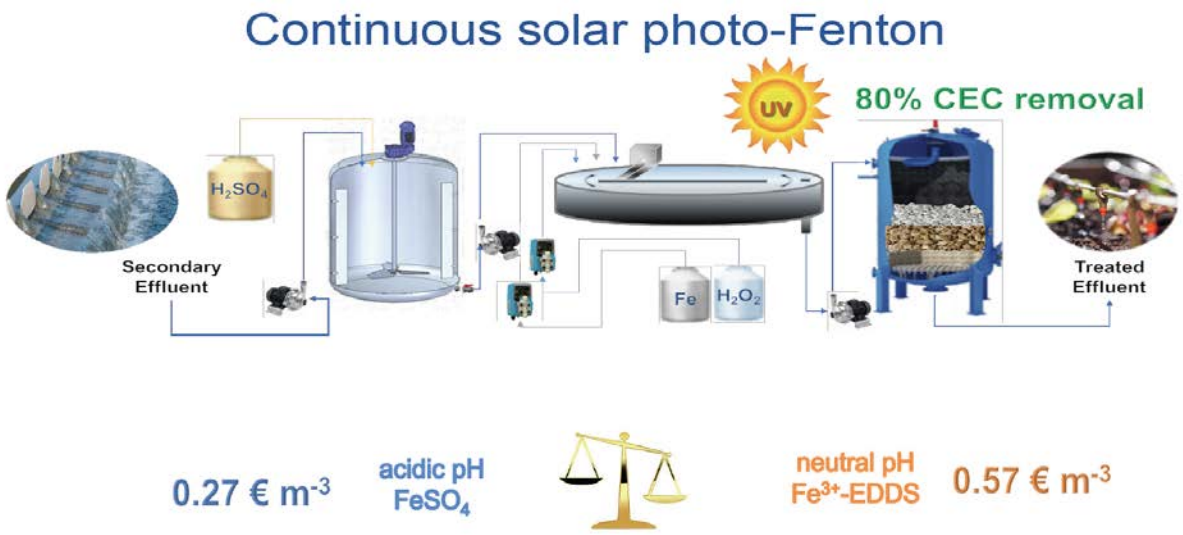
2.3.4 Summary of the activity developed in CIESOL during 2020

Although the impact of the pandemic has been strong, 2020 has been marked by work on the UAL-Feder AQUELOO and Life Ulises projects, as well as the launch of the Life Phoenix and NAVIA projects (Retos-AEI). Among the different and diverse activities carried out this year, it is worth highlighting the intense research work carried out in the continuous mode operation of the RPR (Raceway Pond Reactor) in order to treat

secondary effluents from WWTP using solar photo-Fenton. The group is a pioneer in continuous operation and has studied different treatment alternatives for disinfection and elimination of emerging pollutants in secondary effluents for reuse in agriculture. The photo-Fenton treatment at neutral pH has been studied using the complexes Fe(III)-NTA and Fe(III)-EDDHA.

During 2020, three international doctoral theses have been defended, corresponding to Samira Nahim Granados, Sandra Arzate and Irene Salmerón.

Regarding mobility, during 2020 we welcomed Dr. Antonino Fiorentino, University of Salerno (Italy) and Massimo Dell´Edera, University of Bari (Italy), between the months of September and November. Other planned stays have not been possible due to the pandemic.



Conceptual diagram of the operation of the photo-Fenton solar process in continuous mode for water treatment at acidic and neutral pH.

2.3.5 Collaboration with other CIESOL Functional Units during 2020

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), 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.

2.3.6 Human resources of the Functional Unit.

During 2020, PhD student Elisabeth Gualda Alonso and Dr. María Jesús Abeledo Lameiro have joined the group. Dr. Gracia Rivas, who has joined Enseñanzas Medias, and Irene Salmerón, hired at the University of Luxembourg, have left the group.

Visits and research stays in CIESOL

- Dr. Antonino Fiorentino. University of Salerno (Italy) (01/09/2020-30/11/2020)
- Massimo Dell´Edera. University of (Italy) (01/09/2020-30/11/2020)

Research stays of CIESOL researchers in other institutions:

Students in curricular internships

- Alba Ruíz Espín (14/11/2019-28/01/2020). Chemical Engineering.
- José Daniel Sánchez López (16/11/2020 – 23/01/2021). Chemical Engineering.

2.3.7 Scientific production

Number of papers	Papers in each Quartile				Number of papers with international filiation
	Q_1	Q_2	Q_3	Q_4	
17	13	2		2	8

Papers.

- Unfolding the action mode of light and homogeneous *vs*. heterogeneous photo-Fenton in bacteria disinfection and concurrent elimination of micropollutants in urban wastewater, mediated by iron oxides in Raceway Pond Reactors. I. De la Obra, S. Giannakis, D. Grandjean, F. Breider, G. Grunauer, J. L. Casas López, J. A. Sánchez Pérez, C. Pulgarín. Applied Catalysis B: Environmental 263: 118158, 2020. https://doi.org/10.1016/j.apcatb.2019.118158
- Synthetic fresh-cut wastewater disinfection and decontamination by ozonation at pilot scale. S. Nahim-Granados, G. Rivas-Ibáñez, J. A. Sánchez Pérez, I. Oller, S. Malato, M. I. Polo-López. Water Research 170: 115304, 2020. https://doi.org/10.1016/j.watres.2019.115304
- Best available technologies and treatment trains to address current challenges in urban wastewater reuse for irrigation of crops in EU countries. L. Rizzo, W. Gernjak, P. Krzeminski, S. Malato, C. S. McArdell, J. A. Sanchez Perez, H. Schaar, D. Fatta-Kassinos. Science of the Total Environment 710: 136312, 2020. https://doi.org/10.1016/j.scitotenv.2019.136312
- Wastewater treatment by advanced oxidation process and their worldwide research trends. J. A. Garrido-Cardenas, B. Esteban-Garcia, A. Aguera, J. A. Sanchez Perez, F. Manzano-Agugliaro. International Journal of Environmental Research and Public Health 17(1): 170, 2020. https://doi.org/10.3390/ijerph17010170
- New trend on open solar photoreactors to treat micropollutants by photo-Fenton at circumneutral pH: increasing optical pathway. E. P. Costa, M. Roccamante, C. C. Amorim, I. Oller, J. A. Sánchez Pérez, S. Malato. Chemical Engineering Journal 385: 123982, 2020. https://doi.org/10.1016/j.cej.2019.123982
- Removal of contaminants of emerging concern by continuous flow solar photo-Fenton process at neutral pH in open reactors. S. Arzate, M.C. Campos-Mañas, S. Miralles-Cuevas, A. Agüera, J. L. García Sánchez, J. A. Sánchez Pérez. Journal of Environmental Management 261: 110265, 2020. https://doi.org/10.1016/j.jenvman.2020.110265

- Modeling persulfate activation by iron and heat for the removal of contaminants of emerging concern using carbamazepine as model pollutant. A. Cabrera-Reina, S. Miralles-Cuevas, J. A. Sánchez Pérez, I. Oller, S. Malato. Chemical Engineering Journal 389: 124445, 2020. https://doi.org/10.1016/j.cej.2020.124445
- Determination of dextromethorphan and dextrorphan photo-transformation products by LC/Q-TOF-MS: laboratory scale experiments and real water samples analysis. M.C. Campos-Mañas, S. Miralles-Cuevas, I. Ferrer, M. E. Thurman, J. A. Sánchez Pérez, A. Agüera. Environmental Pollution 265 Part. A: 114722, 2020. https://doi.org/10.1016/j.envpol.2020.114722
- Fe^{3+}-NTA as iron source for solar photo-Fenton at neutral pH in raceway pond reactors. A. Mejri, P. Soriano Molina, S. Miralles, J. A. Sánchez Pérez. Science of the Total Environment 736: 139617, 2020. https://doi.org/10.1016/j.scitotenv.2020.139617
- Neutral or acidic pH for the removal of contaminants of emerging concern in wastewater by solar photo-Fenton? A techno-economic assessment of continuous raceway pond reactors. J. A. Sánchez Pérez, S. Arzate, P. Soriano Molina, J. L. García Sánchez, J. L. Casas López, P. Plaza-Bolaños. Science of the Total Environment 736: 139681, 2020. https://doi.org/10.1016/j.scitotenv.2020.139681
- Fresh-cut wastewater reclamation: techno-economical assessment of solar driven processes at pilot plant scale. S. Nahim-Granados, I. Oller, S. Malato, G. Rivas, J. A. Sánchez Pérez, M. I. Polo-López. Applied Catalysis B: Environmental 278: 119334, 2020. https://doi.org/10.1016/j.apcatb.2020.119334
- Micropollutant degradation by heterogeneous solar photo-Fenton process at circumneutral pH using copper slag. R. García-Estrada, B. Esteban García, R. M. Ramírez-Zamora, J. A. Sánchez Pérez. Journal of Water Process Engineering 38: 101562, 2020. https://doi.org/10.1016/j.jwpe.2020.101562
- Computational Fluid Dynamics (CFD) Modeling of Removal of Contaminants of Emerging Concern in Solar Photo-Fenton Raceway Pond Reactors. R. P. Muniz Moreira, A. Cabrera Reina, P. Soriano Molina, J. A. Sánchez Pérez, G. Li Puma. Chemical Engineering Journal 127392, 2020. https://doi.org/10.1016/j.cej.2020.127392
- A global multinational survey of cefotaxime-resistant coliforms in urban wastewater treatment plants. RB.M. Marano, T. Fernandes, C.M. Manaia,....M.I. Polo-López, S. Nahim–Granados, M.-N. Ponsa, Milena Milakovicai, Nikolina Udikovic-Kolicai... , Eddie Cytryn. Environment International 144: 106035, 2020. https://doi.org/10.1016/j.envint.2020.106035
- Investigating the impact of UV-C/H2O2 and sunlight/H2O2 on the removal of antibiotics, antibiotic resistance determinants and toxicity present in urban wastewater. S.G. Michael, I. Michael-Kordatou, S. Nahim-Granados, M.I. Polo-López, J. Rocha, A.B. Martínez-Piernas, P. Fernández-Ibáñez, A. Agüera, C.M. Manaia, D. Fatta-Kassinos. Chemical Engineering Journal 388: 124383, 2020. https://doi.org/10.1016/j.cej.2020.124383
- Solar Drying of Greenhouse Crop Residues for Energy Valorization: Modeling and Determination of Optimal Conditions. Maria Guadalupe Pinna-Hernández, Francisco Gabriel Acien Fernández, José Gabriel López Segura, José Luis Casas López. Agronomy 2020, 10(12), 2001; https://doi.org/10.3390/agronomy10122001
- Agua residual y economía circular en la industria de IV gama: aplicación de procesos solares y ozono para la regeneración y reutilización agrícola a escala piloto. S. Nahim Granados, A. Agüera López, I. Oller Alberola, S. Malato Rodríguez, J.A. Sánchez Pérez, I. Polo López. Revista IDi del Agua.

Economía Circular. Revista sobre tendencias en la I+D+i de la Plataforma Tecnológica Española del Agua. Nº 2, Pag. 38-41, Octubre 2020.

- Regeneración de aguas residuales mediante foto-Fenton solar, una tecnología en desarrollo. P. Soriano Molina, I. de la Obra Jiménez, E. Gualda Alonso, J. A. Sánchez Pérez. RETEMA Revista Técnica de Medio Ambiente. 226: 86-91. 2020.

Book Chapter

Removal and Degradation of Pharmaceutically Active Compounds (PhACs) in Wastewaters by Solar Advanced Oxidation Processes. S. Malato, J. Giménez, I. Oller, A. Agüera, J. A. Sánchez Pérez. The Handbook of Environmental Chemistry. Springer, Berlin, Heidelberg. 2020. https://doi.org/10.1007/698_2020_688

PhD Thesis

- Desarrollo y aplicación de procesos fotoquímicos y fotocatalíticos para la desinfección, descontaminación y reúso de aguas procedentes de la industria de IV gama. Leila Samira Nahim Granados. Universidad de Almería. 10 de enero 2020. Sobresaliente cum Laude por unanimidad
- Tratamiento de efluentes secundarios de EDAR mediante el proceso foto-Fenton solar: una propuesta de implementación basada en la operación en modo continuo. Sandra Yazmin Arzate Salgado. Universidad de Almería. 5 de marzo 2020. Sobresaliente cum Laude por unanimidad
- Evaluación de procesos electroquímicos asistidos por energía solar para la depuración de aguas. Irene Salmerón García. Universidad de Almería. 25 de septiembre 2020. Sobresaliente cum Laude por unanimidad.

2.3.8 Staff members

José Antonio Sánchez Pérez

Ful Professor Chemical Engineer
UAL
jsanchez@ual.es
(+34) 950 215 314 www.ciesol.com

Maria Inmaculada Polo López

Main Researcher
Senior Researcher OPI - CIEMAT-PSA
mpolo@psa.es
(+34) 950 387 800 www.psa.es

José Luis García Sánchez

Full Professor
UAL

José Luis Casas López

Full Professor
UAL

Sara Miralles Cuevas

Post-doc Researcher
Juan de la Cierva, UAL

Ana Belén Esteban García

Post-doc Researcher
UAL

María Guadalupe Pinna Hernández

Post-doc Researcher
ALCHEMIA Project

Irene de la Obra Jiménez

Post-doc Researcher
UAL

María Jesús Abeledo Lameiro

Post-doc Researcher
CIEMAT-PSA

Paula Soriano Molina

Post-doc Researcher
UAL

Leila Samira Nahim Granados

PhD Student
CIEMAT-PSA/UAL

Elisabeth Gualda Alonso

PhD Student
UAL

2.3.9 Ongoing projects in 2019

2.3.9.1 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 - December 2020

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.

2.3.9.2 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 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.

2.3.9.3 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.

2.3.9.4 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 – March 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:

a) 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.

b) Carry out the conceptual design of a commercial scale reactor and estimate costs.

2.3.9.5 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:

i) 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.

ii) 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.

iii) 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.

2.3.9.6 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.

I. Quantify and remove emerging contaminants through advanced oxidation processes.

II. Quantify and eliminate microplastics through advanced filtration processes.

III. Design a transportable demonstration plant with more than 12 different technologies based on a flexible multi-barrier concept. Plug & play concept.

IV. Optimization of irrigation through intelligent management.

V. 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.

VI. 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.

2.3.10 Participation in Networks during 2020

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.

2.3.11 Dissemination activities

- As in previous years, the functional unit has participated in the European Researchers' Night 2020, 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.
- 'Café con Ciencia' activity that promotes meetings of scientists with small groups of secondary and high school students and their respective teachers in Andalusia, with the aim of sharing experiences and bringing young people closer to research. Members of the functional unit have collaborated in this activity, which, given the health emergency situation, has been carried out through an online platform.
- Organization of the XII CONFERENCE ON THE EUROPEAN UNION. "Innovation in Wastewater Treatment and Regeneration in the European Union" Almería, from November 16 to 20, 2020. Several members of the functional unit have attended and carried out dissemination activities through scientific-technical presentations.
- Dissemination of activities during the final conference associated with the ALICE project (H2020), held online on December 4, 2020, where Dr. Inmaculada Polo presented the presentation entitled: "Reuse of reclaimed wastewater: assessment of chemical and biological cross- contamination and phytotoxicity on crops".
- Oral presentation entitled "ALCHEMIA preliminary Spanish results" at the LIFE ALCHEMIA project seminar "Purification of Drinking Water from Natural Radionuclides and Management Options for NORM" held on 3rd and 4th March 2020, in Viimsi (Estonia).

2.3.12 Projects requested during 2020

- Chemical and microbiological impact of tourism in the Mediterranean, and its mitigation by application of solar-mediated wastewater treatment methods. Call: 2020 Aquatic Pollutants. Rejected.
- Innovative solutions for the safe use of water resources with high concentrations of naturally occurring radionuclides. Acronym NATRAWAT. PRIMA 1st stage. Research and Innovation Actions (RIA). Innovation Actions (IA). Rejected.
- Enhancement of wastewater treatment plant performance using solar thermal energy as driving force. Project acronym: LIFE HELIOS. LIFE Environment and Resource Efficiency project application. Rejected.
- Regeneración de aguas mediante energía solar concentrada. Convocatoria 2020 de proyectos de I+D+i, Consejería de Conocimiento, Investigación y Universidad. Junta de Andalucía. Under evaluation.
- Removal of Emerging Contaminants through an On-farm 3-Technology Reclamation Facility to complete the Water Reuse System (LIFE WaT3EC). LIFE Environment and Resource Efficiency, EU, 2020. Under evaluation
- FONDECYT Regular (Chilean Government) convocatoria 2021 presentado en 2020, Code 1210358 (2021 – 2025) Combination of innovative and cost-effective strategies based on Solar/UVA-LED technologies to remove contaminants of emerging concern from municipal wastewater (Sol/UV-tion). (Budget: $CHL 253.080.000 - aprox. 295.000 euros). Funded.

2.3.13 Others

Final degree projects

- Ana Belén Morillas Tapia (Grado en ingeniería Química Industrial). Inactivación de microorganismos en efluentes secundarios de EDAR municipal mediante procesos basados en UVC-LED
- Alejandro Rodríguez-Villamil Hernández (Máster en Ingeniería Química). Efecto de la temperatura y la absorción de fotones en la eliminación de contaminantes emergentes mediante el proceso foto-Fenton solar.
- Alba Ruiz Espín (Grado en Ingeniería Química Industrial). Evaluación tecno-económica de materiales de relleno de lechos filtrantes para la reducción de la radiactividad natural en aguas subterráneas para consumo humano.
- Marta Domenech Cuevas (Grado en Ingeniería Química Industrial). Eliminación simultánea de contaminantes de preocupación emergente e inactivación de Escherichia coli mediante foto-Fenton en modo continuo usando como fuente de radiación UVA-LED.
- Francisco Gabriel López Martínez (Grado en Ingeniería Química Industrial). Efecto de la fuente de hierro y la composición del efluente de EDAR en la operación en continuo del proceso foto-Fenton solar a pH neutro.
- Lucía Mullor Ureña (Grado en Ingeniería Química Industrial). Diseño de un digestor anaerobio para el tratamiento de lodos de la EDAR El Bobar, Almería.
- Nuria Rodríguez Mancera (Grado en Ingeniería Química Industrial). Control de la temperatura en un reactor con microalgas a partir de geotermia.
- Gabriel Jesús Espinosa Lirola (Máster en Biotecnología Industrial y Agroalimentación). Biotecnología

- GALDEANO LOPEZ, JESUS (Grado en Ingeniería Electrónica Industrial). Evaluación y validación de estrategias de modelado y control del proceso foto-Fenton mediante Easy JavaScript Simulations. Evaluation and validation of modeling strategies and control of the photo-Fenton process using Easy JavaScript Simulations.
- MARTINEZ VALDIVIA, PEDRO JOSE (Grado en Ingeniería Electrónica Industrial). Puesta en marcha y desarrollo de un sistema de supervisión para el proceso foto-Fenton. Start up and development of a supervision system for the photo-Fenton process.
- MARTINEZ ARAN, CELESTINO (Grado en Ingeniería Química Industrial). ESTUDIO DE VIABILIDAD DEL USO DE UNA COLUMNA DE RECTIFICACIÓN EXISTENTE COMO STRIPPER DE AMONIACO. FEASIBILITY STUDY OF THE USE OF AN EXISTING RECTIFICATION COLUMN AS STRIPPER OF AMMONIA.
- PORCEL PUSSETTO, MELISA GISELLE (Grado en Ingeniería Química Industrial). Optimización del proceso de recuperación de amoniaco mediante destilación a vacío en Deretil, S.A. Optimization of the ammonia recovery process by vacuum distillation at Deretil, S.A.

PhD Theses (under development)

- Melina Roccamante (Supervisors: Sixto Malato and Sara Miralles)
- Azahara Martínez García (Supervisors: Inmaculada Polo and Isabel Oller)
- Ilaria Berruti (Supervisor: Inmaculada Polo)
- Elizabeth Gualda Alonso (Supervisors: José Antonio Sánchez Pérez and José Luis Casas López)

Attendance at Transfer and Dissemination Workshops

- Workshop: The Treatment Plant Sketcher Tool and the Pathogen Flow Mapping Tool. 22 de septiembre de 2020. Plataforma online.
- XII JORNADAS SOBRE LA UNIÓN EUROPEA. "Innovación en la Depuración y Regeneración de Aguas Residuales en la Unión Europea" Almería, del 16 al 20 de noviembre de 2020
- LIFE ALCHEMIA Training Seminar. 3rd - 4th March 2020, Viimsi (Estonia) "Purification of Drinking Water from Natural Radionuclides and Management Options for NORM".

2.4 ACTIVITIES OF "MODELING & AUTOMATIC CONTROL" UNIT

2.4.1 Functional unit description

This functional unit 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. 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. Following the experience gained in the ARFRISOL project, 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.

Additional info: https://arm.ual.es/arm-group/about-us/

2.4.2 Main research lines

The main research lines of the group inside the CIESOL Centre are:

- 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.

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/

2.4.3 Main researchers

Manuel Berenguel (ORCID 0000-0002-3349-7506, Scopus Author ID 6701834872)

Manuel Berenguel is Professor of automatic control and systems engineering with the University of Almería. He received the industrial engineering and Ph.D. degrees (Extraordinary Doctorate Award) from the University of Seville, Spain. His research interests include control education and predictive and hierarchical control, with applications to solar energy systems (mainly solar energy), agriculture, and biotechnology. Since May 2019 he is Honorary Visiting Professor at the University of Brescia (Italy), where he is a member of the PhD Commission of the Department of Mechanical and Industrial Engineering. He has been Vice-Rector for ICT (2007-2012) and member of the Governing Council (2007-2015) at the University of Almeria. At this University, he has been Coordinator of the PhD Programme in Computer Science (2013-2016) and Coordinator of the Master in Solar Energy (academic years 2017-2018 to 2019-2020). He is responsible for the research group "Automatic Control, Robotics and Mechatronics" of the University of Almeria (code TEP197, arm.ual.es) since 2000. He has participated in more than 40 R&D projects and more than 40 contracts with companies. He is co-author of the books Advanced Control of Solar Plants (Springer, 1997), Control of Solar Energy Systems (Springer, 2012), Control Automático con Herramientas Interactivas (Pearson Education, 2012), Comfort

Control in Buildings (Springer, 2014) and Modeling and Control of Greenhouse Crop Growth (Springer, 2014). He has been Supervisor and co-Supervisor of 17 PhD Theses in these lines. He is co-author of 152 international journal papers, 196 papers in international conferences and 5 patents. H-index: 46 (Google Scholar), 35 (Scopus), 33 (Web of Science). He has participated in the International Program Committee of 10 international conferences (in one as IPC Chair) and 5 national conferences, where he has been chairman in many occasions. He is reviewer of more than 15 renowned international journals (more than 100 reviews) and from 2013 is adjoin-Supervisor of the journal Revista Iberoamericana de Automática e Informática Industrial (indexed in SCI). He has been member of the board of Governors of the Comité Español de Automática (main Spanish Association in Automatic Control) from 2003 to 2008 and 2012 to 2016, member of IEEE Control System Society from 2000 (Senior Member from 2012) and member of the IFAC Technical Committees TC 6.3. Power and Energy Systems (2012-2020), TC 8.01 Control in Agriculture (2005-2012), TC 8.4 Biosystems and bioprocesses (2008-), TC 9.4 Control Education (2020-). He is member of the Coordination and management committee of the Mixed R&D Center CIESOL between the University of Almería and CIEMAT- Spanish Research Center in Energy, Environment and Technology (from 2005) and member of Scientific Committee of IMDEA Energy from 2015 and of its board of governors since 2019. He was the organizer of the XXVII Jornadas de Automática (the annual meeting of the Spanish Automatic Control Committee) in 2006.

Additional info: https://arm.ual.es/arm-group/people/manuel-berenguel/

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 18 national and international R&D projects.

Additional info: https://arm.ual.es/arm-group/people/lidia-roca-sobrino/

Summary of the group: https://arm.ual.es/arm-group/main-figures/

2.4.4 Summary of the functional unit's activities carried out in CIESOL during 2020

- Web improvement: arm.ual.es, http://www.ciesol.es/index.php?Idioma=ES&Opcion=34&Pagina=3
- Control and optimal management of heterogeneous Resources in agroindustrial production districts integrating renewable energies.
- 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.

- Multi-objective optimization of air conditioning and lighting systems for comfort achievement in sustainable buildings.
- 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.

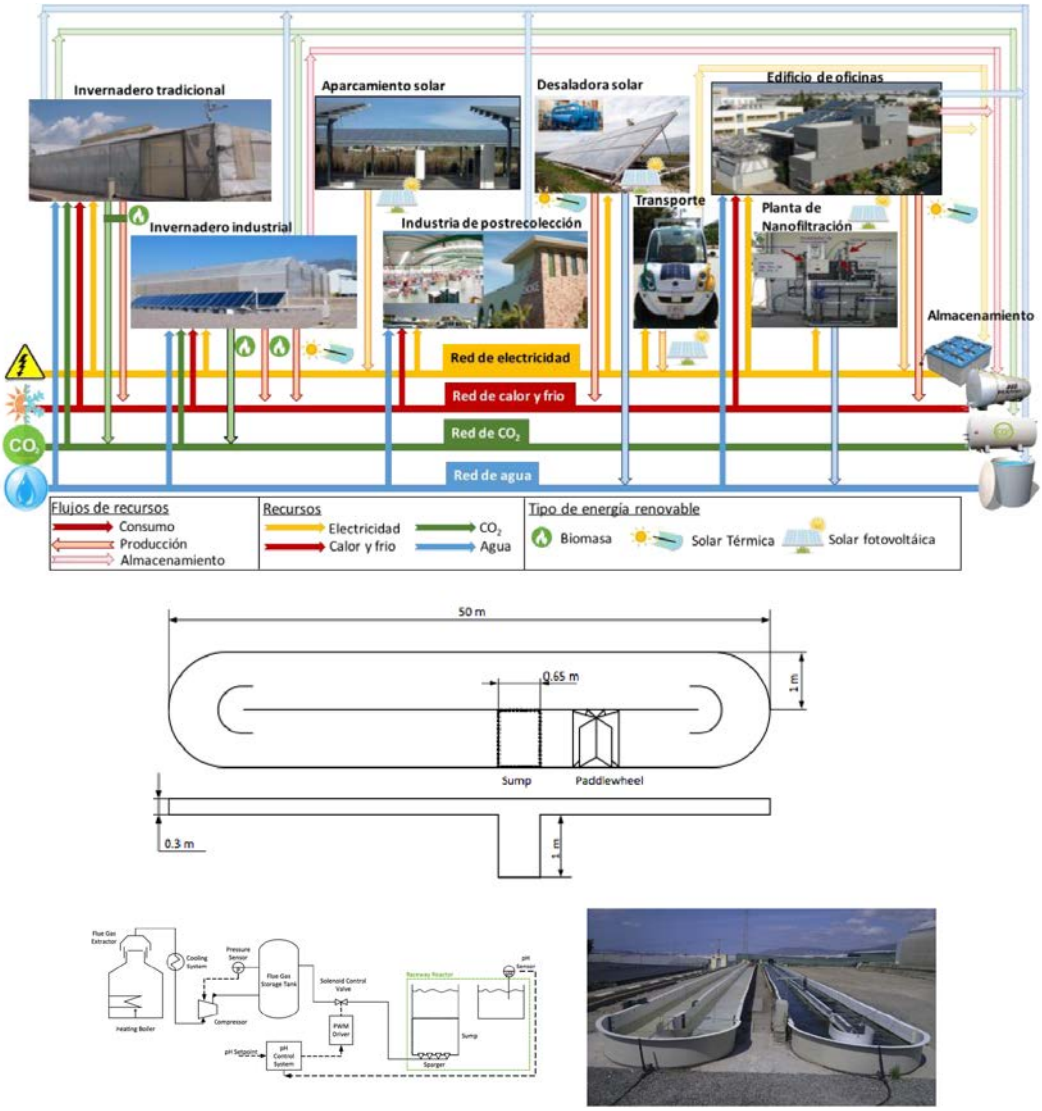


Fig. 2.4.1 Various examples of the activity of the modeling and control unit

2.4.5 Collaboration with other functional units of CIESOL during 2020

During 2020 the Modeling and Control Unit has maintained collaborations with the following CIESOL Functional Units:

- Desalination and Photosynthesis: European projects (SABANA, INDIA 2020), national plan projects (CALRESI), joint publications (desalination, photobioreactors, greenhouses, ...) Joint management of TFG, TFM and Doctoral Theses. Collaboration within the scope of the Sfera III project.
- Environmental Analysis: collaboration at the joint management level of TFG and TFM. Appearance in local press. Collaboration within the scope of the Sfera III project.
- Water Regeneration: collaboration at the joint management level of TFG and TFM. Planning of joint publications. Collaboration within the scope of the Sfera III project.

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

- Master in Solar Energy (http://www2.ual.es/master-solar/), whose coordinator belongs to the Modelling and Control Functional Unit.
- The research group "Automatic Control, 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.
- El grupo de investigación “Automática, Robótica y Mecatrónica” de la Universidad de Almería junto con CIEMAT han colaborado en la línea de investigación de I+D de Automática en plantas termosolares en el marco de diversos proyectos nacionales: DPI2004-07444-C04-04, DPI2007-66718-C04-04, DPI2010-21589-C05-02, DPI2014-56364-C2-R, DPI2017-85007-R.
- Colaboración con la Unidad de Eficiencia Energética en la Edificación UiE3 del CIEMAT. La colaboración establecida a partir del proyecto ARFRISOL, ya concluido, ha abierto nuevas opciones de desarrollo de actividades conjuntas de interés común en el ámbito de la caracterización dinámica de las propiedades térmicas de materiales y elementos.

2.4.6 Human resources of the Functional Unit

Visits and research stays in CIESOL:

- Polanco, Luis. Universidad de Guanajuato, México (11/12/2019-24/06/2020).
- Román, Caio. Universidad Federal de Santa Catarina (UFSC), Brasil (01/09/2019-28/02/2020).
- Pataro, Igor. Universidad Federal de Bahía, Brasil (01/09/2020-31/08/2024).

Research stays of CIESOL researchers in other institutions:

- They have had to be cancelled due to the COVID-19 pandemic.

Students in curricular internships:

- Acién Zapata, Salvador. Grado en Ingeniería Informática (14/11/2019-28/01/2020).
- Cano Lara, Antonio. Industrial Electronics Engineering Degree (14/11/2019-28/01/2020).
- Fiñana Aranega, Rubén. Grado en Matemáticas (15/04/2020-31/05/2020).
- González Hernández, José. Industrial Electronics Engineering Degree (14/02/2020-05/06/2020).
- Martínez Quirantes, Antonio. Industrial Electronics Engineering Degree (05/02/2020-27/05/2020).
- Ramajo Ballester, Álvaro. Industrial Electronics Engineering Degree (08/11/2019-22/01/2020).
- Salvador Criado,Ángel. Industrial Electronics Engineering Degree (9/11/2020-29/01/2021).

- Sánchez Matarín, Luis José. Grado en Matemáticas (15/04/2020-31/05/2020).
- Simal Pérez, Noelia. Industrial Electronics Engineering Degree (14/02/2020-06/06/2020).
- Torres Castro, Asier. Grado en Matemáticas (23/04/2020-31/05/2020).

2.4.7 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	
36	**17**	**12**	**4**	**3**	**19**

The publication history can be consulted at the following link:

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

Papers

- A simple and effective heuristic control system for the heliostat field of solar powr plants. Calvo, N.C., J.D. Álvarez, J.L. Redondo, M. Berenguel, R. Klempous, P.M. Ortigosa. ***Acta Polytechnica Hungarica***. ***Journal of Applied Sciences***, 17(4), 7-26, 2020. DOI: 10.12700/APH.17.4.2020.4.1. Impact Factor (JCR 2019): 1.219, 63/91 **Q3** (Engineering, Multidisciplinary).

  http://www.uni-obuda.hu/journal/Issue101.htm

- Optimal operation of solar thermal desalination systems coupled to double-effect absorption heat pumps. Carballo, J.A., J. Bonilla, L. Roca, A. de la Calle, P. Palenzuela, D.C. Alarcón-Padilla, M. Berenguel. ***Energy Conversion and Management***, 210, 112705, 2020. DOI: 10.1016/j.enconman.2020.112705. Impact Factor (JCR 2019): 8.208, 3/163 Q1 (Mechanics), 11/112 Q1 (Energy & Fuels), 2/61 **Q1** (Thermodynamics).

  https://www.sciencedirect.com/science/article/pii/S0196890420302430

- Solar power mockup for the assessment of advanced control techniques. Carballo, J.A., J. Bonilla, M. Berenguel, J. Fernández, G. García. ***Renewable Energy***, 149, 682-690, 2020. DOI: 10.1016/j.renene.2019.12.075. Impact Factor (JCR 2019): 6.274, 9/41 Q1 (Green & Sustainable Science & Technology), 19/112 **Q1** (Energy & Fuels).

  https://www.sciencedirect.com/science/article/pii/S0960148119319470

- Adaptive UKF-based model predictive control of a fresnel collector field. Gallego, A.J., A.J. Sánchez, M. Berenguel, E.F. Camacho. ***Journal of Process Control***, 85, 76-90, 2020. DOI: 10.1016/j.jprocont.2019.09.003. Impact Factor (JCR 2019): 3.624, 18/63 **Q2** (Automation & Control Systems), 42/143 Q2 (Engineering, Chemical).

  https://www.sciencedirect.com/science/article/pii/S0959152419300691

- Modelado y control automático en destilación solar por membranas: fundamentos y propuestas para su desarrollo tecnológico. Gil, J.D., L. Roca, M. Berenguel. ***Revista Iberoamericana de Automática e Informática Industrial***, 17(4), 329-343, 2020. DOI: 10.4995/riai.2020.13122. Impact Factor (JCR 2019): 1.036, 51/63 **Q4** (Automation & Control Systems), 27/28 Q4 (Robotics).

  https://polipapers.upv.es/index.php/RIAI/article/view/13122

- Hierarchical control for the start-up procedure of solar thermal fields with direct storage. Gil, J.D., L. Roca, G. Zaragoza, J.E. Normey-Rico, M. Berenguel. ***Control Engineering Practice*** 95, 104254, 2020. DOI: 10.1016/j.conengprac.2019.104254. Impact Factor (JCR 2019): 3.193, 24/63 **Q2** (Automation & Control Systems), 80/266 Q2 (Engineering, Electrical & Electronic).

https://www.sciencedirect.com/science/article/abs/pii/S0967066119302114

- Multiobjective control architecture to estimate optimal set points for user comfort and energy saving in buildings. Martell, M., F. Rodríguez, M. Castilla, M. Berenguel. ***ISA Transactions***, 99, 454-464, 2020. DOI: 10.1016/j.isatra.2019.10.006. Impact Factor (JCR 2019): 4.305, 15/63 **Q1** (Automation & Control Systems), 12/91 Q1 (Engineering, Multidisciplinary), 8/64 Q1 (Instruments & Instrumentation).

  https://www.sciencedirect.com/science/article/abs/pii/S0019057819304604

- A new IoT-based platform for greenhouse crop production. Muñoz, M., J.L. Guzmán, J.A. Sánchez, F. Rodríguez, M. Torres, M. Berenguel. ***IEEE Internet of Things Journal***. 2020 (online). DOI: 10.1109/JIOT.2020.2996081. Impact Factor (JCR 2019): 9.936, 3/156 **Q1** (Computer Science, Information Systems), 9/266 Q1 (Engineering, Electrical & Electronic), 5/90 Q1 (Telecommunications).

  https://ieeexplore.ieee.org/document/9097273

- An IoT architecture for water resource management in agroindustrial environments: A case study in Almería (Spain). Muñoz, M., J.D. Gil, L. Roca, F. Rodríguez, M. Berenguel. ***Sensors***, 20, 596, **2020**. DOI: 10.3390/s20030596. Impact Factor (JCR 2019): 3.275, 77/266 Q2 (Engineering, Electrical & Electronic), 15/64 **Q1** (Instruments & Instrumentation).

  https://www.mdpi.com/1424-8220/20/3/596

- A flexible tool for modeling and optimal dispatch of resources in agri-energy hubs. Ramos-Teodoro, J. Giménez-Miralles, A., F. Rodríguez, M. Berenguel. ***Sustainability***, 12, 8820, 2020. DOI: 10.3390/su12218820. Impact Factor (JCR 2019): 2.576, 120/265 **Q2** (Environmental Sciences), 26/41 Q3 (Green & Sustainable Science & Technology).

  https://www.mdpi.com/2071-1050/12/21/8820

- Revisiting the simplified internal model control tuning rules for low-order controllers: Novel 2 DoF feedback controller. Rodríguez, C., E. Aranda-Escolástico, J.L. Guzman, M. Berenguel, T. Hägglund. ***IET Control Theory & Applications***, 14(13), 1700-1710, 2020. DOI: 10.1049/iet-cta.2019.0821. Impact Factor (JCR 2019): 3.343, 23/63 Q2 (Automation & Control Systems), 73/266 Q2 (Engineering, Electrical & Electronic), 14/64 **Q1** (Instruments & Instrumentation).

  https://ieeexplore.ieee.org/document/9178563

- Revisiting the simplified internal model control tuning rules for low-order controllers: feedforward controller. Rodríguez, C., E. Aranda-Escolástico, J.L. Guzman, M. Berenguel, T. Hägglund. ***IET Control Theory & Applications***, 14(12), 1612-1618, 2020. DOI: 10.1049/iet-cta.2019.0823. Impact Factor (JCR 2019): 3.343, 23/63 Q2 (Automation & Control Systems), 73/266 Q2 (Engineering, Electrical & Electronic), 14/64 **Q1** (Instruments & Instrumentation).

  https://ieeexplore.ieee.org/document/9199067

- A new model to analyze the temperature effect on the microalgae performance at large scale raceway reactors. Rodríguez-Miranda, E., F.G. Acién, J.L. Guzmán, M. Berenguel, A. Visioli. ***Biotechnology and Bioengineering***, 2020. DOI: 10.1002/bit.27617. Impact Factor (JCR 2019): 4.002, 39/156 **Q1** (Biotechnology & Applied Microbiology).

  https://onlinelibrary.wiley.com/doi/full/10.1002/bit.27617

- Indirect regulation of temperature in raceway reactors by optimal management of culture depth. Rodríguez-Miranda, E., J.L. Guzmán, F.G. Acién, M. Berenguel, A. Visioli. ***Biotechnology and Bioengineering***, 2020. DOI: 10.1002/bit.27642. Impact Factor (JCR 2019): 4.002, 39/156 **Q1** (Biotechnology & Applied Microbiology).

  https://onlinelibrary.wiley.com/doi/10.1002/bit.27642

- Diurnal and nocturnal pH control in microalgae raceway reactors by combining classical and event-based control approaches. Rodríguez-Miranda, E., J.L. Guzmán, M. Berenguel, F.G. Acién, A. Visioli. ***Water Science & Technology***, 82(6), 1155-1165, 2020. DOI: 10.2166/wst.2020.260. Impact Factor (JCR 2019): 1.638, 62/94 **Q3** (Water Resources), 44/53 Q3 (Engineering, Environmental), 195/256 Q4 (Environmental Sciences).

  https://iwaponline.com/wst/article/doi/10.2166/wst.2020.260/74508/Diurnal-and-nocturnal-pH-control-in-microalgae

- Development of an empirical tomato crop disease model: a case study on gray leaf spot. Wang, H., J.A. Sánchez-Molina, M. Li, M. Berenguel. ***European Journal of Plant Pathology***, 156, 477-490, 2020. DOI: 10.1007/s10658-019-01897-7. Impact Factor (JCR 2019): 1.582, 38/91 **Q2** (Agronomy), 117/234 Q2 (Plant Sciences), 13/36 Q2 (Horticulture).

  http://link.springer.com/article/10.1007/s10658-019-01897-7

- Developing Professional and Entrepreneurship Skills of Engineering Students Through Problem-Based Learning: A Case Study in Brazil. R. Goncalves, M. V. Americano da Costa, B. Joseph, J. L. Guzmán ***International Journal of Engineering Education***, 36(1), 155-169, 2020. Impact Factor (2019 JCR Science Edition): 0,653, 39/42 **Q4** (Education, Scientific Disciplines), 82/91 Q4 (Engineering Multidisciplinary).

  https://www.ijee.ie/contents/c360120A.html

- 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***, 2020 DOI: 10.1007/s10956-020-09860-6. Impact Factor (JCR 2019): 1.644, 124/263 **Q2** (Education & Educational Research).

  https://link.springer.com/article/10.1007/s10956-020-09860-6

- Application of solar energy to seawater desalination in a pilot system based on vacuum multi-effect membrane distillation. Andres, J.A., L. Roca, A. Ruiz, F.G. Acién, J.D. Gil, G. Zaragoza. ***Applied Energy***, 258, 114068, 2020. DOI: 10.1016/j.apenergy.2019.114068. Impact Factor (JCR 2019): 8.848, 9/112 Q1 (Energy & Fuels), 6/143 **Q1** (Engineering, Chemical).

  https://www.sciencedirect.com/science/article/abs/pii/S0306261919317556

- Event-based state-space model predictive control of a renewable hydrogen-based microgrid for office power demand profiles. Castilla, M., C. Bordons, A. Visioli. ***Journal of Power Sources***, 450, 227670, 2020. DOI: 10.1016/j.jpowsour.2019.227670. Impact Factor (JCR 2019): 8.247, 10/112 **Q1** (Energy & Fuels), 3/27 Q1 (Electrochemistry), 27/159 Q1 (Chemistry, Physical).

  https://www.sciencedirect.com/science/article/abs/pii/S0378775319316635

- Modelado y control multivariable del vehículo urbano eléctrico UAL-eCARM. Mañas, F.J., J.L. Blanco, J.L. Torres, A. Giménez. ***Revista Iberoamericana de Automática e Informática Industrial***, 17(2), 144-155, 2020. DOI: 10.4995/riai.2019.12679. Impact Factor (JCR 2019): 1.036, 51/63 **Q4** (Automation & Control Systems), 27/28 Q4 (Robotics).

  https://polipapers.upv.es/index.php/RIAI/article/view/12679

- A general optimal operating strategy for commercial membrane distillation facilities. Gil, J.D., P.R. Da Costa-Mendes, E. Camponogara, L. Roca, J.D. Álvarez, J. Normey-Rico. ***Renewable Energy***, 156, 220-234, 2020. DOI: 10.1016/j.renene.2020.04.074. Impact Factor (JCR 2019): 6.274, 9/41 **Q1** (Green & Sustainable Science & Technology), 19/112 Q1 (Energy & Fuels).

  https://www.sciencedirect.com/science/article/abs/pii/S0960148120306066

- DC-DC Linearized Converter Model for Faster Simulation of Lightweight Urban Electric Vehicles. Gómez, F.J., L. Yebra, F. Gómez-Medina, A. Giménez. ***IEEE Access***, 8(1), 85380-85394, 2020. DOI: 10.1109/ACCESS.2020.2992558. Impact Factor (JCR 2019): 3.745, 61/266 **Q1** (Engineering, Electrical & Electronic), 35/156 Q1 (Computer Science, Information Systems), 26/90 Q2 (Telecommunications).

  https://ieeexplore.ieee.org/abstract/document/9086614

- Techno-economic assessment of a high-efficiency, low-cost solar-thermal power system with sodium receiver, latent heat storage, and supercritical CO2 Brayton cycle. De la Calle, A., A. Bayon, J. Pye. ***Solar Energy***, 199, 885-900, 2020. DOI: 10.1016/j.solener.2020.01.004. Impact Factor: 4.608, 35/112 **Q2** (Energy & Fuels).

  https://www.sciencedirect.com/science/article/abs/pii/S0038092X20300049

- Experimental, computational and thermodynamic studies in perovskites metal oxides for thermochemical fuel production: A review. Bayon, A., A. De la Calle, K. Kamol, R. Alister. ***International Journal of Hydrogen Energy***, 45(23), 12653-12679, 2020. DOI: 10.1016/j.ijhydene.2020.02.126. Impact Factor: 4.939, 30/112 **Q2** (Energy & Fuels), 48/159 Q2 (Chemistry, Physical), 7/27 Q2 (Electrochemistry).

  https://www.sciencedirect.com/science/article/abs/pii/S0360319920307072

- Limitations of Urban Infrastructure for the Large-Scale Implementation of Electric Mobility. A Case Study. López, J.A., F.J. Garrido, J.L. Torres, A. Chofre, A. Giménez. ***Sustainability***, 12(10), 4253, 2020. DOI: 10.3390/su12104253. Impact Factor (JCR 2019): 2.576, 120/265 **Q2** (Environmental Sciences), 26/41 Q3 (Green & Sustainable Science & Technology).

  https://www.mdpi.com/2071-1050/12/10/4253

- A Cable-Driven Exosuit for Upper Limb Flexion Based on Fibres Compliance. Samper, J.L., A. Giménez, M.A. Sánchez-Urán, M. Ferre. ***IEEE Access***, 8, 153297-153310, 2020. DOI: 10.1109/ACCESS.2020.3018418. Impact Factor (JCR 2019): 3.745, 61/266 **Q1** (Engineering, Electrical & Electronic), 35/156 Q1 (Computer Science, Information Systems), 26/90 Q2 (Telecommunications).

  https://ieeexplore.ieee.org/abstract/document/9173782

- Optimal model for energy management strategy in smart building with energy storage systems and electric vehicles. Moya, F.D., J.L. Torres, J.D. Álvarez. ***Energies***, 13, 2020. DOI: 10.3390/en13143605. Impact Factor (JCR 2019): 2.702, 63/112 **Q3** (Energy & Fuels).

  https://www.mdpi.com/1996-1073/13/14/3605

- Thermodynamic Performance and Water Consumption of Hybrid Cooling System Configurations for Concentrated Solar Power Plants. Palenzuela, P., L. Roca, A. Caron, C. Lemarié, J. Gillard, P. Turner, K. Patchigolla. ***Sustainability***, 12(4739), 1-19, 2020. DOI: 10.3390/su12114739. Impact Factor (JCR 2019): 2.576, 120/265 **Q2** (Environmental Sciences), 26/41 Q3 (Green & Sustainable Science & Technology).

  https://www.mdpi.com/2071-1050/12/11/4739

- Six Collective Challenges for Sustainability of Almería Greenhouse Horticulture. Castro, A.J.; López-Rodríguez, M.D.; Giagnocavo, C.; Gimenez, M.; Céspedes, L.; La Calle, A.; Gallardo, M.; Pumares, P.; Cabello, J.; Rodríguez, E.; Uclés, D.; Parra, S.; Casas, J.; Rodríguez, F.; Fernandez-Prados, J.S.; Alba-Patiño, D.; Expósito-Granados, M.; Murillo-López, B.E.; Vasquez, L.M.; Valera, D.L. ***International Journal of Environment Research & Public Health***, 16, 4097, 2020. DOI: 10.3390/ijerph16214097. Impact Factor (JCR 2019): 2.849, 105/265 **Q2** (Environmental Sciences), 58/193 Q2 (Public, Environmental & Ocuppation Health).

  https://www.mdpi.com/1660-4601/16/21/4097

- Evaluation of an Adapted Greenhouse Cooling System with Pre-Chamber and Inflatable Air Ducts for Semi-Arid Regions in Warm Conditions. Cámara-Zapata, J.M.; Sánchez-Molina, J.A.; Wang, H.; Carreño-Ortega, A.; Rodríguez, F. ***Agronomy*** 10, 752, 2020. DOI: 10.3390/agronomy10050752. Impact Factor (JCR 2019): 2.603, 18/91 **Q1** (Agronomy), 65/234 Q2 (Plant Sciences).

  https://www.mdpi.com/2073-4395/10/5/752

- Very Short-Term Power Forecasting of High Concentrator Photovoltaic Power Facility by Implementing Artificial Neural Network. Alamin, Y.I., Anaty, M.K., Álvarez, J.D., Bouziane, K., Pérez, M., Yaagoubi, R., Castilla, M. Belkasmi, M. & Aggour, M. ***Energies***, 13, 1-16, 2020. DOI: 10.3390/en13133493. Impact Factor (JCR 2019): 2.702, 63/112 **Q3** (Energy & Fuels).

  https://www.mdpi.com/1996-1073/13/13/3493

- Evaluation of an Adapted Greenhouse Cooling System with Pre-Chamber and Inflatable Air Ducts for Semi-Arid Regions in Warm Conditions. Montoya, A.P., García-Mañas, F, Guzmán, J.L., Rodríguez, F. Agronomy. 10, 1327; doi:10.3390/agronomy10091327. Impact Factor (JCR 2019): 2.603, 18/91 **Q1** (Agronomy), 65/234 Q2 (Plant Sciences),

  https://www.mdpi.com/2073-4395/10/9/1327

- Automatic Tomato and Peduncle Location System Based on Computer Vision for Use in Robotized Harvesting. Benavides, M., Cantón-Garbín, M., Sánchez-Molina, J., Rodríguez, F. ***Applied Science*** 10, 5887; doi:10.3390/app10175887. Impact Factor (JCR 2019): 2.474 88/177 Q2 (Chemistry, Multidisciplinary), 62/154 **Q2** (Physics, Applied), 32/91 Q2 (Engineering, Multidisciplinary), 161/314 Q3 (Materials Science, Multidisciplinary).

  https://www.mdpi.com/2076-3417/10/17/5887

- Soil wind erosion characterization in south-eastern Spain using traditional methods in front of an innovative type of dust collector. Guerrero, R., Valenzuela, J.L., Torres-Moreno, J.L., Lozano, J., & Asensio, C. ***International Agrophysics***, 34, 503-510, 2020. DOI: 10.31545/intagr/131099. Impact Factor (JCR 2019): 1.655, 36/91 **Q2** (Agronomy).

  http://www.international-agrophysics.org/Soil-wind-erosion-characterization-in-south-eastern-Spain-using-traditional-methods,131099,0,2.html

- Simple Tuning Rules for Feedforward Compensators Applied to Greenhouse Daytime Temperature Control Using Natural Ventilation. Montoya-Ríos, A. P., García-Mañas, F., Guzmán, J. L., y Rodríguez, F. ***Agronomy***, 10(9), 1327, 2020. DOI: 10.3390/agronomy10091327. Impact Factor (JCR 2019): 2.603, 18/91 **Q1** (Agronomy), 65/234 Q2 (Plant Sciences).

  https://www.mdpi.com/2073-4395/10/9/1327

Participation in congresses

- 21st IFAC World Congress (IFAC 2020). Berlin, Germany, 2020 (online).
- European Control Conference (ECC 2020). Saint Petersburg, Russia, 2020 (online).
- 2020 AIChE Annual Meeting, San Francisco, CA, USA (online).
- 26th SolarPACES Conference, Albuquerque, NM, USA, 2020 (online).
- 13th International Conference on Solar Energy for Buildings and Industry (EUROSUN 2020), Athens, Greece (online).
- CSP4Climate, The Cyprus Institute (online), 2020.
- XVII Congresso Ibérico e XIII Congresso Ibero-americano de Energia Solar (CIES), Lisboa, Portugal, online, 2020.

- 14th International Conference on Automatic Control and Soft Computing (CONTROLO 2020), Bragança, Portugal (online).
- II Symposium Ibérico de Ingeniería Hortícola. Ponte de Lima, Portugal, 2020 (online).
- 18th International Conference on Renewable Energies and Power Quality ,Granada, España, 2020 (online).
- Genera - Feria Internacional de Energía y Medioambiente, Madrid, Spain, 2020.
- III Jornadas de Doctorado en Informática (JDI2020), Almería, España, 2020 (online).
- XVIII Simposio CEA de Ingeniería de Control. Murcia, España, 2020.
- V Congreso de Innovación Docente en la Ingeniería Química. Santiago de Compostela, España, 2020.

Contributions to congresses

- Gao, Xiang; Ermanoski, Ivan; De La Calle-Alonso, Alberto; Stechel, Ellen B. High-temperature and fast response: a new heating strategy. 2020 AIChE Annual Meeting, San Francisco, CA, USA, 2020.
- De La Calle-Alonso, Alberto; Ermanoski, Ivan; Gao, Xiang; Stechel, Ellen B. Non-isothermal conditions in countercurrent thermochemical reactors for fuel production. 2020 AIChE Annual Meeting, San Francisco, CA, USA, 2020.
- Ambrosini, A.; Albrecht, K.; Bush, H. E.; De La Calle-Alonso, Alberto; Ermanoski, I.; Farr, T.; Gao, X.; Kury, M. W.; Loutzenhiser, P.; Nguyen, N. ; Stechel, E. B. Solar-Thermal Ammonia Production: A Renewable, Carbon-Neutral Route to Ammonia. 2020 AIChE Annual Meeting, San Francisco, CA, USA, 2020.
- Palenzuela-Ardila, Patricia; Roca-Sobrino, Lidia; Asfand, Faisal; Patchigolla, Kumar. Experimental assessment of a Pilot Scale Hybrid Cooling System for water consumption reduction in CSP plants. 26th SolarPACES Conference, Albuquerque, NM, USA, 2020.
- De La Calle-Alonso, Alberto; Bush, H. Evan; Ermanoski, Ivan; Gao, Xiang; Ambrosini, Andrea; Stechel, Ellen B. Solar-driven Nitrogen Separation Process from Air Based on Two-step Thermochemical Cycle: Thermodynamic Analysis. 26th SolarPACES Conference, Albuquerque, NM, USA, 2020.
- Bayon, Alicia; De La Calle-Alonso, Alberto; Stechel, Ellen B.; Muhich, Christopher. Thermochemical Performance Maps for Redox Materials Performing Thermochemical Water Splitting. 26th SolarPACES Conference, Albuquerque, NM, USA, 2020.
- Gao, Xiang; Ermanoski, Ivan; Ambrosini, Andrea; De La Calle-Alonso, Alberto; Stechel, Ellen B. A Low-pressure Reactor Design for Solar Thermochemical Ammonia Production. 26th SolarPACES Conference, Albuquerque, NM, USA, 2020.
- Muñoz-Rodríguez, Manuel Jorge A. Sánchez-Molina, Manuel Torres, Manuel Berenguel, Cynthia Giagnocavo. Experiencias en el uso de Internet de las Cosas en las tareas de producción en invernaderos mediterráneos. II Symposium Ibérico de Ingeniería Hortícola. Ponte de Lima, Portugal, 2020.
- García-Mañas, F., F. Rodríguez, M. Berenguel. Leaf area index soft sensor for tomato crops in greenhouses. 21st IFAC World Congress (IFAC 2020). Berlin, Germany, 2020.
- Otálora, P., J.L. Guzmán, M. Berenguel, F.G. Acién. Dynamic Model for the pH in a Raceway Reactor using Deep Learning techniques. 14th International Conference on Automatic Control and Soft Computing (CONTROLO 2020). Bragança, Portugal, 2020.
- Leal, M., A. Hoyo, J.L. Guzmán, T. Hägglund. Double back-calculation approach to deal with input saturation in cascade control problems. 14th International Conference on Automatic Control and Soft Computing (CONTROLO 2020). Bragança, Portugal, 2020.

- Giménez-Miralles, J. Ramos-Teodoro, F. Rodríguez, M. Berenguel. Caso de uso de la herramienta ODEHubs para la gestión de recursos energéticos y materiales de un invernadero tradicional mediterráneo. II Symposium Ibérico de Ingeniería Hortícola. Ponte de Lima, Portugal, 2020.
- Ramos-Teodoro, J., M. Castilla, J. D. Álvarez, F. Rodríguez, M. Berenguel. Economic dispatch of a bioclimatic office building considering thermal energy, electricity and water demands. 18th International Conference on Renewable Energies and Power Quality. Granada, España, 2020.
- Castilla, M. F. Rodríguez J.D. Álvarez J. García-Donaire, J. Ramos-Teodoro. A Hardware-in-the-Loop prototype to design Benchmarks for Automation and Control Education. 21st IFAC World Congress (IFAC 2020). Berlin, Germany, 2020.
- Gil, J.D., Roca, L., & Berenguel, M. (2020). Starting-up strategies for solar thermal fields attending to time and economic criteria: Application of hierarchical control. 21st IFAC World Congress (IFAC 2020). Berlin, Germany, 2020.
- Bretones, M.D., J.D. Álvarez, M. Castilla, M. Berenguel. A Fuzzy Controller for Thermal Comfort and Indoor Air Quality in a Bioclimatic Building. European Control Conference (ECC 2020). Saint Petersburg, Russia, 2020.
- Guzman, J.L., M. Berenguel A. Merchan, J.D. Gil, J.D. Alvarez. A virtual lab for modeling and control of a solar collector field. 21st IFAC World Congress (IFAC 2020). Berlin, Germany, 2020.
- Muñoz Rodríguez, Manuel. Actualización de la plataforma IoT para la agricultura intensiva con MaaS e integración de nuevas plataformas. III Jornadas de Doctorado en Informática (JDI2020), Almería, España, 2020.
- García-Mañas, F., F. Rodríguez, M. Berenguel. Gestión de recursos heterogéneos bajo el paradigma de los sistemas ciber-físicos. XVIII Simposio CEA de Ingeniería de Control. Murcia, España, 2020.
- Ramos-Teodoro, J. Aportaciones al control y gestión de sistemas de producción distribuidos: estado actual de la cuestión y desarrollo de una librera para simulaciones. III Jornadas de Doctorado en Informática (JDI2020), Almería, España, 2020.
- Ramos-Teodoro, J., A. Giménez-Miralles, F. Rodríguez, M. Berenguel. Simulación de escenarios de reparto económico en sistemas multi-energía. XVIII Simposio CEA de Ingeniería de Control. Murcia, España, 2020.
- Gil, Juan D.. Sistemas de control para las fases de arranque y operación en plantas de destilación solar por membranas a escala industrial operación en plantas de destilación solar por membranas a escala industrial. III Jornadas de Doctorado en Informática (JDI2020), Almería, España, 2020.
- Fernández-Sevilla, José María; Casas-Lopez, Jose Luis; Pinna-Hernandez, Maria Guadalupe; Acien-Fernandez, Francisco Gabriel; Guzman, Jose Luis; Sanchez-Perez, Jose Antonio. Virtual bioreactors programmed in Easy Java Simulations for the study of enzimatics kinectics. V Congreso de Innovación Docente en la Ingenieria Química, Santiago de Compostela, España, 2020 (póster).
- Casas-Lopez, Jose Luis; Esteban-García, Ana-Belén; Pinna-Hernandez, Maria Guadalupe; Garcia-Sanchez, Jose Luis; Guzman, Jose Luis; Sanchez -perez, Jose Antonio. Virtual labs development using Easy Java Simulations for the study of the micropollutant removal by solar photo-Fenton in secondary WWTP effluents. V Congreso de Innovación Docente en la Ingenieria Química, Santiago de Compostela, España, 2020 (póster).
- Pataro, I. M., Americano da Costa, M. V., Roca, L., Guzmán, J. L., Berenguel, M. An economic D-RTO for thermal solar plant: analysis and simulations based on a feedback linearization control case. XXIII Congresso Brasileiro de Automática (CBA 2020), Evento virtual, Brasil, 2020.

- Lozano, M., Gil, Juan D., Berenguel, M., Roca, L., Pérez, M., De Keyser, R. Real-time multiobjective optimization in solar membrane distillation processes. 13th International Conference on Solar Energy for Buildings and Industry (EuroSun 2020), Evento virtual, 2020.
- Bartali, Ruben., Baker, D., Svaizer, P., Bayer, O., Alarcón-Padilla, D.C., Osório, T., Christodoulaki, R., Vassiliki, D., Kramer, W., Bolognese, M., Prattico, L., Viesi , D., Roca, L., Guillén, E., Fluch, J., Pinarli, D., Erdogan, S., Brunner, C., Cavada, R., Bonizzi, A., Cimatti , A., Zanetti, A., Crema, L. Decarbonization of industrial processes: technologies, applications and perspectives of low temperature solar heat (80-150°C). 13th International Conference on Solar Energy for Buildings and Industry (EuroSun 2020), Evento virtual, 2020.
- Guzmán, J.L., Joseph, B. A Web-Based Unit Operations Lab for Enhancing Design, Control and Optimization in Chemical and Biochemical Engineering Courses. AIChE Annual Meeting. Virtual, 2020.
- Joseph, B., J.L. Guzmán. A Techno-Economic Analysis of Greenhouse Waste and Water Recycling Using Anaerobic Digestion: A Case Study in Food-Energy-Water Nexus. AIChE Annual Meeting. Virtual, 2020.
- Blanco, Julian; Bonilla, Javier; Zarza, Eduardo; Alarcón-Padilla, Diego-Cesar. Optimization of CSP Development in Spain using Inductive Projection Planning Tool based on Artificial Intelligence, CSP4Climate, The Cyprus Institute (online), 2020.
- Blanco, Julian; Bonilla, Javier; Zarza, Eduardo; Alarcón-Padilla, Diego-Cesar. Optimización del desarrollo de la energia termosolar en españa en el contexto de la transición energética. XVII Congresso Ibérico e XIII Congresso Ibero-americano de Energia Solar (CIES), Lisboa, Portugal, online, 2020.
- Bonilla, Javier. Herramienta para optimizar el mix eléctrico aplicando técnicas de inteligencia artificial. Genera - Feria Internacional de Energía y Medioambiente, Madrid, Spain, 2020.
- Bonilla, Javier; Crespo, Luis. Inductive Projection Planning: Putting CSP in the Picture. International Conference on Concentrating Solar Power and Chemical Energy Systems (SolarPACES), Alburquerque, USA (online), 2020.

Organization of events

- Semana de la Informática de la Universidad de Almería. 19-20/02/2020. Almería, España.
- FIRST LEGO League 2019-2020. 15/02/2020. Almería. España.

Previous events: https://arm.ual.es/arm-group/event-organization/

Book chapters

- Model Predictive Control for the management of electrical energy in an agroindustrial microgrid. In Advances in Renewable Energies and Power Quality. Hernández, C., F. Rodríguez, J.C. Moreno, P.R. Da Costa-Mendes, J. Normey-Rico, pp. 279-304. Cambridge Scholars Publishing, ISBN: 1-5275-4530-X, Cambridge, UK, 2020.

PhD Theses

- Barceló Villalobos, Marta. "Optimization of microalgae production in industrial open reactors". International Ph. D. Thesis. U. Almería, Supervisors: J.L. Guzmán, F.G. Acién, 09/07/2020.
- Gil Vergel, Juan Diego. "Hierarchical control and optimization strategies applied to solar membrane distillation facilities". International Ph. D. Thesis. U. Almería, Supervisors: M. Berenguel, L. Roca, 25/06/2020.

2.4.8 Staff members

Manuel Berenguel Soria, PhD

Main Researcher
Professor of Systems Engineering and Automatic Control
UAL
beren@ual.es
(+34) 950 015 683
arm.ual.es, www.ciesol.es

Lidia Roca Sobrino, PhD

Main Researcher
CIEMAT-PSA
lidia.roca@psa.es
(+34) 950387900 (ext. 964)
www.psa.es
www.ciesol.es

Francisco Rodríguez Díaz, PhD

Professor of Systems Engineering and Automatic Control
UAL

Javier Bonilla Cruz, PhD

Researcher
CIEMAT-PSA

Dr. José Luis Guzmán Sánchez

Professor of Systems Engineering and Automatic Control
UAL

Antonio Giménez Fernández, PhD

Assoc. Professor of Mechanical Engineering
UAL

Manuel Pérez García, PhD

Assoc. Professor of Applied Physics
UAL

José Carlos Moreno Úbeda, PhD

Assoc. Professor of Systems Engineering and Automatic Control
UAL

Julián García Donaire, PhD

Assoc. Professor of Computer Architecture and Technology
UAL

José Domingo Álvarez Hervás, PhD

Assoc. Professor of Systems Engineering and Automatic Control
UAL

José Luis Blanco Claraco, PhD

Assoc. Professor of Mechanical Engineering
UAL

Jorge Antonio Sánchez Molina, PhD

Assoc. Professor of Systems Engineering and Automatic Control
UAL

María del Mar Castilla Nieto, PhD

Assoc. Professor of Systems Engineering and Automatic Control
UAL

Alberto de la Calle Alonso, PhD

Researcher
Arizona State University, USA

Francisco Javier Cabrera Corral, PhD

Researcher
Junta de Andalucía

José Antonio Carballo López, PhD

Contratado
Deutschen Zentrums für Luft- und Raumfahrt

José Luis Torres Moreno, PhD

Lecturer in Mechanical Engineering
UAL

Juan Diego Gil Vergel, PhD

Posdoctoral Researcher
UAL

Marta Barceló Villalobos, PhD

Posdoctoral Researcher
UAL

Jerónimo Ramos Teodoro, PhD

Posdoctoral Researcher
UAL

Enrique Rodríguez Miranda

Hired Researcher
Universidad de Brescia

Manuel Muñoz Rodríguez

Hired Researcher
IoF2020

Ángeles Hoyo Sánchez

Predoctoral scholarship
Ministerio de Ciencia, Innovación y Universidades
FPI

Francisco García Mañas

Predoctoral scholarship
Ministerio de Ciencia, Innovación y Universidades
FPU

Pablo Otálora Berenguel

Predoctoral scholarship
Ministerio de Ciencia, Innovación y Universidades
FPU

Marína Martínez Molina

Hired Researcher
CHROMAE (Ministerio de Ciencia, Innovación y Universidades)

Juan Miguel Serrano Rodríguez

Predoctoral scholarship
CIEMAT

2.4.9 Ongoing projects in 2020

The project history can be consulted at the following link:

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

2.4.9.1 Internet of Food and Farm IoF2020

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics".
University of Almería (TEP 197)
72 International partners

Contacts:

Manuel Berenguel (beren@ual.es)
Jorge Sánchez (jorgesanchez@ual.es)
Cynthia Giagnocavo (cgiagnocavo@ual.es)

Source of funding:

H2020 Call for proposals: H2020-IOT-2016-2017 (H2020-IOT-2016). Proposal: 731884 — IoF2020. IoT-01-2016 — Large Scale Pilots. Innovation action.

Duration:

January 2017 – December 2020

Status:

Finalised

Summary:

The European Project Internet of Food & Farm 2020 (IoF2020, Internet of Food and Farming) aims to investigate and promote the large-scale implementation of the Internet of Things (IoT, Internet of Things) in the agricultural and food sector European. With a budget of 30 million euros, co-financed by the European Union, the project has the potential to introduce a paradigm shift in this area, drastically improving productivity and sustainability. The added value of networks and smart websites of interconnected objects,

sensitive to the context and that can be identified, equipped with sensors and remotely controlled in the agri-food sector, will be demonstrated. The project, which focuses on 19 case studies spread across Europe, offers solutions to 5 agri-food areas: arable crops, dairy, meat, vegetables and fruits and takes into account their own needs and obstacles. IoF2020 involves all actors in the food chain: from farmers, cooperatives, equipment and logistics suppliers, food processing companies, to consumer organisations and including ICT developers. The Unit has been involved in the design of highly energy and water-efficient control strategies using IoT technology and trials in commercial tomato greenhouses.

Additional info: https://www.iof2020.eu/

2.4.9.2. SOLWARIS - Solving Water Issues for CSP Plants.

Participants:

Centro de Investigaciones en Energía Solar CIESOL (España), centro mixto UAL-CIEMAT
Plataforma Solar de Almería
Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería (TEP 197)

Contacts:

M. 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

Abstract:

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/

2.4.9.3 Next Generation Training on Intelligent Greenhouses NEGHTRA

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:

Francisco Rodríguez Díaz (frrodrig@ual.es)

Source of funding:

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

Duration:

01/11/2020-31/10/2023

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.

2.4.9.4 Micro-grids for solar self-supply of isolated productive environments 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

Contacts:

Manuel Pérez (mperez@ual.es)

Sources of funding:

Call for Projects on Strategic Themes 2018 ERANET LAC. P918PTE0258

Duration:

01/01/2019 – 31/12/2021

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

2.4.9.5 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)
Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.
Departamento de Informática y Automática de la UNED

Contacts:

José Luis Guzmán (joseluis.guzman@ual.es)
José Luis Blanco (jlblanco@ual.es)
José Sánchez (jsanchez@dia.uned.es)

Sources of funding:

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

Duration:

01/01/2018 – 31/12/2021

Status:

Under development

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 CO2 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/

2.4.9.6 CHROMAE – Control and Optimal Management of Heterogeneous Resources in Agroindustrial production districts integrating renewable Energies

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.

Contacts:

F. Rodríguez (frrodrig@ual.es)
A. Giménez (agimfer@ual.es)

Sources of funding:

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

Duration:

01/01/2018 – 31/12/2021

Status:

Under development

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/

2.4.9.7 CARBON4GREEN Optimization of integral heating system and carbon enrichment in greenhouses

Participants:
Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.

Contacts:
Francisco Gabriel Acién (facien@ual.es)
Jorge Antonio Sánchez-Molina (jorgesanchez@ual.es)

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:
01/10/2019-30/09/2021

Status:
Under development

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. Fundamental aspects are addressed such as:

1. The optimisation of operating conditions and absorbent materials for greater process efficiency.
2. The development of reference frameworks for the modelling, control and monitoring of CO2 storage and enrichment processes, addressing the problem of interoperability and integration with already installed commercial systems.

Additional info: http://www2.ual.es/carbon4green/

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

Participants:
Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.

Contacts:
José Domingo Álvarez Hervás (jhervas@ual.es)
Manuel Berenguel (beren@ual.es)

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:

01/2020-12/2021

Status:

Under development

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.

2.4.9.9 Sustainable, Autonomous, Connected and Open Intensive Farming System (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
Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.

Contacts:

Jorge Antonio Sánchez (jorgesanchez@ual.es)
Manuel Berenguel (beren@ual.es)

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. Centro Mixto de Investigación en Energía Solar UAL-CIEMAT (CIESOL). Referencia proyecto: EQC2019-006658-P (308.850 €).

Duration:

01/2020-12/2021

Status:

Under development

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.

2.4.9.10 PARTICIPATION - Bio-mimetic and phyto-technologies designed for low-cost purification and recycling of water (INDIA-H2O)

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:

01/02/2019 –31/07/2023

Status:

Under development

Summary:

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

Additional info: https://cordis.europa.eu/project/id/820906/es

2.4.9.11 PARTICIPATION - Sustainablle Allgae Biiorefiinery for Agriicullture aNd Aquacullture 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

Contact:

F. Gabriel Acién (facien@ual.es)

Contact in the CIESOL Modelling and Automatic Control Unit:

José Luis Guzmán (joseluis.guzman@ual.es)
Francisco Rodríguez (frrodrig@ual.es)

Sources of funding:

Horizon 2020. European Union's Horizon 2020 Research and Innovation Program under Grant Agreement No. 727874 SABANA.

Duration:

01/12/2016 – 30/11/2020

Status:

En desarrollo

Summary:

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

Additional info: http://www.eu-sabana.eu/

2.4.9.12 PARTICIPATION - Sustainablle Allgae Biiorefiinery for Agriicullture aNd Aquacullture SABANA

Participants:

Centro de Investigaciones en Energía Solar CIESOL (Spain), a joint UAL-CIEMAT centre.

Contacts:

J.A. Sánchez (jsanchez@ual.es)

Contact in the CIESOL Modelling and Automatic Control Unit:

José Domingo Álvarez (jhervas@ual.es)
María del Mar Castilla (mcastilla@ual.es)
Manuel Berenguel (beren@ual.es)

Sources of funding:

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

Duration:

01/01/2019 – 31/12/2022

Status:

Under development

Summary:

SFERA III is a Horizon 2020 project funded under the Research Infrastructure Programme. The consortium is coordinated by CIEMAT-PSA and is made up of a total of 15 partners from 9 EU member countries. The project runs from January 2019 to December 2022 and will receive a grant of 9,103 million euros from the EC over these 4 years. The overall objective of this project is to continue the work done over the last 8 years in the SFERA 1 and SFERA 2 projects and to strengthen the sustainability of European advanced concentrating solar energy research infrastructure activities.

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

2.4.9.13 PARTICIPATION – SmartAgriHubs: Connecting the dots to unleash the innovation potential for digital transformation of the European agri-food sector

Participants:

Universidad de Almería, Cátedra Coexphal-UAL

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

104 international partners

Contacts:

Cynthia Giagnocavo (cgiagnocavo@ual.es)

Contact in the CIESOL Modelling and Automatic Control Unit:

Manuel Berenguel (beren@ual.es)

José Carlos Moreno (jcmoreno@ual.es)

Sources of funding:

Horizon 2020 Framework Programme. Call for proposals H2020-RUR-2018-2020 (H2020-RUR-2018-1). Proposal 818182 (starts 01/11/2018). UAL leader C. Giagnocavo.

Duration:

01/11/2018 – 31/10/2022

Status:

Under development

Summary:

The European Union has made a very strong commitment to the massive implementation of new technologies in intensive agriculture, which has materialised through the SmartAgriHubs project, in which Almeria and the University of Almeria have a very prominent role. SmartAgriHubs aims to bring about a digital transformation in the agri-food sector, leading to an increase in its competitiveness and sustainability. The recently created Almería Digital Innovation Hub, led by Cajamar and COEXPHAL, together with the UAL, Cátedra COEXPHAL-UAL, Hispatec and AgroColor, forms part of the SmartAgriHubs initiative and will be fundamental for the digitalisation of precision horticulture under glass in Almería. This project has a budget of 20 million euros and the University of Almeria is leading the work package of Centres of Competence (CC) across Europe. SmartAgriHubs has already launched a network of 140 Digital Innovation Centres, which in

turn are grouped into nine regional clusters, led by organisations linked to national or regional initiatives and funding strategies, pursuing the digitisation of the agricultural sector.

Additional info: https://www.smartagrihubs.eu/

2.4.9.14 PARTICIPATION – SAFEMPC: Safe and Reliable Energy Management of Microgrids integrating Demand Response Techniques and Stochastic Model Predictive Control

Participants:

Universidad de Sevilla. Research group "Automatic control and Industrial Robotics".
María del Mar Castilla Nieto, Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería.

Contacts:

Carlos Bordóns (bordons@us.es)
Ascensión Zafra (asunzafra@us.es)

Contact in the CIESOL Modelling and Automatic Control Unit:

María del Mar Castilla (mcastilla@ual.es)

Sources of funding:

Proyectos de I+D+I Retos Investigación. Topic: Producción Industrial, ingeniería civil e ingenierías para la sociedad. PID2019-104149RB-I00.

Duration:

01/06/2020 – 31/05/2023

Status:

Under development

Summary:

The project addresses issues such as the design of secure and reliable energy management systems for microgrids integrating risks associated with cybersecurity, resilience to failures in the main grid, diagnosis of failures in microgrids and minimisation of degradation in storage systems by developing stochastic predictive control techniques that optimise the control of the microgrid considering uncertainties.

Additional info: https://investigacion.us.es/sisius/sis_proyecto.php?idproy=32096

2.4.9.15 PARTICIPATION – GESVIP2020: Efficient and safe management of microgrids for the integration of renewable energy in housing using predictive control techniques.

Participants:

Universidad de Sevilla. Research group "Automatic control and Industrial Robotics".
María del Mar Castilla Nieto, Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería.

Contacts:

Carlos Bordóns (bordons@us.es)
José Maestre Torreblanca (pepemaestre@us.es)

Contact in the CIESOL Modelling and Automatic Control Unit:

María del Mar Castilla (mcastilla@ual.es)

Sources of funding:

Proyectos de I+D+I FEDER Andalucía 2014-2020. Junta de Andalucía (Consejería de Economía y Conocimiento). US-1265917.

Duration:

02/02/2020 – 31/01/2022

Status:

Under development

Summary:

The project focuses on efficient and secure energy management at the microgrid level (set of loads, generators and storage systems that can be managed in a coordinated way to operate in isolation or connected to the grid). In particular, the aim is to optimise the generation, storage and consumption of energy within homes and buildings with the integration of renewable energies and taking into account the

particularity of existing loads. The project will propose various control solutions based on the framework of predictive control (MPC) to efficiently and safely manage the operation of micro-grids integrated in buildings.

Additional info: https://investigacion.us.es/sisius/sis_proyecto.php?idproy=30751

2.4.9.16 PARTICIPATION – C3PO: Coalitional Control Applied to Cyber-Physical Systems Optimisation.

Participants:

Universidad de Sevilla. Research group "Automatic control and Industrial Robotics".
María del Mar Castilla Nieto, Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería.

Contacts:

José Maestre Torreblanca (pepemaestre@us.es)

Contact in the CIESOL Modelling and Automatic Control Unit:

María del Mar Castilla (mcastilla@ual.es)

Sources of funding:

Ministerio de Economía, Industria y Competitividad. Plan Nacional 2014 (DPI2017-86918-R)

Duration:

01/01/2018 – 31/12/2020

Status:

Finalised

Summay:

This project focuses on the development of new coalitional strategies for the predictive control of Cyber-Physical Systems (CPS). Predictive control or MPC uses mathematical models to predict the behaviour or evolution of the systems. In this way, the interaction between the different subsystems that make up the CPS can be predicted, which can be used to dynamically form coalitions between controllers with the aim of This can be used to dynamically form coalitions between controllers to improve overall system performance. The ultimate goal is to develop a scalable and robust coalitional control framework for CPS, which constitutes a substantial new advance in the field of distributed control systems with direct applications in large-scale systems. In particular, two real problems used in European projects will be used as case studies: the charging of electric cars in Malaga (in collaboration with Ayesa) and the management of irrigation canals (in collaboration with Mobile Water Management).

Additional info: https://investigacion.us.es/sisius/sis_proyecto.php?idproy=28530

2.4.9.17 PARTICIPATION – CONFIGURA: Predictive Control of Reconfigurable Microgrids with Hybrid and Mobile Storage.

Participants:

Universidad de Sevilla. Research group "Automatic control and Industrial Robotics".
María del Mar Castilla Nieto, Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería.

Contacts:

Carlos Bordons (bordons@us.es)
Miguel Angel Ridao (miguelridao@us.es)

Contact in the CIESOL Modelling and Automatic Control Unit:

María del Mar Castilla (mcastilla@ual.es)

Sources of funding:

Ministerio de Economía, Industria y Competitividad. Plan Nacional 2014 (DPI2016-78338-R)

Duration:

31/12/2016 – 31/12/2020

Status:

Finalised

Summary:

This project deals with energy control in microgrids (which are a set of loads, generators and storage systems that can be managed in a coordinated way to operate in isolation or connected to the grid). Special consideration is given to the problem of interconnection between electric vehicles and microgrids, as well as the problem of topology change due to the connection/disconnection of any generation, storage or charging system. The project develops different control strategies within the framework of Predictive Control to efficiently manage the operation of these systems, addressing reconfigurability both in terms of the components of a microgrid and interconnected microgrids. The control systems also consider criteria that include factors affecting the degradation of storage systems, in order to provide the systems with greater durability.

Additional info: https://investigacion.us.es/sisius/sis_proyecto.php?idproy=27707

2.4.10 Participation in networks during 2020

The network history can be consulted at the following link:
https://arm.ual.es/arm-group/networks-operating-groups/

Solarconcentra – Concentrated Solar Power Technology Platform

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería. CIESOL

9 Public Administrations, 8 Associations, 13 Technology Centres, 87 companies, 22 Universities.

Contacts:

Manuel Pérez (mperez@ual.es)

Sources of funding:

Expediente PTR-2018-001094

Duration:

Indefinite

Status:

Under development (http://www.solarconcentra.org/)

CO2 Technology Platform

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería. https://www.hisparob.es/socios-actuales/

Contacts:

Francisco Rodríguez (frrodrig@ual.es)

Sources of funding:

Expediente PTR2018-001099

Duration:

Indefinite

Status:

Under development (https://www.pteco2.es/es)

Hisparob – Spanish Robotics Technology Platform

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería. https://www.pteco2.es/es/quienes-somos/miembros

Contacts:

José Carlos Moreno Úbeda (jcmoreno@ual.es)

Sources of funding:

Expediente PTR2018-001073

Duration:

Indefinite

Status:

Under development (https://www.pteco2.es/es)

Automática ES Network

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería.
14 Spanish Universities

Contacts:

Manuel Berenguel (beren@ual.es)

Sources of information:

Acciones de Dinamización "Redes de Investigación". Ministerio de Ciencia, Innovación y Universidades. RED2018-102688-T. IP. Carlos Balaguer Bernaldo de Quirós (UC3M)

Duration:

01/01/2019-31/12/2021

Status:

Under development

Control Engineering Thematic Network

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería.
10 Spanish Universities

Contacts:

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

Sources of funding:

Acciones de Dinamización "Redes de Excelencia". Ministerio de Economía, Industria y Competitividad. DPI2017-90823-REDT. IP Ramón Vilanova i Arbós (UAB)

Duration:

01/01/2017-31/12/2019 – Continues to operate without funding

Status:

Under development

Control Education Thematic Network

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería.
12 Spanish Universities

Contacts:

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

Sources of funding:

Acciones de Dinamización "Redes de Excelencia". Ministerio de Economía, Industria y Competitividad.

Duración prevista:

Continues to operate without funding

Status:

Under development

Robotics National Network

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería.
12 Spanish Universities

Contacts:

Antonio Giménez (agimfer@ual.es)

Sources of funding:

Acciones de Dinamización "Redes de Investigación". Ministerio de Ciencia, Innovación y Universidades. DPI2017-90853-REDT. IP. Miguel Ángel Salichs Sánchez-Caballero.

Duration:

01/07/2018-30/06/2020

Status:

Under development

Monitor Network

Participants:

Reseach group "Automatic Control, Robotics & Mechatronics". Universidad de Almería.
https://redmonitor.ietcc.csic.es/index.php/participantes/

Contacts:

José Domingo Álvarez (jhervas@ual.es)

Sources of funding:

Red de excelencia BIA2017-90912-REDT 2018-2020

Duration:

2018-2020

Status:

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/

The history of operational groups can be consulted at the following link:

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

2.4.11 Transfer and Complementary Activities

Contracts with companies

There were no contracts with companies in this period. Only one project has been developed within the scope of the task force with UNICA Group.

The history of transfer activities can be consulted at the following link:

https://arm.ual.es/arm-group/knowledge-transfer/

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 in ERASMUS+ KA 107 Programme

Participants:

- Modeling and Automatic Control Unit
- International Relationship Office of the Universidad de Almería

Contacts:

- Manuel Pérez García (mperez@ual.es)
- María del Mar Sánchez (sri@ual.es)

Description of the activity:

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. Throughout the year 2017, collaborations have been carried out within the framework of this program with the International University of Rabat and the University of the Republic of Uruguay.

Collaboration with the STUDY ABROAD Programme

Participants:

- Modeling and Automatic Control Unit
- International Relationship Office of the Universidad de Almería (sri@ual.es)

Contacto:

- Manuel Pérez García (mperez@ual.es)

- María del Mar Sánchez (sri@ual.es)

Description of the activity:

The summer program STUDY ABROAD of the UAL offers a complete package that includes tuition and accommodation and a set of cultural services to international students who offer specialized courses of 80 hours to be taught in the month of July organized by departments and research centers of the University of Almería The Modeling and Auntomatic Control Unit has coordinated the course called "Energy Transfer Processes in Solar Thermal Installations. Modeling and applications to design ".

Collaboration with PIMA Programme

Participants:

- Modeling and Automatic Control Unit
- International Relationship Office of the Universidad de Almería (sri@ual.es)

Contacts:

- Manuel Pérez García (mperez@ual.es)

Description of the activity:

Exchange of students from the UAL and the Federal University of Santa Catarina (Brazil).

Collaboration with YCGA Programme

Participants:

- Master in Solar Energy (CIESOL)
- International Relationship Office of the Universidad de Almería (sri@ual.es)

Contacts in CIESOL:

- Manuel Berenguel (beren@ual.es)
- José Domingo Álvarez (jhervas@ual.es)
- María José Jiménez Taboada (mjose.jimenez@psa.es).

Description of the activity:

Reception and mentoring of students on the Master's Degree in Solar Energy. During the 2019/2020 academic year, the YGCA programme was developed, a pilot legal migration initiative launched by the European Commission and co-funded by the European Union, through which a circular flow was established with Morocco that allowed 100 young graduates from this country to take a one-year master's degree in Spain, thus contributing to the establishment of legal migration schemes between Spain and the Alaouite kingdom. As part of the programme, and prior to the final Reintegration Phase, students were asked to propose entrepreneurial projects, offering a prize of 10,000 euros for the 10 best entrepreneurial initiatives presented by students participating in the programme in order to help them implement them. The mentored student (Mostapha Mounadi) was one of the winners of these 10 prizes.

Collaboration with the Schneider Electric Agreement

Participants:

- Modeling and Automatic Control Unit
- Escuela Superior de Ingeniería

Contacts:

- Francisco Rodríguez (frrodrig@ual.es)

Description of the activity:

Training of teachers and students in digital technologies for energy management and automation.

2.4.12 Dissemination activities

- Summary: https://arm.ual.es/arm-group/dissemination-of-results/ y https://arm.ual.es/arm-group/news/
- Event: Advanced Course Technological Innovation for intensive greenhouse production. Conference: Digitalizing the greenhouse agriculture. Organizer: Mediterranean Agronomic Institute. Speaker: Francisco Rodríguez Díaz. Year: 2020. Place: Estación Experimental de la Fundación Cajamar "Las Palmerillas"
- Event: Agro-Ateneo. Conference: IoT: the tech big brother. Organizer: La Voz de Almería, Ser Agricultor, Agricultura 2000. Speaker: Francisco Rodríguez Díaz. Year: 2020. Place: Fundación Tecnova
- Event: Webinar. Conference: Big Data and Artificial Intelligence, Improving the profitability of your crops. Organizer: Junta de Andalucía, Operative group RENTIA and COEXPHAL. Year: 2020. Place: Coexphal
- Event: Seminar TAIDA. Conference: Modelling and control of irrigation and fertiliser in greenhouses. Organizer: UPCT. Year: 2020. Place: Cartagena
- Event: Ágora Agrónomos. Conference: Agricultura 4.0. Organizer: Colegio Oficial de Ingenieros Agrónomos de Andalucía. Year: 2020. Place: Colegio Oficial de Ingenieros Agrónomos de Andalucía
- Photo-expo "La UAL da la cara por la Ciencia"
- Qualifying Tournament of the FIRST Lego League
- III Conference on Automation, Robotics and Mechatronics
- Challenge Robotics Club of the University of Almeria
- European Night of the Researchers, Almería
- Week of Science, Almería
- Robotics Club
- European Robotics Week
- Girls Technology Campus
- Informatics Week
- Visit your University
- Scientific News in Almería

2.4.13 Project's applications in 2020

- Unidad de Innovación Conjunta UAL-COSENTINO. Nuevos materiales aglomerados avanzados libres de sílice (Silestone® Silica Free Advanced). Junta de Andalucía. Línea de subvención PROGRAMA DE LIDERAZGO EN INNOVACIÓN ABIERTA, SINGULAR Y ESTRATÉGICA. Tipología:CREACIÓN UNIDADES DE INNOVACIÓN CONJUNTA (UIC). IP UAL Ignacio de las Nieves. Awaiting resolution.
- Suite of open and modular interaction components for superior user experiences in scenarios of collaboration between humans and robots. Call: H2020-ICT-2020-2. Type of action: RIA. Proposal number: 101016987. Proposal acronym: SUITE. Duration (months): 42. Activity: ICT-46-2020-RIA. IP UAL José Carlos Moreno. Not granted.

- PLURAL: PLatforms for rURAL & PLURALity. Horizon 2020. Call: H2020-DT-2018-2020 (Digitising and transforming European industry and services: digital innovation hubs and platforms). Topic: DT-ICT-09-2020. Type of action: IA. Proposal number: 101016667. IP UAL Cynthia Giagnocavo. Not granted.
- AgKnowledge: Agricultural Knowledge and Innovation Systems (AKIS) for enabling farmers to unlock the full potential of competitive and sustainable European agricultural data management and sharing. H2020-RUR-15-2020. Thematic Network. IP Spyros Fountas. IP UAL Cynthia Giagnocavo. Not granted.
- RESONANCE: Co-cREation of innovative Climate Water Energy Food Nexus. SuppOrt tools for the Next generAtion of stakeholder-orieNted transparent poliCiEs. Work programme topic addressed: LC-CLA-14-2020: Understanding climate-water-energy-food nexus and streamlining water-related policies. H2020 Research and Innovation Action. IP Pietro Zambelli (EURAC), IP UAL Juan Reca. Not granted.
- Solar Integrated WAter and poweR generation (SIWAR, proposal number 101022779). Call: H2020-LC-SC3-2018-2019-2020 (BUILDING A LOW-CARBON, CLIMATE RESILIENT FUTURE: SECURE, CLEAN AND EFFICIENT ENERGY). IP: Juan Antonio Andrés-Mañas. Not granted.
- HYCO2BIO - Data-based modelling, control and optimization for the sustainable production of biomass in a microalgae-based biorefinery. Ministry of Science and Innovation (PID2020-112709RB-C21). IP José Luis Guzmán, coordinado Universidad de Almería, Universidad de Murcia. Awaiting resolution.
- Desarrollo de clúster de invernaderos en la zona agrícola de la región de Imereti (Georgia) liderado por el Grupo Desarrolla a la convocatoria Agricultural Project's Management Agency of Georgia Goverment. IP Francisco Rodríguez. Awaiting resolution.
- Simulador para la gestión y optimización de recursos endógenos (agua y energía) en explotaciones agrícolas (AGRO-SIMULADOR). Convocatoria PNDR del Ministerio de Agricultura, Pesca y Alimentación. IP Francisco Rodríguez. Not granted.
- Red de investigación Automatización y TICs en Agricultura (ATICA) junto con 11 Universidades más, 2020. IP Francisco Rodríguez. Not granted.
- Robot colaborativo para transporte inteligente en interior de invernaderos con soporte en IoT AGRICOBIOT (AGRIcultural COllaborative roBot inside the IOT). Convocatoria: PROGRAMA DE AYUDAS A LA I+D+i, EN RÉGIMEN DE CONCURRENCIA COMPETITIVA,EN EL ÁMBITO DEL PLAN ANDALUZ DE INVESTIGACIÓN, DESARROLLO E INNOVACIÓN (PAIDI 2020) (Orden de 7 de abril de 2017, BOJA núm 71, de 17 de abril de 2017). IP José Carlos Moreno. Awaiting resolution.
- MULTISOL Concentrador solar térmico multifuncional. Proyecto UAL-FEDER. IP José Domingo Álvarez, Manuel Pérez. Awaiting resolution.
- Empowering African Food and Nutrition Systems (EAF) Topic: LC-SFS-34-2019, Food System Africa. IP Jorge Antonio Sánchez Molina. Not granted.

2.3.14 Others

Final degree projects:

- Abreu Matute, Santiago Jesús. **ANALYSIS OF MODELING AND DESIGN TOOLS FOR ELECTRICAL STORAGE SYSTEMS IN PHOTOVOLTAIC APPLICATIONS. Master's in Solar Energy.** Supervisor: Manuel Pérez García. Date: 13-Jul-2020.
- Justo Esdras Alarcón**. TECHNICAL AND ECONOMIC ANALYSIS OF THE APPROVAL OF THE COVERAGE OF THE AULARIOS I, II AND III OF THE UNIVERSIDAD DE ALMERÍA FOR PHOTOVOLTAIC SELF-CONSUMPTION. Master's in Solar Energy.** Supervisor: Manuel Pérez García. Date: 10-Nov-2020.

- Boutoil , Hicham **. DESIGN OF AN AUTONOMOUS CLEANING SYSTEM FOR HELIOSTATS. Master's in Solar Energy. Supervisors:** Jesús Fernández Reche, José Domingo Álvarez Hervás. Date: 10-Nov-2020.
- Ruiz Baena, Miguel Ángel**. DESIGN OF A SOLAR REFRIGERATION SYSTEM AND STUDY OF CO2 REQUIREMENTS IN A COLD WINTER. Master's in Solar Energy. Supervisors:** Guillermo Zaragoza del Águila, Jorge Antonio Sánchez Molina. Date: 9-Nov-2020.
- Romero Ramos, José Alfonso**. DESIGN AND TECHNO-ECONOMIC ANALYSIS OF 100% SOLAR INSTALLATIONS (THERMAL + PHOTOVOLTAIC) FOR THE PROCESS OF THERMAL DISTILATION MEASURED AT LOW TEMPERATURE. Master's in Solar Energy. Supervisors:** Diego César Alarcón Padilla, Manuel Pérez García. Date: 24-Sep-2020.
- López Gómez, Irene**. EVALUATION OF THE ENERGY EFFICIENCY OF THE AULARIO II OF THE UNIVERSIDAD DE ALMERÍA: ANALYSIS OF PROPOSALS FOR IMPROVEMENT AND INCREASE OF ITS SOLAR FRACTION. Master's in Solar Energy. Supervisors:** Silvia Soutullo Castro, Manuel Pérez García. Date: 13-Jul-2020.
- Pérez Ruiz, Julia**. OBJECT ORIENTED MODELING OF THE TCP-100 PLANT OF THE ALMERÍA SOLAR PLATFORM. Master's in Solar Energy. Supervisors: Manuel Berenguel Soria, Luis José Yebra Muñoz.** Date: 14-Jul-2020.
- Marín Silvestre, Álvaro**. TECHNO-ECONOMIC MODELLING AND ANALYSIS OF THERMOLLAR CENTRAL RECEIVER PLANTS HYBRIDIZED WITH PHOTOVOLTAIC FOR APPLICATIONS OF COGENERATION OF ELECTRICITY AND WASTEWATER. Master's in Solar Energy. Supervisors:** Diego César Alarcón Padilla, Manuel Pérez García. Date: 24-Sep-2020.
- **Marinone, Esteban. SIMULATION AND ANALYSIS OF THE ENERGY PRODUCTION OF A 1 MW PHOTOVOLTAIC PLANT INTEGRATED IN THE PARKING GARAGE AT THE UNIVERSITY OF ALMERÍA. Master's in Solar Energy.** Supervisor: Manuel Pérez García. Date: 13-Jul-2020.
- Haro Rubio, Antonio**. DESIGN OF A 6.3 TONNE CRANE. Masters's in Industrial Engineering.** Supervisor: José Luis Torres Moreno. Date: 17-Nov-2020.
- Socías Mullor, Alberto**. DESIGN OF A ROBOTIC STATION FOR SARS-COV-2 EPISODE DISTRIBUTION CENTRE. Masters's in Industrial Engineering.** Supervisor: José Luis Torres Moreno Date: 9-Jul-2020.
- Oller Oller, Ángel**. STUDY FOR THE IMPLANTATION OF A POLLINATOR INSECT FARM IN THE PROVINCE OF ALMERÍA. Masters's in Industrial Engineering.** Supervisor: José Luis Torres Moreno. Date: 24-Sep-2020.
- Martínez Molina, Marina**. EXERCISE STUDY FOR A SOLAR POWERED MEMBRANE DISTILLATION MODULE. Masters's in Industrial Engineering.** Supervisors: Manuel Berenguel Soria, Juan Diego Gil Vergel. Date: 24-Sep-2020
- Rodríguez Torres, María José. **MODELLING, CONTROL AND PRODUCTION ANALYSIS OF ABIERTO PHOTOBIOREACTORS WITH DIFFERENT HYDRAULIC AND CELLULAR RETENTION TIMES**. **Masters's in Industrial Engineering.** Supervisor: José Luis Guzmán Sánchez. Date: 19-Nov-2020.
- Lozano López, María Del Mar**. MULTI-OBJECTIVE OPTIMISATION OF THE OPERATION OF A SOLAR-POWERED MEMBRANE DISTILLATION PLANT VIA MPC. Masters's in Industrial Engineering.** Supervisors: Manuel Berenguel Soria, Juan Diego Gil Vergel. Date: 2-Mar-2020.
- Cáceres Pintor, Sergio**. DEVELOPMENT OF A SYSTEM FOR AIDING AND TAKING DECISIONS FOR WINTER FERTIRRIGATION.** Master in Technologies and Applications of Informatics. Supervisor: Jorge Antonio Sánchez Molina. Date: 15-Jul-2020.
- Asensio Amador, Carlos. ADAPTATION OF THE MEASUREMENT AND CONTROL SYSTEM OF THE PEOPLEBOT ROBOT FOR THE IMPLEMENTATION OF THREADING. Industrial Electronics Engineering Degree. Supervisors: Francisco de Asís Rodríguez Díaz, José Carlos Moreno Úbeda. Date: 19-Nov-2020.

- Robles González, Joaquín. DEVELOPMENT OF A SCADA TYPE SYSTEM FOR THE CRECIMIENTO DE CULTIVOS EN EL INTERIOR DE INVERNADEROS. Industrial Electronics Engineering Degree. Supervisors: Jorge Antonio Sánchez Molina, Francisco de Asís Rodríguez Díaz. Date: 15-Jun-2020.
- Díaz Mateo, Néstor. DEVELOPMENT OF THE ELECTRICAL/ELECTRONIC SYSTEM FOR THE AUTOMATION OF A CHERRY TOMATO MEZCLATE MACHINE. Industrial Electronics Engineering Degree. Supervisors: Jorge Antonio Sánchez Molina, Francisco de Asís Rodríguez Díaz. Date: 15-Jun-2020.
- Roda Sánchez, Victor Manuel. DEVELOPMENT OF THE ELECTRICAL AND ELECTRONIC SYSTEM OF A CO2 CAPTURE SYSTEM FOR REMOTE CONTROL AND SUPERVISION. Industrial Electronics Engineering Degree. Supervisors: Francisco de Asís Rodríguez Díaz, Jorge Antonio Sánchez Molina. Date: 17-Jun-2020.
- Cano Lara, Antonio. DEVELOPMENT AND DEPLOYMENT OF A PARALLEL 2 DEGREE ROBOT. Industrial Electronics Engineering Degree. Supervisors: José Luis Torres Moreno, Antonio Giménez Fernández. Date: 22-Sep-2020.
- Berko Danso, Lord Boakye. DESIGN OF A VIRTUAL LABORATORY FOR A FIELD OF CYLINDER-PARABOLIC COLLECTORS WITH TEACHING PURPOSES. Industrial Electronics Engineering Degree. Supervisors: José Domingo Álvarez Hervás, José Luis Guzmán Sánchez. Date: 16-Jun-2020.
- Bonache Sola-Vera, Pablo. DESIGN OF AN OPEN-SOURCE WEATHER STATION. Industrial Electronics Engineering Degree. Supervisors: Jorge Antonio Sánchez Molina, Manuel Muñoz Rodríguez. Date: 21-Sep-2020.
- Navarro Romera, Ana. STUDY AND ANALYSIS OF RESET CONTROLLER DESIGN RULES FOR PRIMER ORDER SYSTEMS. Industrial Electronics Engineering Degree. Supervisors: José Luis Guzmán Sánchez, José Carlos Moreno Úbeda. Date: 21-Sep-2020.
- Galdeano López, Jesús. EVALUATION AND VALIDATION OF MODELING STRATEGIES AND CONTROL OF THE PHOTO-FENTON PROCESS THROUGH EASY JAVASCRIPT SIMULATIONS. Industrial Electronics Engineering Degree. Supervisors: José Luis Guzmán Sánchez, José Luis Casas López. Date: 17-Jun-2020.
- Cortés Martínez, Luis Javier. EASY JAVA SIMULATIONS BASED TOOL FOR LEARNING GREENHOUSE CLIMATE CONTROL TECHNIQUES. Industrial Electronics Engineering Degree. Supervisors: José Luis Guzmán Sánchez, Francisco de Asís Rodríguez Díaz. Date: 23-Jan-2020.
- Ramajo Ballester, Álvaro**. MODELLING, CONTROL AND OPTIMISATION OF AN AUTONOMOUS MULTI-ROBOT SYSTEM FOR INTELLIGENT TRANSPORT**. Industrial Electronics Engineering Degree. Supervisor: José Carlos Moreno Úbeda. Date: 29-Jun-2020.
- **Capilla del Pino, Miguel. MODELLING AND CONTROL OF A SOLAR-POWERED MEMBRANE DISTILLATION SYSTEM**. Industrial Electronics Engineering Degree. Supervisors: Manuel Berenguel Soria, Lidia Roca Sobrino. Date: 28-Jan-2020.
- Chinchilla Pérez, Juan Manuel**. MODELLING AND CONTROL OF CIESOL BUILDING COMFORT WITH CO-SIMULATION TECHNIQUES**. Industrial Electronics Engineering Degree. Supervisors: María del Mar Castilla Nieto, José Domingo Álvarez Hervás. Date: 17-Sep-2020.
- López Moreno, Miguel Ángel**. ENERGY STATUS MONITORING APPLIED TO THE HOME**. Industrial Electronics Engineering Degree. Supervisors: José Luis Guzmán Sánchez, Francisco de Asís Rodríguez Díaz. Date: 15-Sep-2020.
- González Hernández, José**. TEMPERATURE OPTIMISATION IN RACEWAY REACTORS THROUGH MEDIA HEIGHT CONTROL USING WEATHER FORECASTS**. Industrial Electronics Engineering Degree. Supervisor: José Luis Guzmán Sánchez, Enrique Rodríguez Miranda. Date: 16-Sep-2020.

- Cabrera Bautista, Alberto**. COMMISSIONING AND CONTROL OF A MULTI-PUMP MOCK-UP FOR TEACHING ENGINEERING SUBJECTS**. Industrial Electronics Engineering Degree. Supervisors: José Domingo Álvarez Hervás, María del Mar Castilla Nieto. Date: 17-Jun-2020.
- López Expósito, Francisco Román. DEVELOPMENT OF A SYSTEM FOR COUNTING PEOPLE IN BUILDINGS USING VIDEO CAMERAS AND ULTRASONIC SENSORS. Industrial Electronics Engineering Degree. Supervisors: José Domingo Álvarez Hervás, Manuel Berenguel Soria. Date: 17-Nov-2020.
- Enrique Fernández, Juan Francisco**. TECHNICAL AND ECONOMIC ANALYSIS OF THE EXTENSION OF A PHOTOVOLTAIC INSTALLATION IN A SINGLE-FAMILY HOUSE WITHIN THE NEW FRAMEWORK OF SELF-CONSUMPTION WITH SURPLUS ENERGY. Grado en Ingeniería Eléctrica.** Supervisor: Manuel Pérez García. Date: 18-Nov-2020
- Pérez González, Javier**. CAD DESIGN OF A CNC POLISHING MACHINE. Mechanical Engineering Degree.** Supervisor: José Luis Torres Moreno. Date: 16-Nov-2020.
- León García, Víctor Manuel**. TECHNO-ECONOMIC ANALYSIS OF THE IMPLEMENTATION OF A HEATING AND CLIMATE CONTROL SYSTEM IN A GREENHOUSE IN THE PROVINCE OF ALMERIA. Mechanical Engineering Degree.** Supervisors: Manuel Pérez García, Francisco Domingo Molina Aiz Date: 31-Jan-2020.
- García Parra, Francisco**. ANALYSIS AND SYNTHESIS OF A MCPHERSON SUSPENSION USING 3D CAD TOOLS. Mechanical Engineering Degree.** Supervisor: Antonio Giménez Fernández. Date: 1-Jul-2020.
- Forero Forero, Jenny Andrea. CALCULATION AND DIMENSIONING OF AUXILIARY INSTALLATIONS FOR A PHENOL PURIFICATION PROCESS**. Mechanical Engineering Degree.** Supervisors: José Luis Torres Moreno, Emilio Alejandro Cruz González. Date: 16-Nov-2020.
- Molina Caparrós, Jerónimo**. DESIGN OF A CRATE SORTER FOR A PRODUCTION LINE. Mechanical Engineering Degree.** Supervisors: Antonio Giménez Giménez, Antonio Giménez Fernández. Date: 31-Jan-2020.
- López Milán, Javier**. DESIGN OF A BUCKET ELEVATOR FOR A CEMENT FACTORY. Mechanical Engineering Degree.** Supervisor: José Luis Torres Moreno. Date: 28-Sep-2020.
- Tenorio García, Pedro**. DESIGN OF A MASS DOSING TOOL FOR VEINS FOR THE COSENTINO GROUP. Mechanical Engineering Degree.** Supervisor: José Luis Torres Moreno. Date: 30-Jan-2020.
- Rodríguez Fernández, Fernando. DESIGN, PRODUCTION AND POST-PRODUCTION OF A SYNTHETIC OIL RELIEF TANK HTF**. Mechanical Engineering Degree.** Supervisors: José Luis Torres Moreno, Manuel Pérez García. Date: 28-Sep-2020.
- Reca Luque, Carlos. DESIGN AND OPTIMISATION OF A RIGID SAIL FOR BOAT PROPULSION**. Mechanical Engineering Degree.** Supervisors: Antonio Giménez Fernández, Fernando José Aguilar Torres. Date: 22-Sep-2020.
- García Andújar, Alejandro**. EVALUATION OF THE ENERGY EFFICIENCY OF AULARIO III AT THE UNIVERSITY OF ALMERIA. PROPOSAL FOR IMPROVEMENT AND ECONOMIC STUDY. Mechanical Engineering Degree.** Supervisor: Manuel Pérez García. Date: 30-Sep-2020.
- García Pascual, Pedro**. IMPLEMENTATION OF LEAN MANUFACTURING ON PRODUCTION LINE USING COMPUTERISED MAINTENANCE MANAGEMENT SYSTEM. Mechanical Engineering Degree.** Supervisor: José Luis Guzmán Sánchez. Date: 16-Sep-2020.
- González Morales, Rubén Avelino. MODELLING THE WALKING MODES OF THE ROBONOVA HUMANOID ROBOT - I. **Mechanical Engineering Degree.** Supervisors: Francisco de Asís Rodríguez Díaz, José Luis Guzmán Sánchez. Date: 15-Jun-2020.

- Carmona Rodríguez, Loreto**. SYNTHESIS, DESIGN AND ANALYSIS OF MECHANISMS USING SOLIDWORKS AND MATLAB. Mechanical Engineering Degree.** Supervisor: José Luis Torres Moreno. Date: 31-Jan-2020.
- Caro Méndez, Manuel. DEVELOPMENT OF A LOW-COST DRONE BASED ON RASPBERRY PI AND PYTHON. Informatics Engineering Degree. Supervisors: José Carlos Moreno Úbeda, José Luis Guzmán Sánchez. Date: 15-Sep-2020.

PhD Theses under development

- Alamin, Yaser (supervisors José Domingo Álvarez, María del Mar Castilla, Antonio Ruano)
- Carreño Zagarra, José (supervisors José Carlos Moreno, José Luis Guzmán).
- García Mañas, Francisco (supervisors Francisco Rodríguez, Manuel Berenguel).
- García Ruiz, Rubén Antonio (supervisors José Luis Blanco Claraco, Javier López Martínez).
- Gómez Navarro, Francisco José (supervisors Luis José Yebra, Antonio Giménez).
- Hoyo Sánchez, Ángeles (supervisors José Luis Guzmán, José Carlos Moreno Úbeda).
- Montoya Ríos, Ana Paola (supervisors: Francisco Rodríguez Díaz, José Luis Guzmán Sánchez).
- Muñoz Rodríguez, Manuel (supervisors Jorge Antonio Sánchez-Molina, Manuel Torres).
- Otálora Berenguel, Pablo (supervisor José Luis Guzmán).
- Pataro, Igor (supervisors Manuel Berenguel, José Luis Guzmán).
- Ramos Teodoro, Jerónimo (supervisors Francisco Rodríguez, Manuel Berenguel).
- Ran, Liu (supervisors José Luis Guzmán, Li Ming).
- Rodríguez Miranda, Enrique (supervisors Antonio Visioli, José Luis Guzmán).
- Topa Gavilema, Alex Omar (supervisors José Domingo Álvarez, José Luis Torres).

Attendance at Transfer and Dissemination Workshops

- State estimation in robotics: applications to planetary exploration rovers and tutorial on factor graphs. Dr. Giulio Reina (Polytechnic of Bari, Italy) / Dr. Jose Luis Blanco Claraco (UAL). Dates: 9 - 10 January 2020. Duration: 10 hours.
- III Jornadas de Doctorado en Informática de la UAL. 21 February 2020. 9:30 h -12:30h, Sala de Grados del edificio CITE-III, Universidad de Almería.
- Introduction to Applied Supervised Machine Learning. Dr. Antonio Jesús Fernández (Universidad de Extremadura). Dates: 26, 27 and 28 May 2020. Duration: 10 hours.
- Predictive Control meets Evolutionary Game theory. Dr. Carlos Ocampo Martínez (Departamento de Control Automático. Universidad Politécnica de Catalunya) and Dr. Nicanor Quijano (Universidad de los Andes, Colombia). Dates: 30 November-2 December 2020. Duration: 10 hours.

Awards during 2020 (https://arm.ual.es/arm-group/awards/)

- International Federation of Automatic Control. https://arm.ual.es/arm-group/2020/12/19/premio-internacional-en-innovacion-docente-para-el-grupo-automatica-robotica-y-mecatronica-de-la-ual/
- Mathworks: https://es.mathworks.com/company/user_stories/universidad-de-almeria-develops-and-deploys-greenhouse-models-as-a-service-to-maximize-crop-production.html
- Additional info:
    - https://arm.ual.es/arm-group/awards/
    - https://arm.ual.es/arm-group/news/

Other scientific activities

- Manuel Berenguel. Executive Director Revista Iberoamericana de Automática e Informática Industrial (RIAI), UPV, JCR (Q3) and Associate Editor in Energies.
- José Luis Blanco Claraco. Associate Editor IEEE Robotics and Automation Letters, International Journal of Robotics Research.
- Francisco Rodríguez. Associate Editor Frontiers in Control Engineering, DYNA Energia y sostenibilidad
- José Luis Guzmán Sánchez. Vice-Chair EDCOM Committee. Control Education Commiteee (TC9.4). International Federation of Automatic Control.

Additional info:

https://arm.ual.es/arm-group/scientific-committees-rd-management/

https://arm.ual.es/arm-group/about-us/educational-innovation/

2.5 ACTIVITIES OF "SOLAR RESOURCE ASSESSMENT AND SOLAR COOLING"

2.5.1 Functional unit description

Solar Resource Assessment and Solar Cooling unit is composed of the members of the groups "Solar Energy Resources Assessment and Climatology (TEP165)" and "Interdisciplinary Group of Complex Fluids (FQM230). TEP 165 is a stable group since its creation in 1997 within the Andalusian Research Plan of Junta de Andalucía, being responsible since its founding Francisco Javier Batlles Garrido. The group has been considered on numerous occasions as an Excellence Group within the Andalusian Research Plan. It is composed of Ph.D. teachers from Applied Physics area and Computer Languages and Systems area, and three research fellows also Ph.D. FQM230 group was created in 1995, and its research lines are focused on the study of complex fluids. It is currently composed of seven Ph.D., all of them from the Applied Physics area, and it is directed by Manuel Servando Romero Cano.

2.5.2 Main research lines

The main research lines of the unit are the following:

- Evaluation and forecast of solar resource
- Tele detection
- 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)

2.5.3 Main researcher

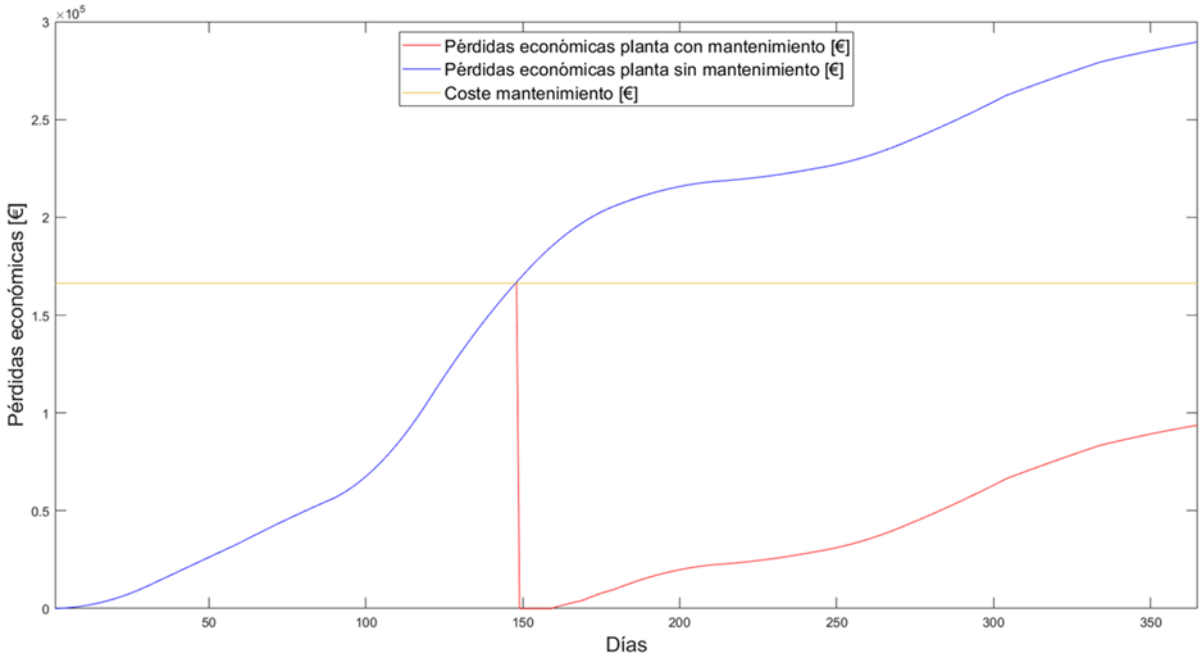
Francisco Javier Batlles Garrido (ORCID 0000-0001-5137-3630, Scopus Author ID 6602731047)

He received his physics degree and the Ph.D. from the University of Granada, Spain, in 1986 and 1995, respectively. He is a professor in the Department of Chemistry and Physics at the University of Almería, Almería, Spain. Since the beginning, he is the head of the research group "Solar Resource Assessment and Climatology" at the University of Almería. Member of the Scientific and Technological Evaluation Commission of Andalusia, within Andalusian Research Plan, from 2002 to 2005. International Evaluator of the National Accreditation Commission of Chile. His research interests include evaluation and forecast of the solar resource, design and optimization of the solar thermal cooling and heating systems. Professor Francisco Javier Batlles Garrido has been the Main Researcher in 8 projects of the Research National Plan, and 1 of the European Community. He has been the Main Researcher of 10 research projects funded by contracts with different companies such as GEMASOLAR 2006, S.L., Torresol Energy O & M, S.A, Solar Millennium, German Aerospace Centre. He has authored and co-authored over 70 articles in international journals, about 150

conference papers, both national and international, as well as a National Book. He has directed 8 doctoral theses.

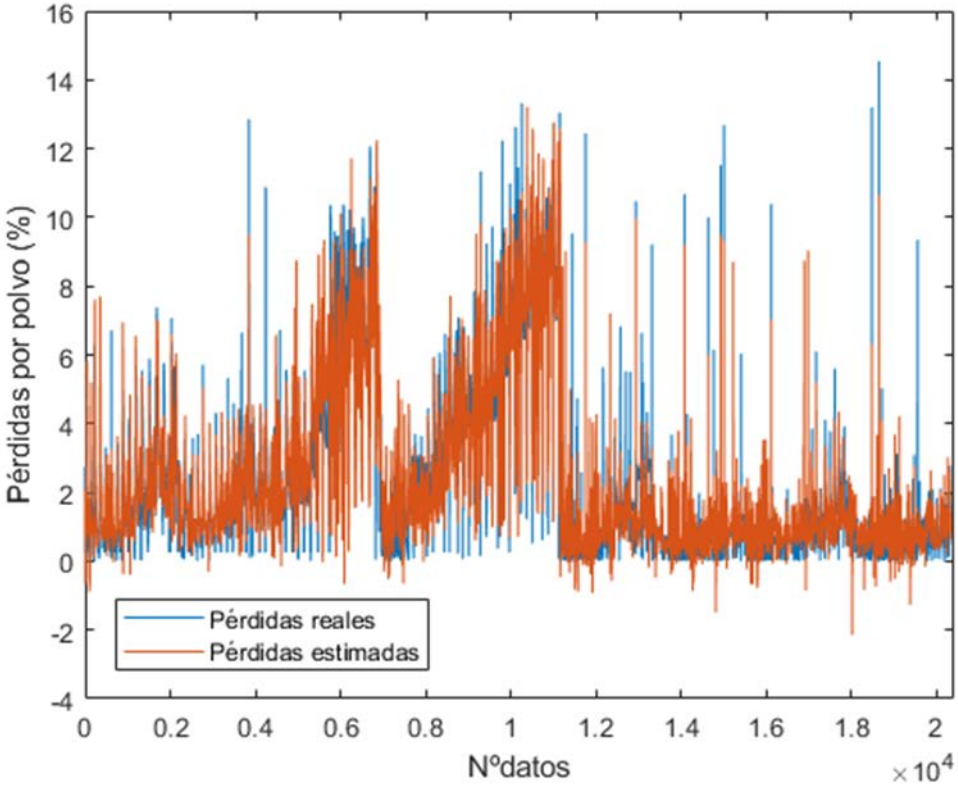
2.5.4 Summary of the functional unit's activities carried out in CIESOL during 2019

The performance of photovoltaic panels decreases depending on the different factors to which they are subjected daily. One of the phenomena that most affects their energy production is dust deposition. This is particularly acute in desert climates, where the level of solar radiation is extreme. In this work, the effect of dust soiling is examined on the electricity generation of an experimental photovoltaic pilot plant, installed at the Solar Energy Research Center (CIESOL) at the University of Almería. An average reduction of 5% of the power of a photovoltaic plant due to dust contamination has been obtained, this data being used to simulate the economic effect in plants of 9 kWp and 1 and 50 MWp. The economic losses have been calculated, and are capable of being higher than 150,000 €/year in industrial plants of 50 MWp. A cleaning strategy has also been presented, which represents a substantial economic outlay over the years of plant operation.



Moreover, fossil fuels and their use to generate energy have multiple disadvantages, with renewable energies being presented as an alternative to this situation. Among them is photovoltaic solar energy, which requires solar installations that are capable of producing energy in an optimal way. These installations will have specific characteristics according to their location and meteorological variables of the place, one of these factors being soiling. Soiling generates energy losses, diminishing the plant's performance, making it difficult to estimate the losses due to deposited soiling and to measure the amount of soiling if it is not done using very economically expensive devices, such as high-performance particle counters. In this work, these losses have been estimated with artificial intelligence techniques, using meteorological variables, commonly measured in a plant of these characteristics. The study consists of two tests, depending on whether or not the short circuit current (Isc) has been included, obtaining a maximum normalized root mean square error

(nRMSE) lower than 7 %, a correlation coefficient (R) higher than 0.9, as well as a practically zero normalized mean bias error (nMBE).



In addition, measurements from the experimental photovoltaic plant continue to be monitored on an uninterrupted basis in order to be able to carry out new data intercomparison campaigns with other solar photovoltaic plants located in Spain.

In the solar cold research line, we have worked fundamentally on the PCMSOL project. Project, which initially was scheduled to finish on 01/12/2019 was extended to 31/05/2020, what allowed us to perform the analysis of the facility with the heat storage tanks in phase change materials in the heating season. This study was carried out in January and February 2020, and showed that the storage tanks can cover the demand of heating during the nights, when no solar radiation is available. Together with the storage tanks of the primary loop, which store the thermal energy captured in the solar collectors, not used during the day, the solar facility can provide heating the whole day and night, without external support from the conventional air-refrigeration (heat pump), implying a saving of 75% in the electricity consumption.

Furthermore, due to the cesation of activities because of the COVID19 pandemic during March and May 2020, the project was automatically extended to 31/12/2020, what made further studies in the summer season possible. These results indicate again that in refrigeration the saving in electricity consumption due to the PCM storage tanks, within the solar-cooling facility is above 40%. Most of the consumption occurs during the night, when the storage system cannot cover the demand of refrigeration. These results were obtained in July, when the cooling needs is maximal, and in September, when the demand is smaller, but also the solar radiation has decreased. In both cases, the saving in terms of electricity consumption is similar.

The following table shows the daily expense in air-conditioning, which includes the electricity and natural gas costs (the latter is used when the solar energy is insufficient to heat up the water in the solar collectors). The data has been averaged yearly, including refrigeration in summer and heating in winter. It can be seen in the table that the monetary saving is proportionally bigger in winter, but quantitatively larger in summer.

	Refrigeration (euro/day)	Heating (euro/day)
SOLAR +PCM	17,706	4,204
SOLAR + Water	20,281	5,266
Conventional air-conditioning	32,935	13,073

2.5.5 Collaboration with other functional units of CIESOL during 2020

- Modeling and Control

2.5.6 Human resources of the Functional Unit

Research stays of CIESOL researchers in other institutions:

- Magdalena Nemś. Wroclaw University of Science and Technology, Poland (28/01/2020 – 22/02/2020)
- Artur Nemś. Wroclaw University of Science and Technology, Poland (28/01/2020 – 22/02/2020)

2.5.7 Scientific production

Number of articles	Number of items in each Quartile				Number of articles with international collaboration
	Q_1	Q_2	Q_3	Q_4	
17	**3**	**6**	**2**	**6**	**14**

Papers

- Economic effect of dust particles on photovoltaic plant production. Alonso-Montesinos, J., Rodríguez-Martínez, F., Polo, J., Martín-Chivelet, N., Batlles, F. J. *Energies, 13(23), 6376, (2020). DOI:* 10.3390/en13236376
- Determination of cloud motion applying the Lucas-Kanade method to sky cam imagery. Mondragón, R., Alonso-Montesinos, J., Riveros-Rosas, D., Bonifaz, R. Remote Sensing, 12 *(16), art. no. 2643, (2020) DOI: 10.3390/RS12162643*
- Determination of the Soiling Impact on Photovoltaic Modules at the Coastal Area of the Atacama Desert. Olivares, D., Ferrada, P., Bijman, J., Rodríguez, S., Trigo-González, M., Marzo, A., Rabanal-Arabach, J., Alonso-Montesinos, J., Batlles, F.J., Fuentealba, E. Energies, *13 (15), art. no. 13153819, (2020). DOI: 10.3390/en13153819*

- Modeling solar extinction using artificial neural networks. Application to solar tower plants. Ballestrín, J., Carra, E., Alonso-Montesinos, J., López, G., Polo, J., Marzo, A., Fernández-Reche, J., Barbero, J., Batlles, F.J. Energy, *199, art. no. 117432, (2020). DOI: 10.1016/j.energy.2020.117432*
- Real-time automatic cloud detection using a low-cost sky camera. Alonso-Montesinos. Remote Sensing, 12 (9), art. no. 1382, (2020). DOI: 10.3390/RS12091382
- Attenuation factor estimation of direct normal irradiance combining sky camera images and mathematical models in an inter-tropical area. Mondragón, R., Alonso-Montesinos, J., Riveros-Rosas, D., Valdés, M., Estévez, H., González-Cabrera, A.E., Stremme, W. Remote Sensing, 12 (7), art. no. 1212, (2020). DOI: 10.3390/rs12071212
- Atmospheric extinction levels of solar radiation using aerosol optical thickness satellite data. Validation methodology with measurement system. Carra, E., Marzo, A., Ballestrín, J., Polo, J., Barbero, J., Alonso-Montesinos, J., Monterreal, R., Abreu, E.F.M., Fernández-Reche. *Renewable Energy, 149, pp. 1120-1132, (2020). DOI: 10.1016/j.renene.2019.10.106*
- Atmospheric horizontal extinction determined with a single digital camera-based system in the scope of solar power tower plants. Barbero, F.J., Alonso-Montesinos, J., Ballestrín, J., Carra, M.E., Fernández-Reche, J. *Measurement: Journal of the International Measurement Confederation, 149, art. no. 107025, (2020). DOI: 10.1016/j.measurement.2019.107025*
- UV-A estimation in atacama desert from GHI measurements by using artificial neural network. Mondaca, G., Trigo-González, M., Marzo, A., Alonso-Montesinos, J., Barbero, J., Salazar, G., Olivares, D., Ferrada, P. *Proceedings of the ISES Solar World Congress 2019 and IEA SHC International Conference on Solar Heating and Cooling for Buildings and Industry 2019, pp. 365-375, (2020). DOI: 10.18086/swc.2019.08.08*
- Typical Meteorological Year methodologies applied to solar spectral irradiance for PV applications. Polo, J., Alonso-Abella, M., Martín-Chivelet, N., Alonso-Montesinos, J., López, G., Marzo, A., Nofuentes, G., Vela-Barrionuevo, N. *Energy, 190, art. no. 116453, (2020). DOI: 10.1016/j.energy.2019.116453*
- Analysis of the local factors that influence the cementation of soil and effects on PV generation at the plataforma solar del desierto de atacama, Chile. Olivares, D., Trigo-González, M., Marzo, A., Ferrada, P., Llanos, J., Araya, F., López, G., Polo, J., Alonso-Montesinos, J., Gueymard, C. *Proceedings of the ISES Solar World Congress 2019 and IEA SHC International Conference on Solar Heating and Cooling for Buildings and Industry 2019, pp. 1051-1060, (2020). DOI: 10.18086/swc.2019.19.08*
- Characterization of PV soiling losses in urban mediterranean environment. Polo, J., Martín-Chivelet, N., Alonso, M., Sanz, C., Batlles, F.J., López, G., Zitouni, H., Alonso-Montesinos, J., Vela, N., Bosch, J.L., Barbero, J. *Proceedings of the ISES Solar World Congress 2019 and IEA SHC International Conference on Solar Heating and Cooling for Buildings and Industry 2019, pp. 756-763, (2020). DOI: 10.18086/swc.2019.15.03*
- Effect of cloudiness on solar radiation forecasting. López, G., Sarmiento-Rosales, S.M., Gueymard, C.A., Marzo, A., Alonso-Montesinos, J., Polo, J., Martín-Chivelet, N., Ferrada, P., Barbero, J., Batlles, F.J., Vela, N. *Proceedings of the ISES Solar World Congress 2019 and IEA SHC International Conference on Solar Heating and Cooling for Buildings and Industry 2019, pp. 2098-2108, (2020). DOI: 10.18086/swc.2019.43.05*

- Relevance analysis of atmospheric variables in the production of an experimental pv power plant considering dust deposition in the mediterranean coast. Alonso-Montesinos, J., Barbero, J., Batlles, F.J., Rodríguez-Martínez, F., López, G., Polo, J., Martín-Chivelet, N., Alonso, M., Vela, N., Marzo, A., Ferrada, P., Cortés, M. *Proceedings of the ISES Solar World Congress 2019 and IEA SHC International Conference on Solar Heating and Cooling for Buildings and Industry 2019, pp. 2062-2073, (2020). DOI: 10.18086/swc.2019.43.01*
- Modeling of the discharging process of a heat storage tank filled with PCM to cover the heat demand of a building. A. Nemś, M. Nemś, S. Rosiek, A.M. Puertas, B. Gil, J. Kasperski, F.J. Batlles. *Proceedings of the ISES Solar World Congress 2019 and IEA SHC International Conference on Solar Heating and Cooling for Buildings and Industry 2019, (2020). DOI: 10.18086/swc.2019.24.07*
- Development and Results from Application of PCM-Based Storage Tanks in a Solar Thermal Comfort System of an Institutional Building—A Case Study. F.J. Batlles, B. Gil, S. Ushak, J. Kasperski, M. Luján, D. Maldonado, M. Nemś, A. Nemś, A.M. Puertas, M.S. Romero-Cano, S. Rosiek, M. Grágeda. E*nergies **13**, 3877 (2020).*
- Model for the Discharging of a Dual PCM Heat Storage Tank and Its Experimental Validation. A. Nemś, A.M. Puertas. *Energies **13,** 5687 (2020).*

Congress assistance

- SIEC 2020, Vigo – Online, España, 2020.
- IX Simposio Ciencias Experimentales, Almería, España, 2020.

Congress contributions

- Metodologías para la determinación de la extinctión atmosférica de la radiación solar para distintos usos y casos de aplicación. E. CARRA; J. BALLESTRÍN; J. FERNÁNDEZ-RECHE; A. MARZO; J. BARBERO; R. MONTERREAL; R. ENRIQUE; J. ALONSO-MONTESINOS. XVII Congreso Ibérico y XIII Congreso Iberoamericano de Energía Solar, Lisboa, Portugal, 2020. (Oral).
- Modelo de estimación de la producción FV para una planta solar industrial de 23 MWp. M. TRIGO-GONZALEZ; J. C. ACOSTA; A. MARZO; M. CORTÉS; C. PORTILLO; J. ALONSO-MONTESINOS; F. J. BATLLES. XVII Congreso Ibérico y XIII Congreso Iberoamericano de Energía Solar, Lisboa, Portugal, 2020. (Póster).
- Detección de nubes con cámaras de cielo de bajo coste, para la optimización de plantas solares. J. ALONSO-MONTESINOS. IX Simposio Ciencias Experimentales, Almería, España, 2020. (Póster).
- El uso de las tecnologías digitales aplicado a sesiones presenciales para su adaptación a unavirtualización completa, frente a la pandemia del COVID-19. J. ALONSO-MONTESINOS. V International Symposium of Science Teaching (SIEC 2020), Online, 2020. (Comunicación).

Congresses organization

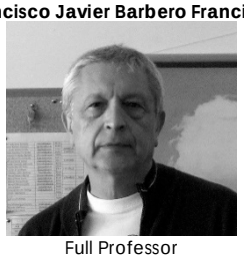
- Curso “Energía Solar: recursos, tecnologías y aplicaciones”, Huelva, España, 24/08/2020 – 27/08/2020.

2.5.8 Staff members

Francisco Javier Batlles Garrido

Main Researcher -Full Professor
UAL
fbatlles@ual.es (+34) 950 015 914
www.tep165.com

Francisco Javier Barbero Francisco



Full Professor
UAL

Joaquín Alonso Montesinos

Post-doc Researcher
UAL

Mercedes Martínez Durbán

Full Professor
UAL

Manuel Servando Romero Cano

Full Professor
UAL

Antonio Manuel Puertas López

Full Professor
UAL

2.5.9 Ongoing projects in 2020

2.5.9.1. Short-term prediction of the production of energy in a photovoltaic plant and influence of fouling of the panels in the production of the same (PVCastSOIL)

Participantes:

University of Almería (Spain), University of Huelva (Spain), CIEMAT (Spanish researching center).

Contactos:

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

Fuente de financiación:

Ministerio de Economía y Competitividad.

Duración prevista:

January 2018 – December 2020

Situación:

In progress.

Resumen:

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.

2.5.9.2 Thermal energy storage with phase change materials for solar cooling and heating applications: A technology viability analysis (PCMSOL)

Participants:

Universidad de Almería – CIESOL

Universidad de Antofagasta (Chile),

Universidad Técnica de Breslavia (Polonia)

Universidad Católica de Bolivia en Cochabamba (Bolivia),

Phase Change Technologies, S.L. (Bilbao, España)

Contact:

Antonio M. Puertas (apuertas@ual.es)

Fuente de Financiación:

Comisión Europea (ERANET-LAC Joint call 2015-2016), a través del MINECO (Ref. PCIN-2016-013)

Duración prevista:

December 2016 – December 2020

Situación:

In progress in 2020.

Resumen:

PCMSOL is a project coordinated between two European University, to sud-American Universities and the company Phase Change Technologies S.L. In the project, several materials for thermal storage in the form of latent heat have been developed and tested for the application in air-conditioning. This possibility is particularly useful in systems based on solar energy, as this can solve the problem of the intermitency of the primary energy source. In our case, thermal energy is stored in the formed of latent heat, or phase change enthalpy, in a material with the transition temperature in the appropriate range for air-conditioning in buildings or houses. In winter, the phase transition should take place between 40ºC and 50ºC, whereas in summer, the appropriate range is between 7ºC and 12ºC. In this project, several mixtures of inorganic salts been designed, and compared with commercial PCMs. Using commercial equivalents to the materials desing within the project, two 2000 liters tanks have been installed in CIESOL, filled with PCM containers, and the several strategies have been designed to the reduce the overall electricity consumption of the facility. The project is complemented with a model for the charging and discharging kinetics of the tanks, as well as studies of the economic viability and an environmental assessment.

The results indicate that, yearly, the the storage tanks imply a saving of more than 40% in the electricity consumption for air-conditioning. This storage system is also compared with thermal storing in water as sensible heat, which is more conventional. The system based on phase change materials yields an additional saving with respect to water of almost 10% in electricity consumption, but it implies also a larger investment. Our results indicate that the payback period for a building like CIESOL is 9 years using phase change materials and only 6 using water. The environmental impact, on the other hand, is smaller in the case of storage in latent heat, as derived by the greenhouse gases emissions and water consumption.

2.5.10 Transfer and Complementary Activities

Contratos con empresas

OTRI contract with the company Agrinova Science, S.A for an amount of € 71,800

Convenios con Universidades

University of Antofagasta (Chile)

Politechnica Wroclawsk (Polonia)

Colaboración con otros centros

Centro de Desarrollo Energético de Antofagasta (Chile)

2.5.12 Project's applications in 2020

An innovative solar-powered cooling device, based on climate-friendly refrigerant and thermal energy storage. LIFE Climate Change Mitigation project application. I.P Sabina Rosiek. Coordinator UAL Antonio Puertas López

2.5.13 Others

Degree and master's final projects:

- Francisco Rodríguez Martínez (Solar Energy Master degree). Efecto del ensuciamiento por polvo en la producción de paneles fotovoltaicos.
- Noelia Simal Pérez (Degree in Electric Engineering). Estimación de las pérdidas por polvo de una planta fotovoltaica experimental, utilizando técnicas de inteligencia artificial.
- Álvaro Castro Vizcaíno (Degree in Mechanical Engineering). Estudio de un sistema de refrigeración solar: Estrategias de funcionamiento.

Doctoral theses in progress

- Mauricio Trigo González (Francisco Javier Batlles Garrido y Joaquín Alonso Montesinos)
- Román Mondragón Rodríguez (Joaquín Alonso Montesinos)

2.6 ACTIVITIES OF "DESALINATION AND PHOTOSYNTHESIS"

2.6.1 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 two fields. The 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 collaboration with other units within CIESOL which raise frequent colaborations.

2.6.2 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.

2.6.3 Main researchers

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

2.6.4 Summary of the functional unit's activities carried out in CIESOL during 2020

In the microalgae production line different research lines are in progress, such as those related with the production of microaslgae for high value applications, mainly food and feed bnut also the production of biostimulants and biopesticides, or those related with the treatment of residuals, mainly wastewaters both urban or animal, and flue gases. These includes ALQUABIOTIC with BIORIZON BIOTECH focused into the production of aquafeed for aquaculture, AL4BIO with UPC focused into the production of biostimulants from effluent after secondary treatment, ALGAE4CONTROL with BIORIZON BIOTECH focused to the production of biopesticides from microalgae, BLUECARE with BIORIZON BIOTECH focused to the production of cosmetics products from mcirlagae, SETEC with SYTCOM focused to the production of bioplastics from flue gases using microalgae, BIOREFINA with MIGUEL SANCHEZ E HIJOS focused into the production of biofertilizers from vegetable residuals, GREENFARM with Uva and focused into the treatment of animal wastewaters to produce agriculture related products, and SABANA financed by the EU Commission thorugh the H2020 programme focused to the production of agriculture and aquaculture related products from microalgae using residuals. On this year, two additional research lines has been started in collaboration with other functional units from CIESOL such as the recovery of heat and CO2 from flue gases to be used in greenhpouses through the CARBON4GREN project financed by the UAL-FEDER programme, and the removal of emerging pollutants through the ULISES project financed by the LIFE programme from the EU.

Two new projects related to desalination began this year. WATER-MINING aims to demonstrate a seawater desalination scheme with zero liquid discharge powered by solar thermal energy that can be more sustainable than the current technologies of reverse osmosis connected to the grid, especially if the goal is to produce water for irrigation. To achieve this, the improvement in the efficiency of a multi-effect distillation plant will be evaluated after a pre-treatment of seawater with nanofiltration allows the plant to operate at a higher temperature and with a higher concentration factor. The brine produced will be crystallized to produce high purity sodium chloride, and the distilled water will be remineralized with the brine from the nanofiltration (richer in divalent ions) to be used for irrigation water. The concept includes the use of solar thermal energy as the main source of energy. On the other hand, in the INTELWATT project, the unit will participate in a solar membrane distillation development applied to salinity gradient power production. A pilot plant will be built in Catellgali (Barcelona), consisting of an integrated system of reverse electrodialysis (RED) and membrane distillation with solar energy to valorize the brine from a collector that comes from mining activities.

The Desalination team has continued working in the activities of the European project SOLWARIS, collaborating with the companies TSK (coordinator of the Project) and INDETEC (partner of the Project and manufacturer of the Water Recovery System) in the manufacturing of the Water Recovery System with the technology Multi-Effect Evaporation (MEE), as well as in the definition of the technical specifications of the intermediate equipment and instruments required for the integration of the MEE unit into the CSP plant La Africana located in Córdoba (Spain). Likewise, the team has collaborated with DLR (partner of the Project and leader of WP2) and INDEREC in the design of the operation at partial load of the MEE plant for an O&M optimizer that DLR is developing within the Project. The main activity in 2020 has been focused in the tasks related with modelling of the MEE plant and definition of the control loops for optimization of the process, that CIEMAT-PSA coordinates. Together with researchers of the Functional unit "Modelling and Control" a dynamic model of the MEE plant has been developed in Modelica, and validated with in the design point with data provided by INDETEC, obtaining a good agreement between the results from the model and the design ones. All this activity has been included in a Deliverable (DL 5.3) that was delivered to the Commision in October 2020 and in a publication that will be sent to a SCI journal in 2021. With respect to the optimization, all process variables were defined, as well as the optimization criteria. Also, the developed model was upgraded for optimization purposes.

Regarding the EERES4WATER Project (Promoting Energy-Water Nexus resource efficiency through Renewable Energy and Energy Efficiency, INTERREG ATLANTIC AREA) the main activity during 2020 has been focused on the development of two case studies where the techno-economic feasibility of autonomous solar desalination concepts in the Canary Islands at small and large scale has been evaluated. Regarding the small scale, the implementation of small multi-effect distillation (MED) plants powered by solar energy, both thermal and photovoltaic, has been evaluated to cover both energy needs of the distillation plant. The results have shown that the high investment cost of the MED plant is a handicap for its selection compared to other alternatives such as the combination of photovoltaic and reverse osmosis (RO). As for large capacity systems, the CSP+PV+RO combination has been shown to be an alternative that can offer more competitive costs than conventional desalination when considering the real costs of generation on the islands. Capacity factors above 90% have been obtained thanks to the thermal storage systems of the CSP plant, which offer an alternative with less environmental impact than the PV-RO plants due to the low capacity factor of the latter. On the other hand, work has continued to support the University of Seville and ITC in terms of updating the performance obtained with the latest developments in membrane distillation pilot plants.

2.6.5 Collaboration with other functional units of CIESOL during 2020

During 2020 we have collaborated closely with the Functional Unit "Modelling and Control" in the framework of SOLWARIS project in which the University of Almería is third party. We have worked jointly in the tasks related with modelling, optimization and control, accomplishing with all the items of the milestones so far.

2.6.7 Scientific production

Number of articles	Number of items in each Quartile				Number of articles with international collaboration
	Q_1	Q_2	Q_3	Q_4	
34	27	4	1	2	15

Doctoral Theses

- AUTHOR: Marta Barcelo Villalobos TITLE: Optimización de la producción de microalgas en reactores abiertos de escala industrial. CALIFICACIÓN: Apto "cum laude" Date: Julio 2020

Patents

- TITLE: Proceso para la obtención, a nivel industrial, de un extracto concentrado en compuestos bioplaguicidas a partir de microalgas y/o cianobacterias, extracto así obtenido y uso del mismo. Patent number: P202031068 Date:. 26 octubre 2020 Applicant: BIORIZON BIOTECH, S.L.

- TITLE: PROCEDIMIENTO DE OBTENCIÓN DE CONCENTRADOS DE BIOFERTILIZANTES Y BIOESTIMULANTES DE USO AGRICOLA A PARTIR DE BIOMASA DE MICROALGAS, INCLUYENDO CIANOBACTERIAS. Patent number: ES 2693793 B2, P 201830923. Date: 22/05/2020. Applicant: BIORIZON BIOTECH, S.L.

Papers

- Optimal operation of solar thermal desalination systems coupled to double-effect absorption heat pumps. J.A. Carballo, J. Bonilla, L. Roca, A. de la Calle, P. Palenzuela, D.C Alarcón-Padilla, M. Berenguel. Energy Conversion and Management, 210, 112705. 2020. https://doi.org/10.1016/j.enconman.2020.112705
- Comparative assessment of the annual electricity and water production by concentrating solar power and desalination plants: A case study. P. Palenzuela, B. Ortega-Delgado, D.-C. Alarcón-Padilla. Applied Thermal Engineering, 177, 115485. 2020. https://doi.org/10.1016/j.applthermaleng.2020.115485
- Annual thermodynamic analysis of a Concentrating Solar Power + Photovoltaic + Multi-Effect Distillation plant in northern Chile. C. Mata-Torres, P. Palenzuela, A. Zurita, J.M. Cardemil, D.-C. Alarcón-Padilla, R. Escobar. Energy Conversion and Management, 213, 112852. 2020. https://doi.org/10.1016/j.enconman.2020.112852
- Thermodynamic Performance and Water Consumption of Hybrid Cooling Systems Configurations for Concentrated Solar Power Plants. F. Asfand, P. Palenzuela, L. Roca, A. Caron, C.-A. Lemarié, J. Gillard, P. Turner, K. Patchigoll. Sustainability, 12, 4739. 2020. doi:10.3390/su12114739
- Hierarchical control for the start-up procedure of solar thermal fields with direct storage. J.D. Gil, L. Roca, G. Zaragoza, J.E. Normey-Rico, M. Berenguel.. Control Engineering Practice, 95, 104254, 2020.
- Application of solar energy to seawater desalination in a pilot system based on vacuum multi-effect membrane distillation. J.A. Andrés-Mañas, L. Roca, A. Ruiz-Aguirre, F.G. Acién, J.D. Gil, G. Zaragoza.. Applied Energy, 258, 114068, 2020.
- Performance increase of membrane distillation pilot scale modules operating in vacuum-enhanced air-gap configuration. J.A. Andrés-Mañas, A. Ruiz-Aguirre, F.G. Acién, G. Zaragoza.. Desalination 475, 114202, 2020.
- Can seawater desalination be a win-win fix to our water cycle? A. Pistocchi, T. Bleninger, C. Breyer, U. Caldera, C. Dorati, D. Ganora. M.M. Millan, C. Paton, D. Poullis, F. Salas Herrero, M. Sapiano, R. Semiat, C. Sommariva, S. Yuece, G. Zaragoza. Water Research, 182, 115906, 2020.
- Degradation of Emerging Contaminants Diclofenac, Sulfamethoxazole, Trimethoprim and Carbamazepine by Bentonite and Vermiculite at a Pilot Solar Compound Parabolic Collector. J.I. Martínez-Costa, M.I. Maldonado Rubio, R. Leyva-Ramos. Catalysis Today 341, 26-36, 2020.
- Fenton and solar photo-Fenton processes in the depuration of wastewater resulting from production of grape juice. A factorial design. Poblete, R., Cortes, E., Maldonado, M.I. Journal of Chemical Technology and Biotechnology, 5(5), pp. 1329-1336, 2020.
- Parabolic trough collector field dynamic model: Validation, energetic and exergetic analyses. J.A. Carballo, J. Bonilla, M. Berenguel, P. Palenzuela. Applied Thermal Engineering. 148, 777-786. 2019. DOI: https://doi.org/10.1016/j.applthermaleng.2018.11.093
- Flashing light does not improve photosynthetic performance and growth of green microalgae. Schulze, C. Brindley, J.M. Fernández, R. Rautenberger, H. Pereira, R.H. Wijffels, V. Kiron. Bioresource Technology Reports Vol. 9, 100367, 2020. https://doi.org/10.1016/j.biteb.2019.100367

- Spirulina for the food and functional food industries, Lafarga, T., Fernández-Sevilla, J.M., González-López, C., Acién-Fernández, F.G. Food Research International, 137, no. 109356. 2020. DOI: 10.1016/j.foodres.2020.109356
- Processing Nannochloropsis gaditana biomass for the extraction of high-value biocompounds. Sales, R., del Carmen Cerón-García, M., Navarro-López, E., González-López, C.V., Tsuzuki, M.Y., Acién-Fernández, F.G., Alarcón-López, F.J., Molina-Grima, E. Journal of Applied Phycology, 32 (5), pp. 3113-3122. 2020. DOI: 10.1007/s10811-020-02156-7
- Year-long assessment of a pilot-scale thin-layer reactor for microalgae wastewater treatment. Variation in the microalgae-bacteria consortium and the impact of environmental conditions. Sánchez Zurano, A., Garrido Cárdenas, J.A., Gómez Serrano, C., Morales Amaral, M., Acién-Fernández, F.G., Fernández Sevilla, J.M., Molina Grima, E. Algal Research, 50, art. no. 101983. 2020. DOI: 10.1016/j.algal.2020.101983
- Bioactive peptides and carbohydrates from seaweed for food applications: Natural occurrence, isolation, purification, and identification. Lafarga, T., Acién-Fernández, F.G., Garcia-Vaquero, M. (2020) Algal Research, 48, art. no. 101909. 2020. DOI: 10.1016/j.algal.2020.101909
- A novel photo-respirometry method to characterize consortia in microalgae-related wastewater treatment processes. Sánchez-Zurano, A., Gómez-Serrano, C., Acién-Fernández, F.G., Fernández-Sevilla, J.M., Molina-Grima, E. Algal Research, 47, art. no. 101858. 2020. DOI: 10.1016/j.algal.2020.101858
- Development of an efficient and sustainable energy storage system by hybridization of compressed air and biogas technologies (BIO-CAES). Llamas, B., Ortega, M.F., Barthelemy, G., de Godos, I., Acién, F.G. Energy Conversion and Management, 210, art. no. 112695. 2020. DOI: 10.1016/j.enconman.2020.112695
- Biostimulant Potential of Scenedesmus obliquus Grown in Brewery Wastewater. Navarro-López, E., Ruíz-Nieto, A., Ferreira, A., Gabriel Acién, F., Gouveia, L. Molecules, 25 (3), art. no. 66. 2020. DOI: 10.3390/molecules25030664
- Optimization of a new culture medium for the large-scale production of protein-rich arthrospira platensis (oscillatoriales, cyanophyceae) Gómez, C., Guzmán-Carrasco, A., Lafarga, T., Acién-Fernández, F.G. Journal of Phycology. 2020. DOI: 10.1111/jpy.13111
- Sustainable production of microalgae in raceways: Nutrients and water management as key factors influencing environmental impacts. Herrera, A., D'Imporzano, G., Acién Fernandez, F.G., Adani, F. Journal of Cleaner Production, art. no. 125005. 202 DOI: 10.1016/j.jclepro.2020.125005
- Growth, biostimulant and biopesticide activity of the MACC-1 Chlorella strain cultivated outdoors in inorganic medium and wastewater Karolína Ranglová, Gergely Ernö Lakatos, João Artur Câmara Manoel, Tomáš Grivalský, Francisca Suárez Estrella, Francisco Gabriel Acién Fernández, Zoltán Molnár, Vince Ördög and Jiří Masojídek Algal Research, aceptado Noviembre 2020
- The role of microalgae in the bioeconomy . F. Gabriel Acién Fernández, Alberto Reis, René H. Wijffels, Maria Barbosa, Vitor Verdelho, Bernardo Llamas New BIOTECHNOLOGY, aceptado Noviembre 2020
- Effects of dietary use of two lipid extracts from the microalgae Nannochloropsis gaditana (lubián, 1982) alone and in combination on growth and muscle composition in juvenile gilthead seabream, sparus aurata. Sales, R. Galafat, A., Vizcaíno, A.J., Sáez, M.I., Martínez, T.F., Cerón-García, M.C., Navarro-López, E., Tsuzuki, M.Y., Acién-Fernández, F.G., Molina-Grima, E., Alarcón, F.J. Algal Research, aceptado 2020
- Solar drying of greenhouse crop residues: modelling and determination of optimal conditions. M. Guadalupe Pinna-Hernándeza, Ignacio Martínez Soler, F. Gabriel Acien Fernández, José Gabriel López Segura and José Luis Casas López. Agronomy 2020, 10, 2001; doi:10.3390/agronomy10122001
- 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, [S.l.], v. 18, n. 1, p. 1-18, dic. 2020. ISSN 1697-7920
- ABACO: A new model of microalgae-bacteria consortia for biological treatment of wastewaters. Ana Sánchez-Zurano, Enrique Rodríguez-Miranda, José Luis Guzmán, Francisco Gabriel Acién Fernández, José M. Fernández-Sevilla, Emilio Molina-Grima Applied Sciences 11(3),998, pp. 1-24 2021 doi:10.3390/app11030998
- Biostimulants obtained after pilot scale high pressure homogenization of Scenedesmus sp. grown in pig manure.Elvira Navarro-López, María del Carmen Cerón-García, Mercedes López-Rodríguez,

Francisco Gabriel Acién-Fernández, Emilio Molina-Grima Algal Research, 52 doi:10.1016/j.algal.2020.102123

- A short pulse of dietary algae boosts immune response and modulates fatty acid composition in juvenile Oreochromis niloticus. Jorge García-Márquez, Rosa María Rico, María del Pilar Sánchez-Saavedra, Juan Luis Gómez-Pinchetti, Francisco Gabriel Acién, Félix López L. Figueroa, Francisco Javier Alarcón, Miguel Ángel Moriñigo, Roberto Teófilo Abdala-Díaz. Aquaculture Research 51 4397–4409. 2020
- Scale-Up of a Fibonacci-type photobioreactor for the production of Dunaliella salina . Juan Pablo Díaz, Cristian Inostroza, F. Gabriel Acién Journal Applied Biochemistry and Biotechnology, 193(1):188-204. 2021. DOI 10.1007/s12010-020-03410-x
- Computational Fluid Dynamics (CFD) Applied to the Design of Photobioreactors for the Production of Microalgae. Cristian Inostroza, Alessandro Solimeno, Joan García Serrano, F. G. Acién Fernández, J. M. Fernández-Sevilla Conferencia de COMSOL Multiphysics, Malaga; 70-75 (ISBN 978-84-09-21335-1).
- Year-long production of Scenedesmus almeriensis in pilot-scale raceway and thin-layer cascade photobioreactors. Ainoa Morillas España, Tomas Lafarga, Cintia Gómez-Serrano, Francisco Gabriel Acién-Fernández, Cynthia Victoria González-López. Algal Research Volume 51, 2020, doi:10.1016/j.algal.2020.102069
- A new model to analyze the temperature effect on the microalgae performance at large scale raceway reactors. E. Rodríguez-Miranda, F.G. Acién, J.L. Guzmán, M. Berenguel, and A. Visioli. Biotechnology and Bioengineering. In press. 2020. doi:10.1002/bit.27617
- Modeling of photosynthesis and respiration rate for microalgae-bacteria consortia.Sánchez Zurano, A., Gómez Serrano, C., Acién-Fernández F.G., Fernández-Sevilla J.M., Molina-Grima E. Biotechnology and Bioengineering, 118(2), 952-962. 2021 doi:10.1002/bit.27625

Congress attendance

- CSP4Climate 2020 International Online Conference (The Cyprus Institute), 17 Dec 2020.

Congress contributions

- Membrane Distillation as an Alternative for Solar Desalination. G. Zaragoza. CSP4Climate 2020 International Online Conference (The Cyprus Institute), 17 Dec 2020. Oral invitada.

- Economia circular en procesos de microalgas. F. G. Acién. Hub de innovación digital del proyecto ICT-BIOCHAIN. Videoconferencia. 2020. Conferencia por invitación.
- Opportunities for light utilization improvement in large scale reactors. F. G. Acién, Jose M. Fernandez Sevilla Workshop “Light in Algal Biotechnology”. Videocoference. 2020. Conferencia por invitación.
- Challenges in the design and operation of industrial raceway reactors . F. G. Acién. Challenges in algal biotechnology (Nedbal). Videocoference. 2020. Conferencia por invitación.
- Las microalgas en la bioeconomía del mundo marino. F. G. Acién. Curso de verano: Gestión de subproductos y restos hortícolas: una circularidad posible. Videocoference. 2020. Conferencia por invitación.
- Technologies for the production of algae extracts for Biostimulants and Biofertilizers. F. G. Acién. Technical Webinar on Algae biofertilziers and biostimualnts (EABA). Videocoference. 2020. Conferencia por invitación.
- SABANA project: Demonstrating the application of microalgae in agriculture and aquaculture. F. G. Acién. Flash Webinar EU Programmes and Opportunities (EABA). Videocoference. 2020. Conferencia por invitación.

- Produccion de microalgas acoplada al tratamiento de residuos. F. G. Acién. Seminario Tecnico Las microlalgas y sus apliacciones (Fundacion Cajamar). Videocoference. 2020. Conferencia por invitación.
- Potential transformation of macroalgae for biofertilizers/biostimulant. F. G. Acién. TEchnical Webinar Atlantic Sargassum Belt (EABA). Videocoference. 2020. Conferencia por invitación.
- La ecoinnovación y el aprovechamiento de los residuos. F. G. Acién. Recapacicla (UAL). Videocoference AÑO: 2020. Conferencia por invitación.
- SABANA Proyecto. F. G. Acién. Programa Doctorado en Acuicultura. Universidad Católica del Norte -Chile. 2020. Conferencia por invitación.
- Contribucion de las algas a la bioeconomia. F. G. Acién. II Congreso Internacional Multidisciplinario. Videoconferencia (Xalapa, México). 2020. Conferencia por invitación.
- SABANA project: Demonstrating the application of microalgae in agriculture and aquaculture. F. G. Acién. AlgaEurope 2020. Videoconferencia (Brussles, Belgium). 2020. Conferencia por invitación.
- Major factors limiting the development of microalgae based processes. F. G. Acién. AlgaEurope 2020. Videoconferencia (Brussles, Belgium). 2020. Conferencia por invitación.

Book Chapters

- Valorization of microalgae and energy resources. Cynthia V. González-López, Francisco García Cuadra, Natalia Jawiarczyk, Jose M. Fernández-Sevilla and Francisco G. Acién-Fernández. Publisher InTechOpen. 2020. DOI: 10.5772/intechopen.90072
- Removal of contaminants of emerging concern by microalgae-based wastewater treatments and related analytical techniques. A. Agüera, P. Plaza-Bolaños, F.G Acién Fernández. Current Developments in Biotechnology and Bioengineering: Emerging Organic Micro-pollutants. 2020. (ISBN 9780128195949).
- Exploring the potential of microalgae for the bioremediation of agro-industrial wastewaters. Alcantara, C., Acien-Fernandez, F.G., Fernandez-Sevilla, J.M., Riano, B., Hernandez, D., Garcia-Gonzalez, M.C., Larran, A., Tomas, C., Blanco, S., Becares, E., Ortiz, S., Garcia-Encina, P., Bolado, S., Munoz, R. Konur, O., (Ed.), Handbook of Algal Science, Technology and Medicine, 641-658. Academic Press, London (2020).

2.6.8 Staff members

José María Fernández Sevilla

Main Researcher
Professor of Chemical Engineering
UAL
jfernand@ual.es
(+34) 950 015 899

Guillermo Zaragoza del Águila

Main Researcher
Distinguished Researcher
CIEMAT - Plataforma Solar de Almería
guillermo.zaragoza@psa.es
(+34) 950 387941

Francisco Gabriel Acién Fernández

Professor of Chemical Engineering
UAL

Diego César Alarcón Padilla

Senior Researcher
CIEMAT

Cintia Gómez Serrano

Associate Researcher
UAL

Alba Ruiz Aguirre

Associate Researcher
CIEMAT

Patricia Palenzuela

Senior Researcher
CIEMAT

Juan Antonio Andrés Mañas

Associate Researcher
CIEMAT

Jose Peña Martín

Associate Researcher
UAL

Ismael Martín Cara

Associate Researcher
UAL

Martina Ciardi

Associate Researcher
UAL

2.6.9 Ongoing projects in 2020

2.6.9.1 Bio-Mimetic and Phyto-Technologies designed for low-cost purfication and recycling of water (INDIA-H2O)

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

Contacts:

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

Funds:

European Commission, Horizon 2020 programme.

Time Period:

February 2019 – August 2023

Current situation:

Ongoing

Summary

INDIA-H20 will develop, design and demonstrate high-recovery, low-cost water treatment systems for saline groundwater and industrial wastewaters. The focus for developments is in the arid state of Gujarat, where surface water resources are very scarce. Solutions will be demonstrated in small-scale rurally relevant low-cost systems for brackish groundwater treatment for use as safe drinking water, which will be extended to include phyto-technology solutions for rural domestic wastewater treatment. Systems will remove salinity and emerging pollutants (e.g. agricultural chemicals), valorise rejected brines in halophytic crop cultivation.

For specific industrial wastewater in textile, desalination and dairy cost-effective high-efficiency hybrid technologies for water recycling with minimum liquid discharge will be developed and demonstrated using advanced membrane technologies to achieve the required water quality for recycling.

A centre of excellence will be established in water treatment membrane technologies, design operation and monitoring.

Objectives

Develop novel batch-reverse osmosis technology for a 10-fold reduction in specific energy consumption with high fractions of water recovery (80%) reducing /m^3 operating costs to below €0.35/m^3 (<30 rupees/m^3).

Develop forward osmosis at pilot scale for use in wastewater recovery applications including hybrid arrangements with reverse osmosis for further reduction in energy consumption.

Develop business models to exploit the developed solutions to mutual EU/India economic advantage.

Produce policy briefs on economic models and governance arrangements for viable adoption of the developed systems.

2.6.9.2 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.

2.6.9.3 Intelligent Water Treatment Technologies for water preservation combined with simultaneous energy production and material recovery in energy intensive industries (INTELWATT)

Participants:

NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS" (HE)
CONSIGLIO NAZIONALE DELLE RICERCHE (IT)
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS (FR)
PUBLIC POWER CORPORATION S.A. (HE)
WARRANT HUB SPA (HE)
TECHNISCHE HOCHSCHULE KOLN (DE)
THE UNIVERSITY OF BIRMINGHAM (UK)
POLITECNICO DI TORINO (IT)
CUT MEMBRANE TECHNOLOGY GMBH (DE)
BIA KUNSTSTOFF- UND GALVANOTECHNIK GESCHAFTSFUHRUNGS- GMBH (DE)
FUELICS IDIOTIKI KEFALAIOUXIKI ETAIREIA (HE)
STICHTING IHE DELFT INSTITUTE FOR WATER EDUCATION (NL)
STUDIO FIESCHI & SOCI SRL (IT)
TECHEDGE ESPAÑA SL (ES)
ACSA OBRAS E INFRAESTRUCTURAS SAU (ES)
UNIVERSITY OF JORDAN
REDSTACK BV (NL)
PSA-CIEMAT (ES)
NIJHUIS WATER TECHNOLOGY BV (NL)
NOKIA SOLUTIONS AND NETWORKS HELLASSOLE SHAREHOLDER SOCIETE ANONYMEORKS HELLAS SA (HE)

Contacts:

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

Funds:

European Commission, Horizon 2020 programme

Time Period:

May 2015 – April 2019

Current situation:

ongoing

Summary

In the past, industrial infrastructures were developed within a context of unconstrained water resource availability. This is no longer the case. Unsustainable uses of water resources and population dynamics along with climate change affect this critical resource, which is becoming scarce. The EU-funded intelWATT project will develop innovative, cost-efficient, smart separation technologies applied in energy- and water-intensive industries. Three case studies in electricity production, mining and electroplating facilities will demonstrate water preservation along with energy production and material recovery. The proposed solutions will also target zero liquid discharge while implementing maximum water reuse. For instance, the project aims to recover up to 75 % of chromium and copper and 50 % of nickel, present in effluents, while preserving 65 % of fresh water for reuse.

Objectives

IntelWATT aims to develop innovative, cost efficient, smart separation technologies applied in energy and water intensive industries. The goal of the project is to demonstrate 3 TRL7 case studies that will achieve water preservation along with energy production and material recovery. The proposed solutions will also target at zero liquid discharge while implementing maximum water reuse. Tailor made sensors and automated decision making mechanisms will optimize the process conditions in real time. The case studies will be implemented in crucial EU and global industrial applications such as electricity production, mining and metal plating.

-Case study 1: Demonstration prototype for CTBD treatment. The development of efficient, cost effective, smart solutions for water management in a thermoelectric power plant, aiming at minimization of the cooling tower blow down (>99% recovery) trough developing a pilot unit of 100 m3/day treatment capacity installed in the premise of PPC's unit V (natural gas combined circle facility, Megalopolis, Greece) based on a closed loop, near zero liquid discharge approach.

-Case study 2: Demonstration of a symbiotic concept between industries: sustainable production of energy and water. In case study 2, in which PSA-CIEMAT participates, a pilot plant will be built in Catellgali (Barcelona), which will consist of an integrated reverse electrodialysis (RED) system and membrane distillation with solar energy to valorise a collector of brine that comes from mining activities, with the aim of treating about 40 m3 / day of brine, producing more than 120 MJ of electrical energy and 25 m3 / day of deionized water

-Case study 3: The application of a novel, hybrid high recovery RO (HRRO) / Ion exchange (IX) resin prototype will demonstrate the recovery of valuable electrolytes and fresh water preservation in a plastic electroplating facility. The process is aiming towards recovering up to 95 % of Chromium and Copper and 50% of Nickel, while preserving 65% of fresh water.

Implement smart sensor technology for online monitoring, real time process adaptation and deep learning, with customizable intelligent industrial process software module based on an agnostic protocol connectivity cloud infrastructure.

2.6.9.4 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:

The main objectives of this project are:

- 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.

2.6.9.5 Optimization of the treatment of purines with microaloges 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:

JM Fernandez-Sevilla (jfernand@ual.es)

Funds:

Ministerio de Economia, Industria y Competitividad

Time Period:

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

Current situation:

Started 2018

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.

2.6.9.6 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)

Funds:

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 2020

Current situation:

In progress.

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).

2.6.9.7 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

Funds:

Provate 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.

2.1.9.8 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

Funds:

RETOS COLABORACION 2017, Ministerio de Economía y Competitividad

Time Period:

October 2018– September 2021.

Current situation:

In progress

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.

2.6.9.9 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

Funding:

NEOTEC-CDTI, EXP - 00104234/SNEO-20171045

Time period:

1 Enero 2019 – 31 Diciembre 2021

Current situation:

In progress.

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.

2.6.9.10 Mejora de la calidad nutricional de alimentos para acuicultura mediante la incorporación de hidrolizados de microalgas enriquecidos en microorganismos probióticos - ALQUABIOTEC.

Participants:

Global Feed
Biorizon Biotech SL
DMC Research
Universidad de Granada
Universidad de Almeria

Contacts:

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

Funding:

FEDER-INTERCONNECTA 2018

Time period:

1 Enero 2019 – 31 Diciembre 2020

Current situation:

In progress.

Abstract

The ALQUABIOTIC project aims to develop a new feed for aquaculture in which part of the fishmeal has been replaced by a microalgae hydrolyzate enriched in probiotic microorganisms. Specifically, the project aims to develop high-quality food of sustainable origin, which guarantees not only the growth of organisms, but also increases their health, resistance to stress and disease-causing agents within farming systems. This is an applied research project led by the company GLOBAL FEED, in which the biotech companies DMC Research Center and Biorizon Biotech also participate, together with two public research organizations, the University of Almería and the University of Granada. GLOBAL FEED, as a leading company in animal feed products, is interested in the development of new products for its application in aquaculture. Biorizon Biotech, pioneer in the application and development of enzymatic hydrolyzates of microalgae, aims to diversify in applications of its products, such as The case of aquaculture, where DMC with extensive experience in the development of probiotic products and microorganisms with application in human and animal nutrition, has already developed additives for this aquaculture sector. The consortium constituted under the title ALQUABIOTIC is interested in applying these products to develop a line of differentiated aquaculture products for making sustainable use of natural resources, especially by replacing fishmeal with microalgae hydrolyzates, and with the application of probiotics, with the ultimate goal each of them to improve their position in the market with respect to the competition.

Objetives.

ALQUABIOTIC contemplates the development of a production process that includes the optimization of a microalgae hydrolyzate and the selection of probiotic microorganisms for use in feeding aquaculture species of commercial interest, combining basic and applied research. In this sense, it is intended to develop a hydrolysis process to obtain an algal preparation rich in partially hydrolyzed protein of high biological value that can be used as an alternative ingredient to fishmeal in aquaculture feed, as well as to know the bioavailability of essential amino acids, and other nutrients in it to have enough information on the Arthrospira hydrolyzate to assess its nutritional value compared to fishmeal.

2.6.9.11 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

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).

2.6.10 Participation in networks during 2020

- RENUWAL action supported by the CYTED from 2020 to 2022.
- EIP Water Action Group: “Renewable Energy Desalination” (G. Zaragoza is coordinator)
- Water Europe Working Group: “Renewable Energy and Desalination” (G. Zaragoza is leader)

2.6.11 Transfer and Complementary Activities

- “Renewable energy desalination in the WEF Nexus”, Webinar “Technology options for the Water-Energy-Food nexus” organizado por EU-GCC Clean Energy Technology Network (“Addressing the Water-Energy- Food (WEF) Nexus in the context of Climate Change and Sustainable Development”), 14 octubre 2020.

- “Performance tests of commercial systems”, en el Webinar Panel Discussion on Thermal Desalination by Membrane Distillation (“International Colloquia on Thermal Innovations”) organizado por el MIT, 10 noviembre 2020.

2.6.12 Project’s applications in 2020

- “Next generation water-smart management systems: large scale demonstrations for a circular economy and society “ (WATERMINING) H2020-SC5-2018-2019-2020 (Greening the economy in line with the Sustainable Development Goals (SDGs))

- "Integrated sustainable desalination systems for enhancing water and energy efficiency in agriculture" (SmartDeSYS2), ENI CBC Mediterranean Sea Basin Programme
- "Optimal Management of Unconventional WAter Sources" (OMUNWAS), ENI CBC Mediterranean Sea Basin Programme
- EUWADI: Modernization of Engineering Learning: Sustainable Energy for Water (EPPKA2 - Cooperation for innovation and the exchange of good practices)
- "A Mediterranean greenhouse model combining a network of innovative cross-sectorial technologies and control systems in organic horticulture" (GROWTH). PRIMA S1 2019 Farming Systems IA
- "Sustainable Water production and management system for crop irrigation" (SUSTAINWATER). PRIMA RIA Management of low-quality waters under water scarcity and climate change conditions
- "Algae for Nutrient recycle, Sustainable Water reuse and biofErtilizer pRoduction" (Algas para el reciclado de nutrientes, la reutilización sostenible del agua y producción de biofertilizantes) (ANSWER). Proyectos de I+D en el marco del Programa Operativo FEDER Andalucía 2014-2020. Jose m Fernández Sevilla.
- DigitAlgaesation, H2020-MSCA-ITN-2020, Francisco Gabriel Acién Fernández
- PRODIGIO, H2020-LC-SC3-2020-RES-RIA, Francisco Gabriel Acien Fernandez
- NICOLE, H2020-LC-SC3-2020-RES-RIA, Francisco Gabriel Acien Fernandez
- NUTRIFY, H2020-RUR-2020-2, Francisco Gabriel Acién Fernández
- PROALG, ERA CoBioTechs 3rd joint call, Francisco Gabriel Acien Fernandez
- WALBIO, H2020-MSCA-ITN-2020, Francisco Gabriel Acién Fernández
- Bio2feed, PRIMA Call 2020, Francisco Gabriel Acién Fernández
- LIFE HELIOS, LIFE 2014-2020, LIFE 2020 Environment and Resource Efficiency project application, Francisco Gabriel Acién Fernández
- ALBIOME, COST, OC-2020-1, Francisco Gabriel Acién Fernández

3. INFRASTRUCTURES AND SCIENTIFIC-TECHNOLOGICAL CAPABILITIES OF THE CENTER

Since its creation, the center has gradually increased the number and capacities of its scientific-technological infrastructures. The extensive and advanced equipment that is available, gives the possibility of offering a quality service and high competitiveness.

Our center is continuously trying to improve, optimizing our facilities as much as possible and remodeling deteriorated or obsolete infrastructures.

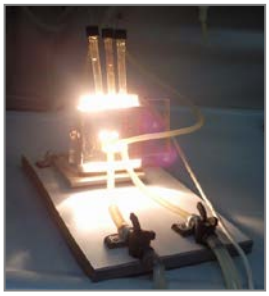
3.1 FACILITIES AND INFRASTRUCTURES OF THE SOLAR ENERGY CHEMICAL USE AREA

Autotrace.

Autotrace s 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.

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..

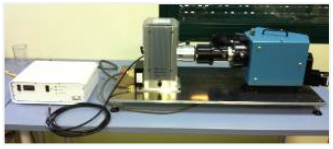


Micromolar photochemical system.

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

UPLC Agilent Technologies series 1200.

This equipment allows the analysis of substances present in aqueous and organic media with high precision and with a relatively short time analysis by reverse chromatography due to their ability to work at high pressure. This device is used for the detection of contaminants in water and allows the removal of these contaminants to be studied with the different processes studied in the CIESOL.

SHIMADZU GC-2010 Gas chromatograph.

The gas chromatograph is equipped with a capillary column Supelco SP-2330 with a FID detector, with the possibility of sample injection split/splitless. It is mainly used to separate and identify organic substances produced in catalytic processes with organometallic compounds and using sunlight and/or heat as the energy source.

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..

BRUKER 320MS Mass spectrometer triple quadrupole coupled to BRUKER 450GC gas chromatograph.

This chromatographic system complements the previously mentioned ones because it allows analysis of organic compounds of low/medium polarity. It is used especially for the determination of trace levels of contaminants such as synthetic fragrances, and pesticides, among others.

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.

Chemical oxygen demand analyzer (COD).

It is used to estimate the amount of organic matter and its oxidation state. The combination of this measure with BOD and TOC allows good overall quality characterization of a wastewater.

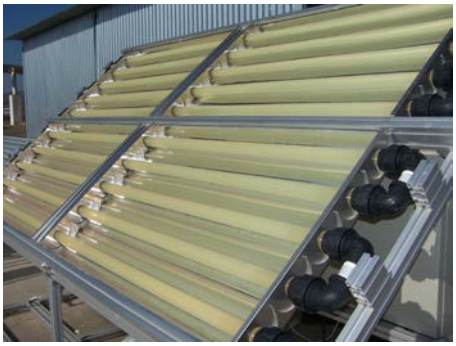
Analizador de la demanda química de oxígeno (DQO). Se emplea para estimar la cantidad de materia orgánica presente y su estado de oxidación. La combinación de esta medida con la DBO y el TOC permite una buena caracterización global de la calidad de un agua residual

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.

3.2 FACILITIES AND INFRASTRUCTURES IN THE AREA OF SOLAR ENERGY USE

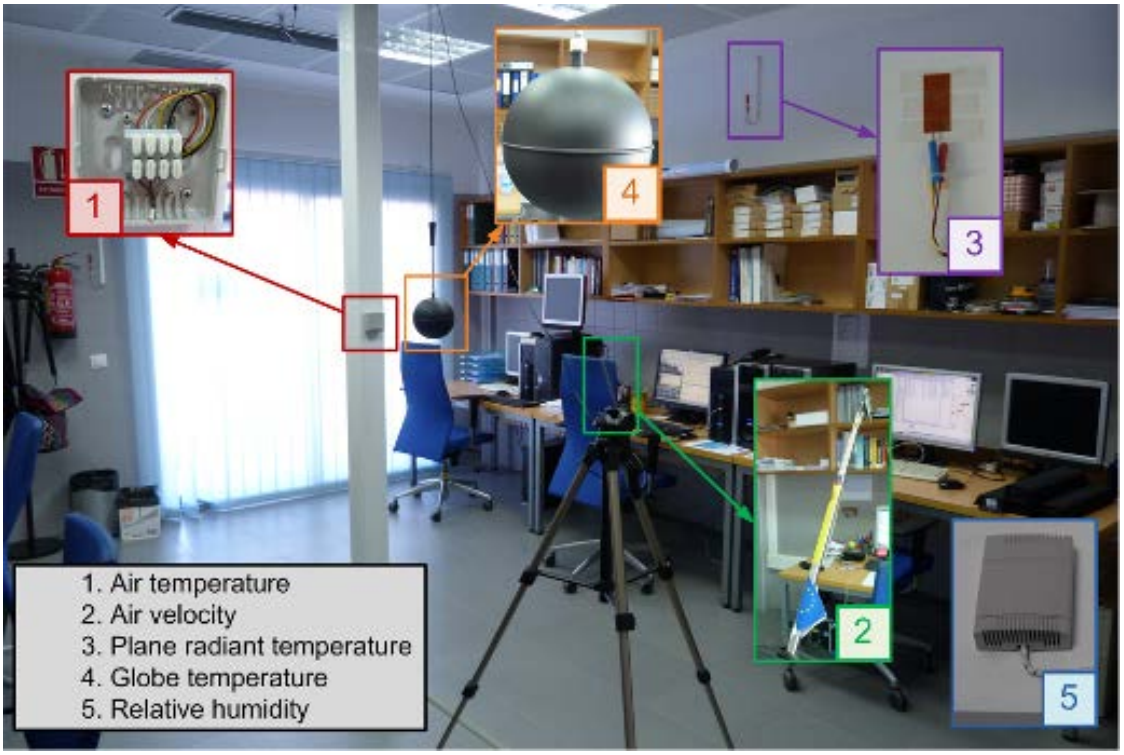
Plant for the use of solar thermal energy. The installation has a collector field which collects the energy from solar radiation to heat water, which is stored in tanks.

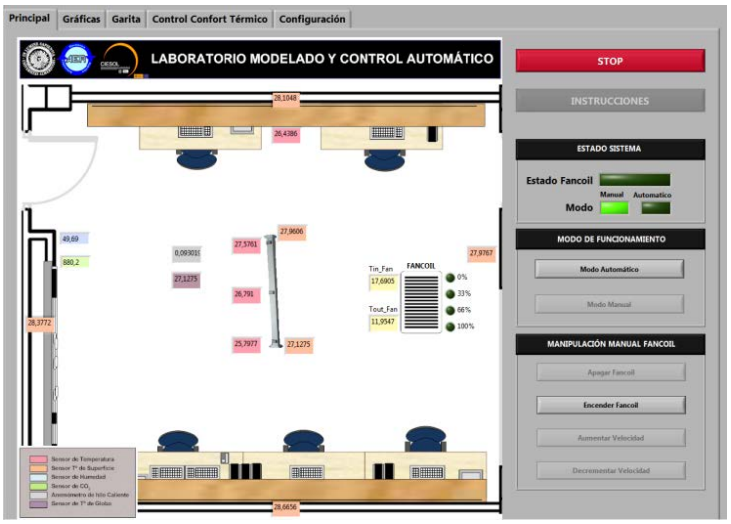
Solar collector field

In winter the water in the heating circuit is heated using a heat exchanger, while in summer it is cooled using a Yazaki absorption machine. In addition, the system has a gas boiler to act as a back-up at certain times and a conventional electric machine to provide service on days when there is insufficient radiation.

Meteorological station: The Solar Energy Resources and Climatology group has a complete top-level meteorological station, consisting of radiometric instrumentation, sky cameras, satellite images and other instrumentation to monitor and characterise the atmosphere in its lowest layer. This has made it possible to develop cloud prediction systems and weather forecasting systems to determine irradiance levels in the short term. In addition, there is an experimental photovoltaic plant dedicated to characterising the production losses due to dust deposition on the surface of photovoltaic panels. This weather station is awaiting to be complemented with new devices.

The Modelling and Control group maintains the basic building monitoring infrastructure.





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

During 2020, two regional and national infrastructure grants have been processed to improve the centre's equipment by providing it with a new monitoring and control system (incorporating the latest data acquisition technologies, IoT, monitoring, etc.); and on the other hand, to acquire infrastructures that will enable the setting up of an agricultural production system with water and energy management under the circular economy paradigm. 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 and is being installed at the IFAPA-La Cañada Centre on the basis of the agreement signed between the University of Almeria and IFAPA.

New photovoltaic modules for the CIESOL Smart-grid

Lithium batteries for electricity storage

New advanced inverters

New Agroconnect photovoltaic field and photobioreactors of the SABANA project

Thermal, electrical and CO2 storage tanks

Reverse osmosis plant

During 2020, the energy utilisation area has expanded the facilities with the following two contracting dossiers:

Procurement and installation of Contracting File 815.20. Lot II:

Expansion of the photovoltaic plant and installation of new devices. This file includes the installation of:

- 12 LONGI Solar LR4-72 HPH 450M G2 photovoltaic modules.
- 2 BYD L 10.5 batteries.
- One Fronius Symo Gen24 8.0 Plus inverter-charger.
- One electric vehicle charging point Circutor eHome T1C32
- A Parrot Sequoia+ multispectral sensor.

The photovoltaic modules are installed on the roof of the building, while the batteries and the inverter-charger are in the hall on the first floor, the charging point is on the outside façade of the courtyard, inside a protective panel, and the Sequoia+ sensor is in the Automation and Control laboratory.

Photovoltaic modules, inverter-charger and electric vehicle recharging point

Procurement and delivery of hardware for Procurement File 815.20 Lot III:

Delivery of hardware components of an indoor location system for robotics applications, consisting of the following parts:

- 13 SEWIO SWA07-00-00 beacons (anchors).
- 13 brackets for the beacons.
- 4 location sensors (tags) SEWIO SWT06-01-00

The hardware components of this system were delivered, pending installation and commissioning of the system, all of this once the work affecting the centre has been completed.

Beacon with brackets and location sensor.

4 COMITTEES AND ACTIVITY RESPONSIBLES.

4.1 CIESOL MANAGEMENT

Director	**José Antonio Sánchez Pérez**
	Full Professor University of Almería
	jsanchez@ual.es

Subdirector	**Sixto Malato Rodríguez** OPI Researcher - PSA (CIEMAT) CIEMAT sixto.malato@psa.es

4.2 EQUIPO TÉCNICO

Área Química	**Octavio Malato Rodríguez** omalato@ual.es
Área Energética	**Blas Salvador Criado** Youth Guarantee Contract as of 1 October 2020 bsc373@ual.es

4.3 ACTIVITY MANAGERS

Activity	University of Almería (UAL)	Plataforma Solar de Almería (PSA)
Organometallics and Photochemistry	**Antonio Romerosa** Full Professor UAL romerosa@ual.es	**Christoph Richter** DLR-PSA CIEMAT christoph.richter@dlr.de
Environmental Analysis	**Ana Agüera** Full Professor UAL aaguera@ual.es	**Isabel Oller** OPI PhD-CIEMAT-PSA isabel.oller@psa.es
Water Regeneration	**José Antonio Sánchez Pérez** Full Professor UAL jsanchez@ual.es	**Inmaculada Polo López** OPI PhD-CIEMAT-PSA mpolo@psa.es
Modeling and Automatic Control	**Manuel Berenguel** Full Professor UAL beren@ual.es	**Lidia Roca Sobrino** OPI PhD-CIEMAT-PSA lroca@psa.es
Desalination and Photosynthesis	**José M. Fernández** Associate Professor UAL jfernand@ual.es	**Dr. Guillermo Zaragoza** OPI PhD-CIEMAT-PSA guillermo.zaragoza@psa.es
Solar Resource	**Javier Batlles** Associate Professor UAL fbatlles@ual.es	

4.4 COORDINATION AND MONITORING COMMITTEE

Diego Valera (University of Almería Vice Chancellor)	vinvest@ual.es
Manuel Berenguel (Full Professor UAL)	beren@ual.es
Julián Blanco (Plataforma Solar de Almería Director, CIEMAT)	julian.blanco@psa.es
Eduardo Zarza (CIEMAT Researcher)	eduardo.zarza@psa.es

4.5 SCIENTIFIC COMMITTEE

Ángela Fernández Curto Deputy Assistant Director-General Large Scientific and Technical Facilities MINECO-Spanish Goverment.	af.curto@ciencia.gob.es
Sebastián Dormido Full Professor of Computer Science and Control UNED	sdormido@dia.uned.es
Ana María Amat Payá Full Professor of Universidad Politécnica de Valencia	aamat@txp.upv.es
David Serrano Full Professor of Chemical Engineering and IMDEA-Energy Director	david.serrano@imdea.org