

www.energy.imdea.org

annual report

2023



research for a sustainable
energy development



David Serrano

Director of IMDEA Energy

Móstoles, December 2024

annual report

2023

www.energy.imdea.org

I have the pleasure to introduce the 2023 Annual Report of the IMDEA Energy Institute. IMDEA Energy is a research centre created by the Regional Government of “Comunidad de Madrid” as a public Foundation to develop R&D activities aimed at the development of a sustainable and fully decarbonized energy system, prioritizing scientific excellence, technology transfer and social impact. The quality of the research developed by IMDEA Energy has been recognized with the prestigious accreditation as a “María de Maeztu” Research Unit, granted by the State Research Agency and the Spanish Ministry of Science, Innovation and Universities.

The year 2023 has been marked by a series of events and the adoption of political strategies in the international context that have had notable consequences on the establishment of energy priorities, to which IMDEA Energy has been receptive. Among them, it is worth mentioning the acceleration in the achievement of decarbonization and energy security objectives framed in the REPowerEU plan, launched in May 2022, as the EU’s response to phase out Russian fossil fuel imports. Moreover, in March 2023, the EU’s commitment to the creation of a manufacturing ecosystem for net-zero technologies and products in the EU was firmly materialized through the Net-zero Industry Act. Also relevant, regarding prioritization of technological developments, has been the EC communication in October 2023 for the update of the SET-Plan.

In full alignment with such priorities, IMDEA Energy has been involved in high-impact R&D activities and projects associated to key challenges related with renewable energy technologies, production of sustainable fuels, energy storage materials and devices, smart management of electricity demand and networks, efficient final use of energy, CO₂ valorisation and elaboration of sustainability studies of new technologies and energy systems. Additional aspects like circular economy and digitalisation have been also subject of intensification in our portfolio of activities.

In terms of personnel, the IMDEA Energy Institute had 142 employees on 31 December 2023 with a gender balance of 54% men and 46% women, of which 103 were researchers. In addition, 48 students and 45 visiting researchers were hosted during the year, demonstrating the great interest that our research lines and infrastructures generate in other institutions. The high quality of the scientific results is demonstrated by the publication of 113 articles, with 95.9% of them in Q1 journals (Scival).

The research carried out at IMDEA Energy is mainly developed within the framework of projects and contracts. In 2023, the total number of active projects and contracts was 104, with an important presence of international projects, which contributed with 42% of the external income. This fact, together with additional resources coming from resilience/recovery fund programmes and the participation in multiple contracts with companies and national and regional projects, provides IMDEA Energy with a high degree of self-financing of the research activities.

These excellent results, together with those of previous years, have made possible IMDEA Energy to be positioned as a world-class research institute. These achievements must be acknowledged to the IMDEA Energy staff by its outstanding effort, commitment and dedication, as well as to the Regional Government of “Comunidad de Madrid” by its valuable and highly appreciated support.

words from the director...

annual report
2023
www.energy.imdea.org

editor

imdea energy institute

graphic design

base 12 diseño y comunicación

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about us

The IMDEA Energy Institute is a research centre created by the Regional Government of Comunidad de Madrid in the year 2006 that operates as a non-profit foundation. The Scientific Programme of the IMDEA Energy Institute aims at contributing to the future establishment of a sustainable and decarbonised energy system, economically competitive and securing energy supply.

The IMDEA Energy Institute is committed with having a significant impact on R&D energy challenges by bringing together high quality researchers, providing them with excellent infrastructures and resources, and promoting their close collaboration with the industrial sector.



strategic framework

The strategic framework guiding the R&D priorities of IMDEA Energy is based on goals and priorities established by energy plans and research programmes at regional, national and international levels; such as the UN's Sustainable Development Goals, the Green Deal for Europe, the Clean Energy Transition Partnership, new European Strategic Energy Technology (SET) Plan with the selected

targets for 2030 and 2050; the European Research Programme Horizon Europe; the National Integrated Plan on Energy and Climate; the Spanish Strategy on Science, Technology and Innovation; technology roadmaps of recognized international institutions and associations and implementation agreements of the International Energy Agency.



laboratories

The building and laboratories of IMDEA Energy Institute are located at the Technological Park of Mostoles, Madrid, over a land of 10,000 m².

Research topics

Production of sustainable fuels

Concentrated solar power

Energy storage

Smart management of electricity demand

Energy systems with enhanced efficiency

Valorization of CO₂ emissions

Techno-economic evaluation of energy systems

The excellent R&D capabilities and the first class research facilities make IMDEA Energy the ideal partner for companies, research centres and universities

The building has been awarded with the prestigious LEED Gold Certificate and the A Energy Efficiency Certificate.



building



IMDEA Energy

Unit of Excellence

“María de Maeztu”

IMDEA Energy’s commitment to excellence in the recruitment of human resources, the selection of cutting-edge research lines, the provision of top-level scientific equipment and, in particular, the high quality and impact of its scientific contributions was recognized in 2020 through 2024 with the accreditation as a “María de Maeztu Unit of Excellence”, granted by the



Unit of Excellence “María de Maeztu”

Ministry of Science and Innovation. IMDEA Energy forms part of the SOMMa network of Severo Ochoa/María de Maeztu distinguished centers.

The award grant has allowed IMDEA Energy to reinforce its lines of research on decarbonization of mobility by electrification and the production of hydrogen, solar fuels and waste-derived fuels. Particularly noteworthy is the significant presence of projects related to the production of sustainable fuels for aviation, three European projects and one regional hub, as a result of this prioritization. With the support of Maria de Maeztu grant, the Institute has improved all the performance indicators in terms of scientific-technological excellence; attracting talent and training; internationalization, technology transfer and dissemination.

Prof. David Serrano, PI of the María de Maeztu Unit and Director of Institute IMDEA Energy, has been awarded the Miguel Catalán 2023 Research Award of the Community of Madrid in the modality of scientific career. This important recognition values his scientific achievements, his contribution to the training of researchers, the pioneering of new research lines and the national and international impact of his work throughout his professional career.

Dr. Patricia Horcajada, guarantee researcher of the Maria de Maeztu Unit and head of the Porous Materials Unit at IMDEA Energía, has been recognized in the “Doctor of Alcalá” 2023 Research Excellence Awards of the University of Alcalá in the category of Young Researcher in Experimental Sciences. This award considers the excellence of the scientific contributions, the impact of the same, the leadership capacity, as well as the balance and quality of the research career.



our structure



Responsible of managing and dealing with the main business administration and scientific activities of the Institute.



THERMOCHEMICAL PROCESSES UNIT

ELECTROCHEMICAL PROCESSES UNIT

BIOTECHNOLOGICAL PROCESSES UNIT

HIGH TEMPERATURE PROCESSES UNIT

ELECTRICAL SYSTEMS UNIT

PHOTOACTIVATED PROCESSES UNIT

SYSTEM ANALYSIS UNIT

ADVANCED POROUS MATERIALS UNIT

- Financial management and human resources.
- Project management.
- External relationships and technology transfer.
- Infrastructure and facilities management.
- Health and safety.
- Central research laboratories and resources.
- Dissemination and communication.

BOARD OF TRUSTEES

The highest decision-making body responsible of the government, representation and administration, aiming to ensure the achievement of the established goals.

PRESIDENT

Prof. Dr. Martin Kaltschmitt
Institute for Environmental Engineering and Energy Economics
Hamburg University of Technology, Germany

VICE-PRESIDENT

Mr. Emilio Viciana
Regional Minister of Universities, Science and Research
Comunidad de Madrid, Spain

REGIONAL ADMINISTRATION REPRESENTATIVES

Mrs. Ana Ramírez
Deputy Regional Minister of Universities, Science and Research
Comunidad de Madrid, Spain

Mrs. Ana Cremades
General Director of Research and Technological Innovation
Comunidad de Madrid, Spain

Mr. Nicolas Casas
General Director of Universities
Comunidad de Madrid, Spain

Mrs. Bárbara Fernández-Revuelta
Deputy General Director for Research
Comunidad de Madrid, Spain

Mr. Rafael García
Deputy Regional Minister of Environment and Agriculture
Comunidad de Madrid, Spain

Mr. José de la Sota
Scientific Coordinator
Fundación para el Conocimiento madri+d
Comunidad de Madrid, Spain

INSTITUTIONAL TRUSTEES

Prof. Dr. José Antonio Calles
Rey Juan Carlos University, Spain

Dr. Yolanda Benito
Centre for Energy, Environmental and Technological Researchs, CIEMAT, Spain

Prof. Dr. José Ramón Ares
Autónoma University of Madrid, Spain

Prof. Dr. Carlos del Cañizo
Polytechnic University of Madrid, Spain

IMDEAS TRUSTEES

Prof. Dr. Arturo Romero
Complutense University of Madrid, Spain
(appointed by IMDEA Water)

Prof. Dr. Paula Sánchez
Castilla – La Mancha University, Spain
(appointed by IMDEA Materials)

SCIENTIFIC TRUSTEES

Prof. Dr. Antonio Monzón
University of Zaragoza, Spain

Dr. Francisco Gírio
National Laboratory of Energy and Geology
Portugal

Prof. Dr. Manuel Berenguel
University of Almería, Spain

Dr. Rufino Navarro
Institute of Catalysis and Petrochemistry, CSIC
Spain

EXPERT TRUSTEES

Dr. José Jacinto Monge
Rey Juan Carlos University, Spain

Mrs. África Castro
H2B2, Spain

COMPANIES TRUSTEES

Ms. Adriana Orejas
Repsol, S.A Spain

Mrs. Pilar González
Iberdrola S.A., Spain

Mr. Vicente Alvarado
Empresarios Agrupados Internacional S.A.
Spain

SECRETARY

Mr. Alejandro Blázquez
Advisoring Tercer Sector, Spain

SCIENTIFIC COUNCIL

Advisory body responsible of the elaboration of the scientific programme and of the establishment of the goals to be achieved by periods of four years as well as of the assessment of the annual performance.

Prof. Dr. Martin Kaltschmitt
Institute for Environmental Engineering and Energy Economics
Hamburg University of Technology, Germany

Prof. Dr. Antonio Monzón
Chemical Engineering and Environmental Technologies
Department
University of Zaragoza, Spain

Dr. Francisco Gírio
Bioenergy Unit
National Laboratory of Energy and Geology, Portugal

Prof. Dr. Michael Froeba
Department of Applied Inorganic Chemistry
University of Hamburg, Germany

Prof. Dr. Manuel Berenguel
Department of Computing Sciences
University of Almería, Spain

Dr. José A. Olivares
Los Alamos National Laboratory, USA

Dr. Rufino Navarro
Institute of Catalysis and Petrochemistry, CSIC, Spain

Prof. Dr. Gonzalo Guillén-Gosálbez
Chemical and Bioengineering Institute
ETH Zurich, Switzerland

Prof. Dr. Elena Gálvez
Institute of Nanoscience and Materials of Aragón
Zaragoza, Spain

Prof. Dr. Silvia Bodoardo
Electrochemistry Group,
Politecnico di Torino, Italy

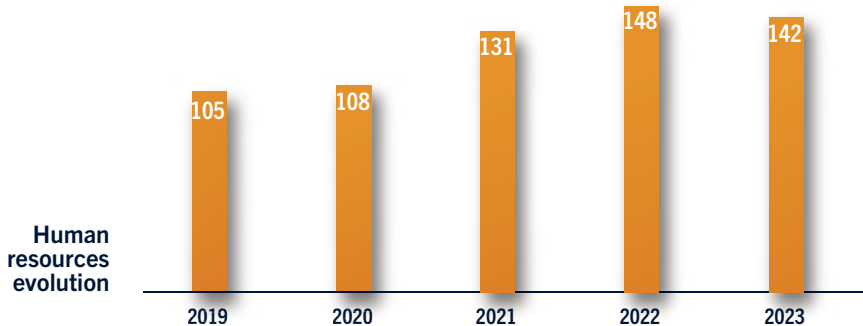
Prof. Dr. Valeria Nicolosi
School of Chemistry, CRANN, AMBER & I-Form
Trinity College Dublin, Ireland



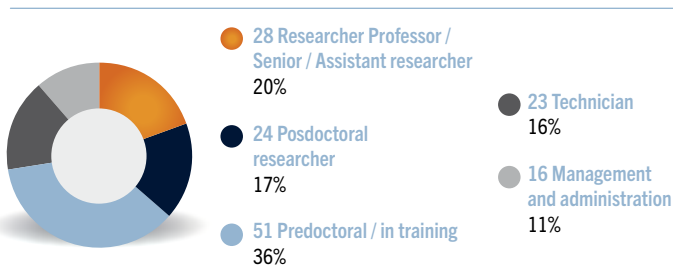
in figures

IMDEA Energy is firmly committed to the objective of providing the Institute with a world-class staff and prestigious researchers. Accordingly, the Institute is developing from the beginning a selective process for the recruitment of scientists.

human resources



Human resources distribution by the 31st of December of 2023

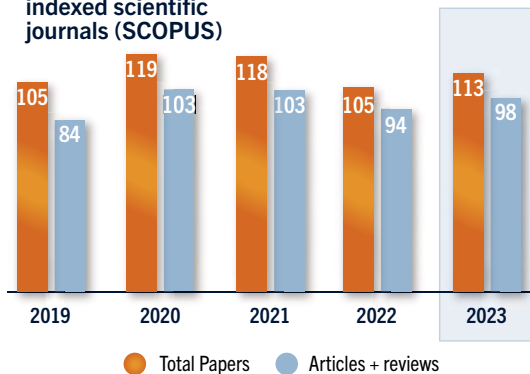


47 students in connection with the IMDEA Energy Institute in 2023

Mobility actions in 2023

22 secondments of IMDEA Energy researchers
45 visiting researchers

Publications in indexed scientific journals (SCOPUS)



2023

81 oral presentations, 30 invited conferences and 35 poster communications.

6 Ph.D. thesis defended.

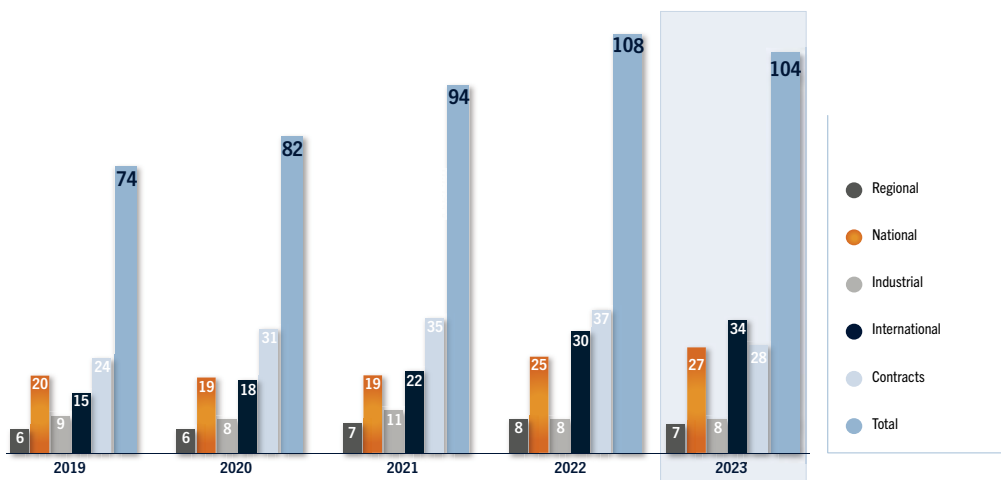
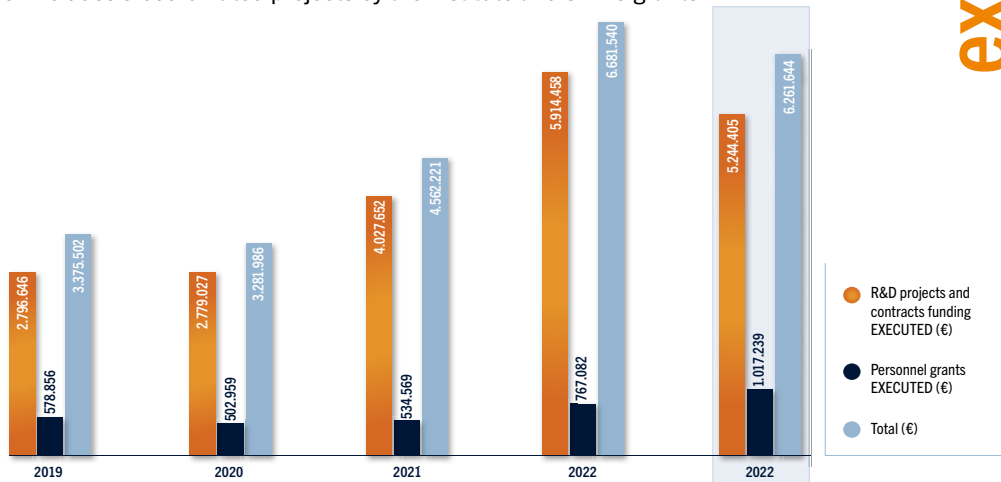
2 new patents and 2 brands have submitted and 1 software registered.

R&D results

The portfolio of the Institute research projects is characterized by its diversity in terms of funding source, being remarkable the high degree of collaboration with industries and research institutions of the energy sector.

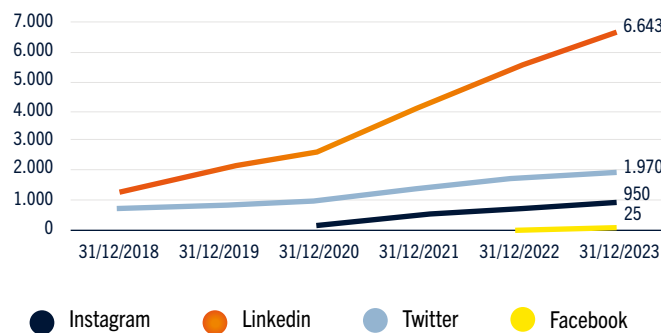
IMDEA Energy has increased its involvement and leadership in projects funded in international competitive calls during 2023, being active a total of 34 international projects. This number includes 9 coordinated projects by the Institute and 3 ERC grants.

external funding



Evolution of the followers in social networks

9.588 followers at the end of 2023
21% of increase respect to 2022



social impact



cooperation & networking



Cooperation and networking with industry, research centers and academia in R&D and innovation is one of the key objectives of the IMDEA Energy Institute. In 2023 IMDEA Energy maintained direct collaborations with 71 research organizations and universities and 43 industrial partners, mainly within the framework of ongoing R&D projects.

During 2023 IMDEA Energy had an active participation in 53 associations, technology platforms, expert groups and associations in the energy sector, 13 of them were international, as an essential point to increase its external visibility, establish new links with companies and research organizations and obtain updated information on the initiatives in the different fields of energy.





research lines

Energy storage coupled to renewable energy and transport



Technologies and systems for the storage of energy enabling the increased penetration of renewable energies and the distributed generation of electricity.

Electrochemical energy storage

- Nanostructured materials for electrochemical capacitors and advanced batteries.
- Electrochemical capacitors with high energy density.
- Low-cost redox flow batteries.
- Development of testing protocols for batteries and supercapacitors.

Thermal and thermochemical energy storage

- Phase change materials (PCM) with macro-encapsulated structures and storage systems for solar thermal power plants and industrial waste heat recovery.
- Thermal energy storage with gas/solid systems in thermoclines and moving bed exchangers.
- Thermochemical storage systems making use of high temperature redox reactions.

Production of sustainable fuels



Biofuels, alternative fuels and bioproducts aiming at the decarbonisation of the transport sector.

- Biofuels and bio-products from microalgae carbohydrates.
- Biofuels via fast pyrolysis or catalytic pyrolysis of lignocellulose biomass and residues.
- Upgrading of bio-oils by catalytic hydrodeoxygenation processes.
- Development of CO₂-free fuels by solar driven thermochemical cycles.
- Solar fuels production by artificial photosynthesis.
- Valorization and dehalogenation of plastic wastes.

Concentrated solar power



Efficient and dispatchable solar concentrating technologies for power generation, industrial process heat and production of solar fuels and chemicals.

- Optical design of modular schemes for solar thermal power plants.
- Solar receivers and reactors for new heat transfer fluids.
- Solar technologies for fuels and chemicals production with CSP.
- Increasing solar-to-electricity conversion efficiency and dispatchability.



Smart management of electricity demand



Management, reliability and stability aspects of future electricity networks and new algorithms for demand management and renewable integration.

- Demand forecasting and network management algorithms.
- Reliability of power systems with high penetration of renewables.
- Building and residential demand modelling.
- Distribution network applications and services.
- Power electronics and power interfaces.

Energy systems with enhanced efficiency



Technologies and strategies for efficient end-use of energy in buildings, industrial processes and environmental applications.

- Control systems and algorithms for energy efficiency in industrial applications.
- Capacitive deionization for energy efficient water treatment.
- Solar heat for medium and high temperature industrial processes.
- Integration of renewable energy technologies in buildings.

Valorization of CO₂ emissions



CO₂ valorization routes by its transformation into high-demand valuable products.

- CO₂ photoreduction for energy storage and fuels production.
- Multifunctional materials and solar reactors for photoactivated processes.
- Thermo-catalytic routes for CO₂ transformation in industrial processes.

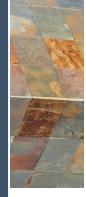
Techno-economic evaluation of energy systems



Sustainability assessment, optimisation of processes and modelling for energy planning.

- Process simulation and optimization.
- Life cycle management, sustainability and social aspects.
- System modelling and technology roadmapping.

research lines



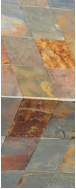
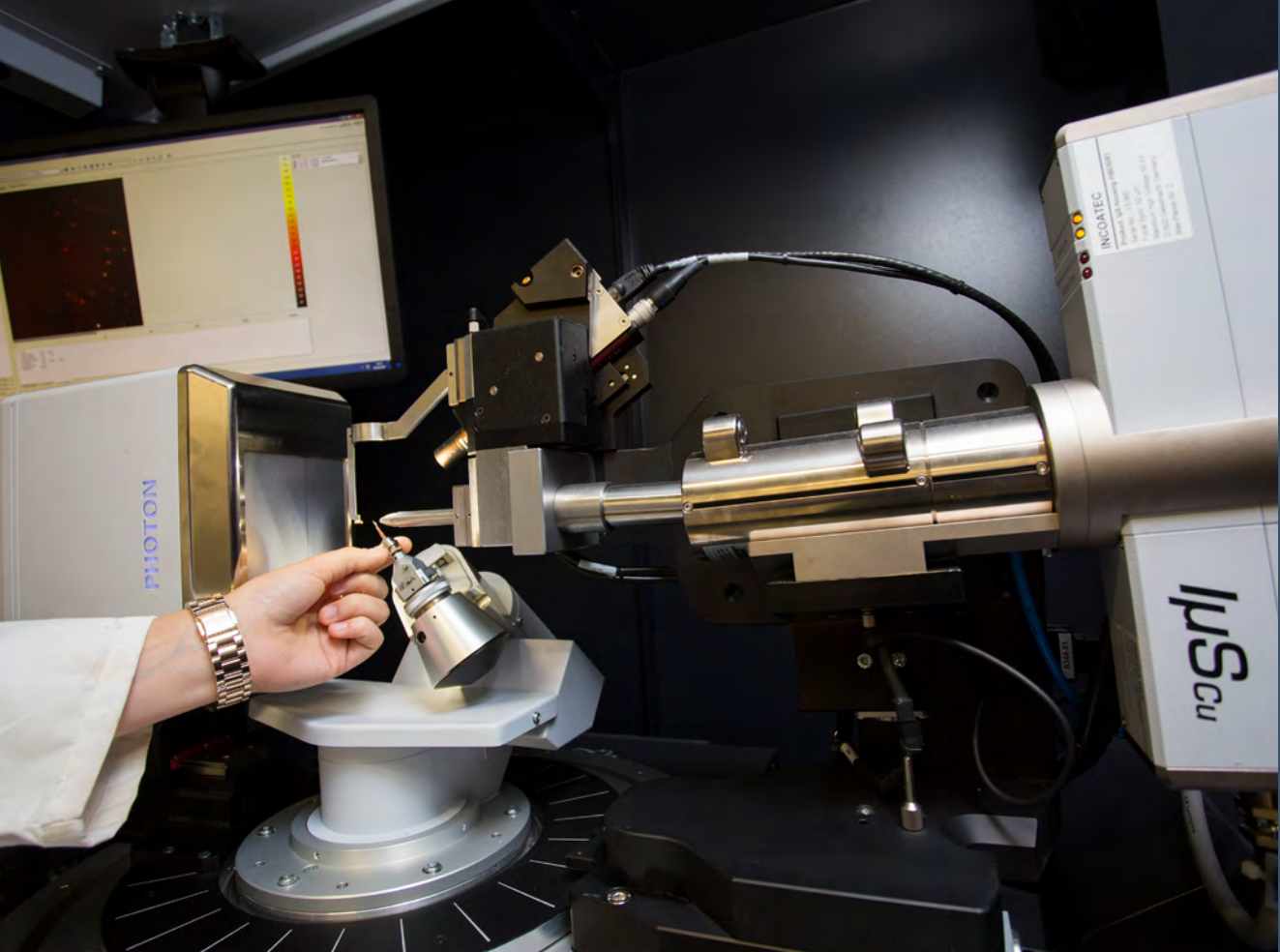
scientific facilities

Instrumental Techniques

- Chemical characterization techniques: mass spectrometry; gas/mass chromatography; NO_x chemiluminescence analyzer; pyrolyzer / gas chromatography- mass spectrometry (Py/GC-MS); elemental analysis ICP – OES; AOD decomposition system (calorimetric pump) and CHONS.
- Thermogravimetric analysis (TG-DTA) in an oxidising (air), inert (Ar) or reductive (10% H₂/Ar) atmosphere.
- Properties of solids: textural and chemisorption.
- X-ray diffraction with PDF structural analysis and controlled atmosphere chamber up to 900 °C and 10 bar.
- Spectroscopy: IR (DRIFT, ATR and VEEMAX), UV-vis-NIR, Raman and fluorescence.
- Thermal diffusivity determination.
- Microscopy: atomic force, SEM, FEG-SEM.
- Biotechnological characterisation techniques: GC, HPLC equipped with different columns and detectors (IR, MS, UV-VIS, HPAEC-PAD). Electrophoresis instrumentation for recombinant DNA technology, protein purification and analysis.
- Near-ambient pressure (NAP) XPS which allows the in-situ characterisation of photocatalytic processes under illumination at different gas atmospheres and pressures up to 25 mbar.



scientific facilities



Pilot Plants Facilities

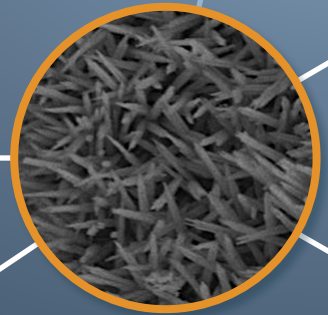
- High Flux Solar Simulator Kiran-42 with an electrical power of 42 kW that with the use of seven 6- kWe short-arc Xenon lamps is able to reach irradiances at the focal point near $4,000 \text{ kW/m}^2$ and a total power of 12 kW.
 - Test bench of batteries for the programming of different test procedures and charge and discharge cycles. It allows analyzing the electrochemical devices performance, cyclability, aging and failure modes.
 - Smart Grids Laboratory for the simulation of electrical systems operation, including the integration of renewable energies, storage systems and electric vehicle in order to get an efficient management of the energy resources.
 - Pilot plant for the production of advanced biofuels via thermochemical transformations of biomass: catalytic pyrolysis and hydrodeoxygenation.
- Photobioreactors pilot plant which has been designed in order to compare and optimise the most common algae cultivation systems.
 - Solar fuels photoreactor formed by a compound parabolic concentrator (CPC) coupled to a gas chromatograph.

Solar Field

- Consisting of 169 heliostats, 3 m^2 each, with an experimental platform located on top of an 18 m height tower. This facility allows testing receivers, reactors and materials up to 250 kW thermal power under irradiances above 2000 kW/m^2 .

research units

**Thermochemical
Processes Unit**



**Electrochemical
Processes Unit**

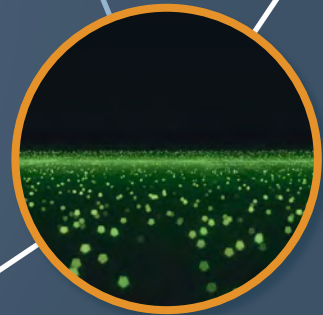


**High Temperature
Processes Unit**

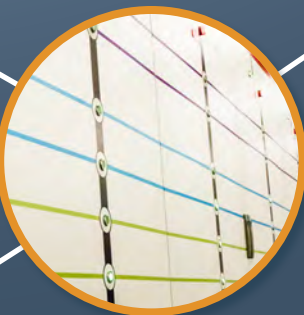
**System Analysis
Unit**



**Biotechnological
Processes Unit**



**Photoactivated
Processes Unit**



**Electrical Systems
Unit**



**Advanced Porous
Materials Unit**

Thermochemical Processes Unit



Prof. Dr. David P. Serrano
Research Professor
Head of the Unit



Dr. Patricia Pizarro
Senior Researcher
(Associated)



Dr. Javier Feroso
Senior Assistant
Researcher



Dr. Inés Moreno
Senior Assistant
Researcher
(Associated)



R&D OBJECTIVES

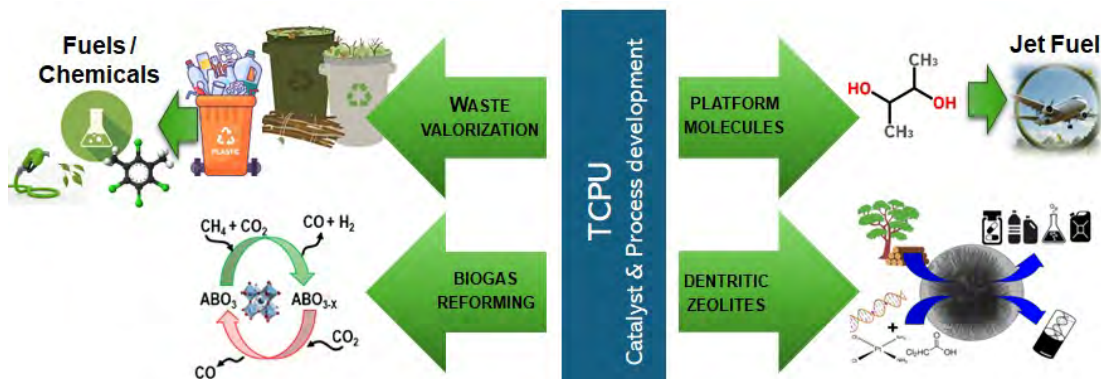
- Development of materials (catalysts and adsorbents) for the improvement or adaptation of thermochemical processes that contribute to the energy transition and circular economy using waste as a resource.
- Development of zeolitic materials with dendritic morphologies with excellent and unique properties of great interest in different applications.

R&D LINES

- Dry reforming of biogas to hydrogen or synthesis gas by thermochemical cycles;
- Valorization of wastes by thermochemical-catalytic route;
- Catalytic conversion of waste-derived platform molecules;
- Catalysts for biogas reforming by chemical reaction cycles;
- Development of dendritic zeolites and their potential applications.

RELEVANT R&D ACTIVITIES AND NETWORKING

- In 2023 UPTQ has participated in 11 research projects distributed in the following topics: 8 on organic waste valorization (including biogas reforming); 2 on the development of biofilters from biochars and hydrochars, 1 on the synthesis and applications of dendritic zeolites. “Comunidad de Madrid” funded 3 projects: BIOCHARFILT (Grant to attract young research talent), BIO3 (Research and Development Activity Program between Research Groups of the Community of Madrid) and HUBS MADRID + CIRCULAR. The national government funded 4 research projects: ADBIOCAP, UPGRES, CIRPLACAR and HYWARE. In addition, UPTQ participates in the European project PCoN-M3 (Japan Concert), coordinates the Horizon Europe project called BIOCTANE and Prof. David P. Serrano is the PI of the “Advanced Grant” TODENZE. Finally, UPTQ participates in the 0-EMISION project as a subcontractor.
- UPTQ maintains contact with several universities and research centers in Spain and Europe, such as ICP-CSIC, Universidad Rey Juan Carlos, Universidad Autónoma de Madrid, CIEMAT, University of Calabria (Italy), Charles University (Czech Republic), Ábo Akademi University, Universidade Federal do Rio Grande do Norte (Brazil), Universidade Federal do Rio Grande do Sul (Brazil). On the other hand, Prof. Dr. David Serrano has been during the year President of the Spanish Zeolite Group and member of the steering committee of the European Federation of Zeolite Associations (FEZA), as well as member of the advisory board of CIESOL (joint center University of Almeria - CIEMAT/PSA) and of the advisory committee of Singular Infrastructures of the Ministry of Science, Innovation and Universities



High Temperature Processes Unit



Dr. José González-Aguilar
Senior Researcher
Head of the Unit



Dr. Manuel Romero
Research Professor



R&D OBJECTIVES

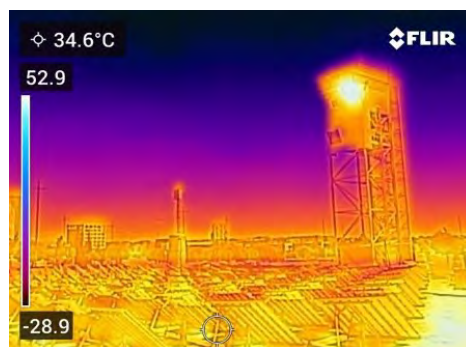
- Modular, efficient, dispatchable and cost-effective high temperature solar concentrating technologies for production of solar fuels and chemicals, industrial process heat and power generation.

R&D LINES

- Modular schemes of solar thermal systems for their integration into urban and industrial environments;
- Advanced solar receivers and reactors (pressurized, volumetric and particles) and heat exchangers.
- High temperature thermal storage (thermochemical, sensible and phase change).
- Synthesis of solar fuels and chemicals through solar and electrolytic processes at high temperature.
- Analysis of integration of solar energy in industrial processes, heat recovery and environmental impact (advanced thermodynamic cycles, water-energy nexus, glint and glare).

RELEVANT R&D ACTIVITIES AND NETWORKING

- In 2023 the High Temperature Process Unit (HTPU) focused its research on solar thermal technologies, with special emphasis on applications involving high temperature and very high concentration of sunlight. In 2023, HTPU maintained the coordination of this topic in “Comunidad de Madrid” through the regional research program ACES2030-CM (2019-2023). In addition, at the regional level, within Repsol’s HUB-MADRID+CIRCULAR, developed new concepts for H2 production via dry reforming of biogas driven with solar energy and high temperature electrolysis and the coordination of a research line on solarized SOE in the GreenH2-CM project. Developed research on concentrating solar towers in the national R&D project HECTOR. In terms of industrial cooperation, good examples are solar heat with SEENSO Renoval; corona discharge devices for cooling in solar power plants and in vehicles with the company CEDRION and it is worth mentioning the continued collaboration with Synhelion and CEMEX in the production of solar clinker. EU collaborations continued in the FCH/JU PROMETEO project on solar heat and power for SOE; in the H2020 SFERA III project (Solar Installations for the European Research Area - Third Phase); Sharp-sCO2 on the development of high-efficiency air-sCO2 hybrid solar power plants; and the Sun to Liquid II project on solar energy production of aviation fuels using concentrated solar power.
- In addition, HTPU participates in the Joint Program on Concentrated Solar Power (EERA JP-CSP). At the national level, HTPU also participates in the Spanish technology platform on CSP (SolarConcentra) and in the Energy Storage Working Group (GIA), an initiative of the Spanish Ministry of Economy and Competitiveness, and participates in the IEA SolarPACES Tasks I and II. Dr. José González acted as member of the Board of Directors of the International Solar Energy Society (ISES) and Dr. Manuel Romero as member of the Executive Board of the Spanish Association of Solar Energy (AEDES).



Electrochemical Processes Unit



Dr. Jesús Palma
Senior
Researcher
Head of the Unit



**Dr. Rebeca
Marcilla**
Senior
Researcher



**Dr. Enrique
García -
Quismondo**
Senior Assistant
Researcher



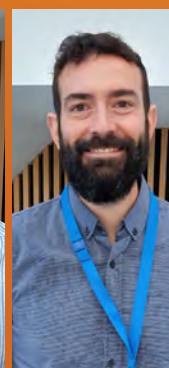
**Dr. Andreas
Mavrantakis**
Senior Assistant
Researcher



Dr. Julio Lado
Senior Assistant
Researcher



Dr. Patil Nagaraj
Senior Assistant
Researcher



Dr. Sergio Pinilla
Senior Assistant
Researcher



R&D OBJECTIVES

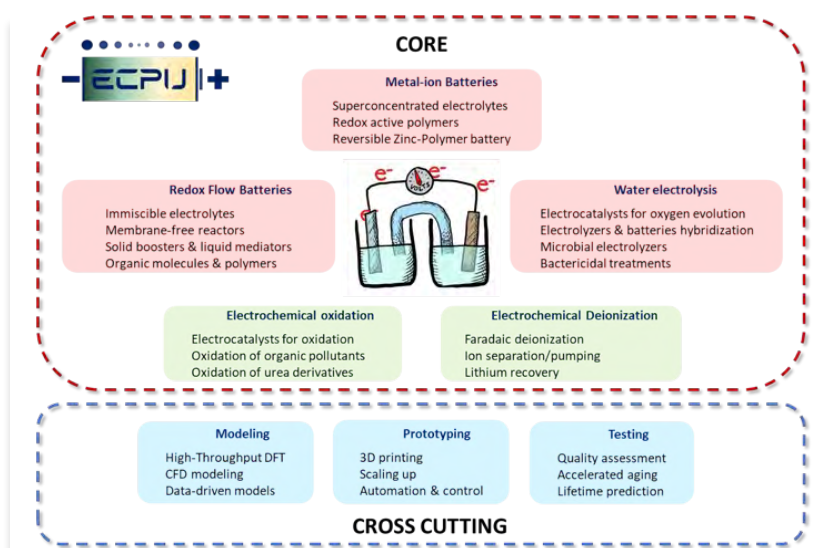
- Electrochemical energy storage devices and systems for stationary and transport applications.
- Electrochemical energy-efficient devices and processes for energy and environmental applications.

R&D LINES

- Design and construction of flow batteries with novel chemicals free of critical materials to improve efficiency, increasing energy density and reducing costs per kWh stored.
- Materials and components to improve the performance, cyclability and recycling of lithium-ion batteries and other metals.
- Design and scale-up of capacitive and faradaic deionization processes to capture value-added or potentially hazardous ionic species dissolved in natural or wastewater of high salinity and in industrial effluents from, for example, battery recycling.
- New methodologies for accelerated testing of batteries and supercapacitors to determine their aging depending on storage and use conditions.
- Application of electrochemical methods for the electro-oxidation of organic pollutants.
- Production of renewable hydrogen by electrochemical methods.

RELEVANT R&D ACTIVITIES AND NETWORKING

- In 2023 ECPU has participated in a total of 22 research projects, 7 of them were European: 1 ERC Consolidator (MFreeB), 2 Horizon 2020 FET-Proactive (HySolChem and LIGHT-CAP), 1 EIC Open (MeBattery), 1 Marie Curie ITN (POLYSTORAGE) and 1 EDF (NOMAD). Regarding national projects, they were as follows: 1 Knowledge development (OMBAT), 3 Ecologic and digital transition (MicroBat, Solarless and BEST-MODA), 1 Recovery Transformation and Resilience program (Nitro-D-Cell). With respect to Regional projects, 3 were Talent Attraction projects (CADFUNES, SELECTVALUE and ADEMOSSBat), 1 was an Industrial Doctorate (BAILEM), 1 Innovation Hub (Madrid+Circular) and 1 Strategic Positioning on Green H2 and Fuel Cells (Green H2-CM). Additionally, 4 contracts were carried out with companies, Verisure, Aqualia, Sener and Unbound Potential.
- In 2023 ECPU maintained the usual networking activities in National and International organizations participating in working Groups of the European Technology and Innovation Platform on Batteries (Batteries Europe) and the European Battery Partnership Association (BEPA). Members of the unit have been actively participating in to the Electrochemistry Specialized Group of the Spanish Royal Society of Chemistry as treasurer (Rebeca Marcilla) and in the Spanish Technology Innovation Platform on Energy Storage as vice-president (Jesus Palma).



Biotechnological Processes Unit



Dr. Cristina González
Senior Researcher
(Associated)
Head of the Unit



Dr. Elia Tomás
Senior Assistant
Researcher



R&D OBJECTIVES

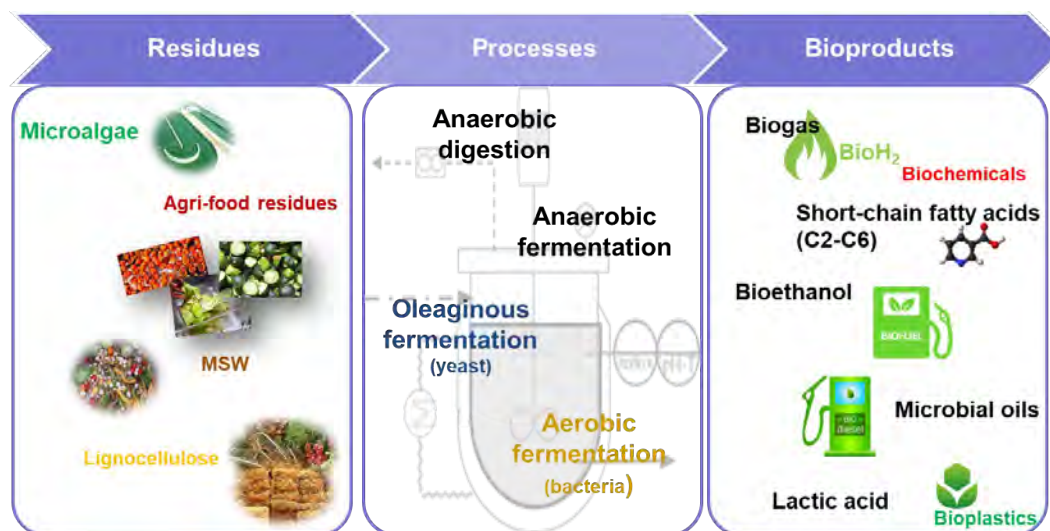
- Recovery of C (N and P) from waste to produce biofuels and bioproducts

R&D LINES

- Anaerobic digestion of waste streams for biogas production.
- Anaerobic fermentation of waste streams to produce short-chain fatty acids (SCFAs).
- Biofuels and lignocellulosic bioproducts.
- Use of the carboxylate platform: production of hydrogen and microbial oils.

RELEVANT R&D ACTIVITIES AND NETWORKING

- In 2023, the Biotechnological Processes Unit (BTPU) has participated in projects related with the use of different residual streams for the production of alternative compounds (short chain fatty acids, lactic acid and microbial oils) as well as energy products (ethanol and biogas). In this period, BTPU has participated in 9 projects, out of which 3 were European (PRODIGIO H2020 2021-2023, OLEOFERM-ERA CoBioTech 2021-2024 and YAF HORIZON-MSCA-2022-DN-01 2023-2028), 4 national (BIOMIO-2021-2024, UPGRES_2021-2024, RAVIOLIC 2022-2024, RESOPLA 2022-2024) and 2 regionals (ALGATEC-2019-2024 via their services offered in the BIOOPEN Lab and Madrid+Circular-2021-2023). Both BIOMIO and RESOPLA are coordinated projects led by BTPU. In the same line, OLEOFERM and YAF are international projects coordinated by BTPU.
- Acknowledging the importance of gaining international visibility and establishing key collaboration, BTPU is actively participating in several networking COST Actions (Greenering, Euromicroph and WIRE). In this sense, BTPU leads the European project YEAST4BIO (2019-2024), supported COST Action of H2020, which involves more than 150 researchers from 34 countries. Also, at international level, the Unit participates in RENUWAL (2019-2023), a Latin-American network focused on microalgae cultivated in wastewater. As a result of the participation in the above-mentioned projects, BTPU actively collaborates with leading Research Groups and companies along Europe. BTPU is member of BIOPLAT.



Electrical Systems Unit



Dr. Milan Prodanovic
Senior Researcher
Head of the Unit



Dr. Javier Roldán
Senior Assistant
Researcher



R&D OBJECTIVES

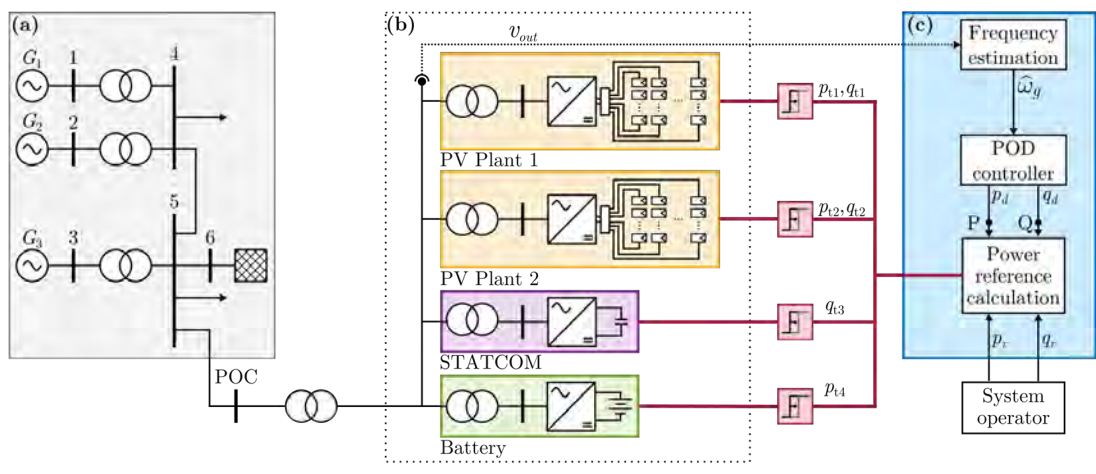
- Improved control and stability aspects of future electricity networks with high share of renewable and storage technologies.
- Optimisation based algorithms for demand management and renewable integration.
- Increased energy efficiency in industrial applications.

R&D LINES

- Renewable and energy storage integration.
- Control of power converters for applications in electricity networks.
- Stability of power networks with high penetration of renewables.
- Energy management and energy efficiency applications.

RELEVANT R&D ACTIVITIES AND NETWORKING

- In 2023 Electrical Systems Unit (ESU) participated in several research and development projects. Principal research activities were performed within the frameworks of European project DRES2MARKET (2020-2023) and national projects REDEFUERTES (2023-2026) and FLEXENER (2021-2023). These projects addressed control, stability and flexibility aspects of renewable and storage integration to power networks as well as control of power electronics interfaces in grid applications. National projects BEST and SOLARFLESS (2022-2025) addressed the issues of holistic modelling of battery systems and their hybridization with renewable plants. With respect to industrial collaborations, the main project was DYNAMIC-COMPENSATION (2023-2026) that deals with the design of a new product for power conditioning as well as COPOWCO in collaboration with IMV Corporation, addressing the issue of electromagnetic compatibility of power converters in industrial applications.
- ESU participated in activities of the Spanish Platform for Power Networks (FUTURE), in particular in the Power Electronics workgroup. In 2023 ESU continued its role in the Spanish Platform on ICT applications in Energy Efficiency (EnerTIC) as an associated member.



System Analysis Unit



Dr. Javier Dufour
Research Professor
Head of the Unit



Dr. Diego Iribarren
Senior Researcher



Dr. José Luis Gálvez
Senior Assistant
Researcher



R&D OBJECTIVES

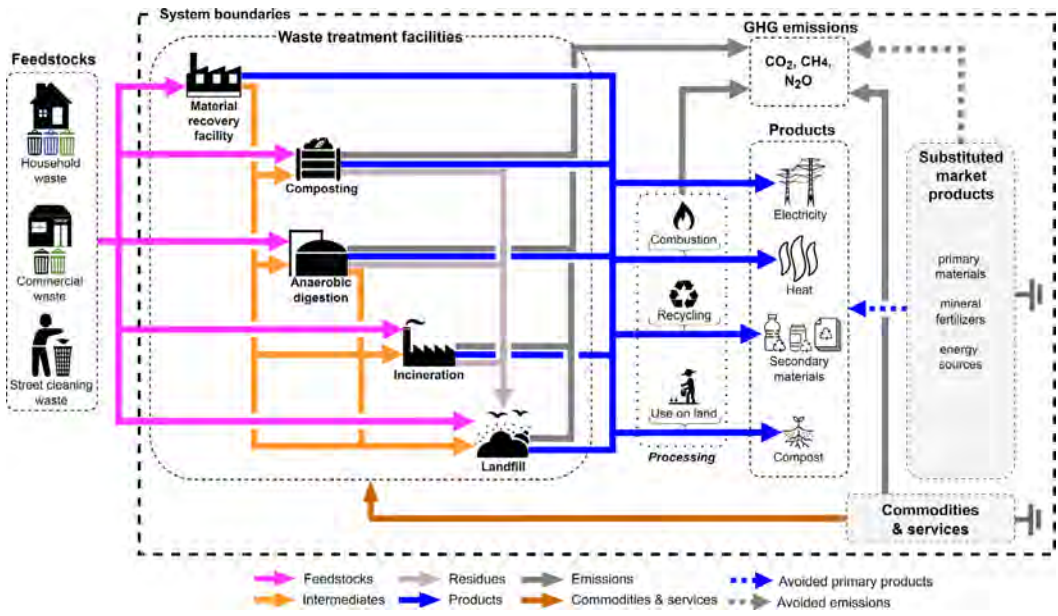
- Sustainability assessment of energy systems
- Process design, scale-up, simulation and optimization
- Energy systems modelling for energy planning

R&D LINES

- Sustainable-by-design hydrogen systems.
- Role of waste and waste-to-energy technologies in the framework of circular economy and production of clean fuels.
- Development of sustainability-oriented energy models.

RELEVANT R&D ACTIVITIES AND NETWORKING

- In 2023 the Systems Analysis Unit has contributed to several international, national and regional projects, mainly with the sustainability assessment and/or the optimization of systems. In the hydrogen field, SAU has participated in 6 European projects (SH2E H2020-FCHJU (2021-2024), as coordinator, eGHOST H2020-FCHJU (2021-2024), as well as coordinator, NOUVEAU HORIZON-RESILIENCE (2022-2025), NIMPHEA HORIZON-JTI-CLEANH2 (2023-2026), JUST-GREEN AFRH2ICA HORIZON-JTI-CLEANH2 (2023-2025), and HYPOP HORIZON-JTI-CLEANH2 (2023-2025)), one national project (HYWARE), one regional (Green H2 Madrid) and 3 contracts. Related to photoactivated processes, the Unit participated in the projects HYSOLCHEM FETPROACT (2021-2024) and DESIRED HORIZON-CL5 (2022-2026), both funded by the European Commission, one domestic one (SOLFUTURE (2021-2024)), and one regional (FotoArt-CM). In the waste-to-energy and circularity field, SAU collaborated in 2 European projects (LIFE Superbiodiesel (2020-2024) and OLEOFERM-ERA CoBioTech (2021-2024)) and 2 national ones (UPGRES (2021-2024) and CIRPLACAR (2022-2024)). Additionally, SAU is contributing to the NOMAD project (2022-2026), funded by the European Defence Fund, and is developing a contract for the sustainability assessment of recycled carbon fibre.
- At the networking level, Javier Dufour is Deputy Leader of the Cross-Cutting Activities Technical Committee of Hydrogen Europe Research, and Diego Iribarren is Coordinator of the Spanish Network for Life Cycle Assessment.



Photoactivated Processes Unit



Dr. Victor A. de la Peña
Senior Researcher
Head of the Unit



Dr. Marta Liras
Senior Researcher



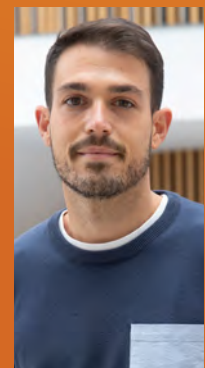
Dr. Mariam Barawi
Senior Assistant
Researcher



Dr. Laura Collado
Senior Assistant
Researcher



Dr. Freddy Oropeza
Senior Assistant
Researcher



Dr. Miguel García
Senior Assistant
Researcher



R&D OBJECTIVES

- Covering the processes and technologies that allow a smart and efficient light harvesting to drive photon-activated processes for energy and environmental applications.

R&D LINES

- Solar fuels and chemicals production including: CO₂ photoreduction, H₂ production, N₂ fixation and added value chemical synthesis.
- Pollutants removal (i.e. NO_x and VOCs photodegradation).
- Design and synthesis of multifunctional materials: inorganic, organic and hybrid systems.
- Full-spectrum light harvesting technologies for electron transfer processes.
- Combination of advanced characterisation and theoretical calculation for fundamental studies of reaction mechanisms.
- Photoreactors and devices (photocatalytic, photothermocatalytic and photoelectrocatalytic) for energy and environmental applications.
- Smart window devices based on electrochromic materials and semiconductor nanocrystals with Localised Surface Plasmon Resonance (LSPR).
- Photobatteries design.
- Photoactive materials for theragnosis applications.
- Development of robotic platforms orchestrated by AI for new-energy solutions (BRAIN Lab).

RELEVANT R&D ACTIVITIES AND NETWORKING

- In 2023 the Photoactivated Processes Unit (PAPU) has participated in 18 research projects and 7 grants funded at regional, national and European level. Dr. Víctor A. de la Peña O'Shea, senior researcher and head of the PAPU, as former holder of ERC-CoG, was awarded two ERC-PoC (NANOCPs and DEMONIA) which have overlapped during 2023. Also, in the European context, PAPU coordinated a FET Proactive action (HYSOLCHEM), was partner of an MSCA Staff Exchanges (BETTER XPS) and participated in a CSA flagship proposal (SUNER-C). In addition PAPU has participated in several national projects: Nympha (Retos, 2020-2023, novaCO2 (Retos, 2021-20254), ARMONIA (JIN 2021-2024) and N-GREEN Retos 2023-2026), SOLFUTURE (*Lineas estrategias* call) and SolarChem 5.0 and PEC2Change (ecological and digital transition call), being coordinators of both SOLFUTURE and SolarChem 5.0. At the regional level, PAPU has coordinated the FotoArt-Cm (New Generation of Multifunctional Materials for Artificial Photosynthesis). In relation with industry, PAPU holds projects with the Mercedes and HFC companies.
- PAPU participates at international level in different initiatives. Víctor de la Peña O'Shea is the Spanish representative in the SUNERGY Action and in the Sunlight to X innovation community. On the other hand, PAPU participates in the Spanish CO₂ technological platform (PTECO₂) where the head of the Unit is the General secretary, the technological sustainable chemistry platform (SUSCHEM) and in the Iberian Photocatalysis Association (AIF). In addition, Víctor A. de la Peña O'Shea is president of the the Specialized Group on Energy (GEEN) of Spanish Royal Society of Chemistry and Marta Liras is president of the Specialized Group on Photochemistry (GRUFO) of the Spanish Royal Society of Chemistry.



Advanced Porous Materials Unit



Dr. Patricia Horcajada
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Head of the Unit



Dr. Yolanda Pérez
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(Associated)



Dr. Tania Hidalgo
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Dr. Catalina Biglione
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Researcher



R&D OBJECTIVES

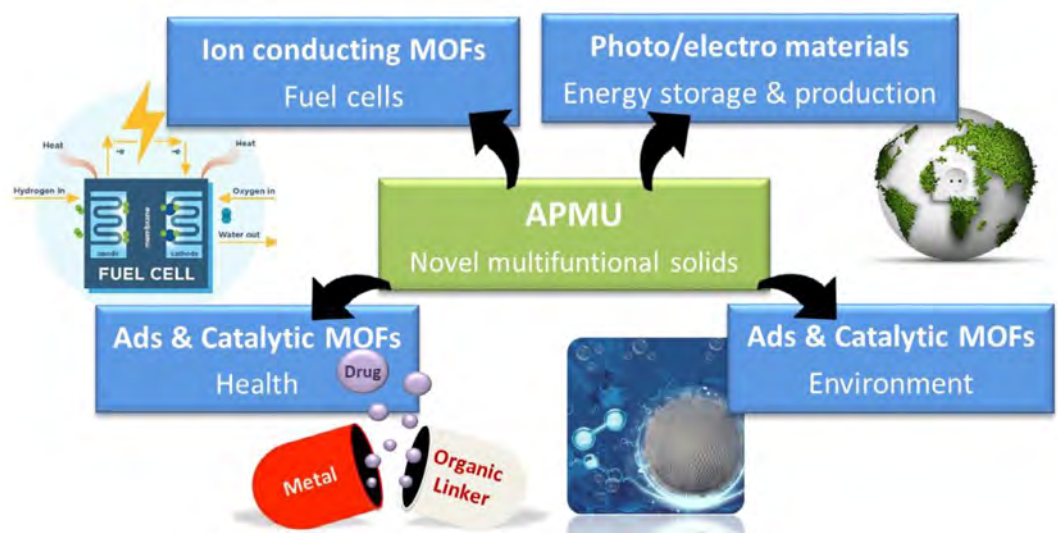
- Development of innovative multifunctional solids.
- Full understanding of the structural features for improving and/or adapting the materials properties to specific applications.
- Adapted devices (including scale-up and shaping) for their final applications.

R&D LINES

- Fuel cells and electrolyzers: new materials with ionic conductivity.
- Energy storage and production: novel photo/electroactive materials.
- Environmental applications: adsorbent and catalytic materials.
- Health applications: biocompatible materials with adsorbent and catalytic properties.

RELEVANT R&D ACTIVITIES AND NETWORKING

- During 2023, the Advanced Porous Materials Unit (APMU) has coordinated 2 European projects: a MSCA-ITN project HeatNMof (2020-2024) focused on the heating triggered drug release using nanometric inorganic-metal organic framework (MOF) composites and a M-ERA.NET C-MOF.Cell (2020-2023) working on MOF composites as efficient electrolytes in fuel cells (FCs). APMU also actively participates in a COST action (EU4MOF) involving 10 different countries. Likewise, it has running five national projects: 2 national projects on water decontamination (ESENCE 2020-2023 and MOFseidon 2020-2023), one focused on FCs and electrolyzers (H2MOF 2022-2024), one dealing with CO2 valorization (NAPOLION 2023-2026) and a collaboration networking for the development of multifunctional metallo drugs in diagnosis and therapy (MetalloDrug 2019-2023), APMU is also involved in two projects with regional fundings: Clorato (2020-2023) an industrial doctorate in coll. with Canal de Isabel II for drinking water purification; and HUB Madrid+Circular (2021-2023) developing new catalysts for hydrotreatment of pyrolytic and catalytic oils.
- APMU has a high-quality and broad frame of collaborations, including some relevant academic institutions at the National (e.g. ITQ, USC, UGR, UCM, UAH) and international level (e.g. Stockholm Univ., ICGM-CNRS, TU/e, Univ. Antwerp), as well as companies in different sectors (e.g. Immaterial, Canal Isabel II, DAM, Lantania, ISERN, Repsol).



annex



R&D projects,
and contracts



personnel grants



mobility actions



indexed scientific publications
(SCOPUS)



intellectual property



books and chapters
of books



other publications



congress communications



PhD thesis defended



organization of scientific and
industrial events



organization of internal
seminars



participation in science
dissemination activities



training of students



annex

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